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## Article

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# The Concept of Using the Excess Rate of Return in the Study of the Impact of EU ETS on the Value of Enterprises

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## ABSTRACT

The aim of the study is to assess the impact of the EU ETS on the profitability and the excess rate of return (ERR), which is the difference between profitability and the cost of capital. The study was conducted between 2008 and 2016 on a sample of 91 very large companies covered by the EU ETS. Models for panel data were used for the analysis. No statistically significant relationship between emission allowances and return on equity was found. However, a statistically significant relationship between emission allowances and ERR was detected. This could mean that companies were able to pass on the cost of emission allowances to their counterparties. However, greenhouse gas emissions entail greater exposure to the price risk of emission allowances, which the companies were unable to diversify, resulting in an increase in the cost of equity. Moreover, the study shows that the effect of emission allowances on the value of companies may not be symmetrical, as the variable under study was only statistically significant when it took on positive values (GHG emissions were higher than the allocation). As proven, an analysis of the excess returns can help to explain some of the inconsistencies and contribute to a better understanding of the impact of the EU ETS on the value of companies. The research carried out helps to answer the question of who bears the costs of reducing greenhouse gases and is it true that there are no costs for companies and therefore the introduction of the EU ETS has not affected their value. The conclusions of this study may be of interest to policymakers, investors but also to the public.

*JEL Classification:* G320; G380; H220; H230

*Keywords:* value of firm, pollution tax, EU ETS, incidence, corporate regulation.

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## 1. INTRODUCTION

The European Emissions Trading Scheme (EU ETS) was launched in 2005 in order for EU countries to effectively meet their greenhouse gas emission reduction commitments under the Climate Convention (Directive 2003/87/EC of the European Parliament and of the Council). It covers around 45% of the EU's total greenhouse gas emissions. The EU ETS operates on a cap-and-trade basis with partially free allocation. An upper limit on emissions (cap) is set and then emissions allowances are either auctioned (trading) or allocated for free (grandfathering).

The EU ETS target for 2020 was to achieve a level of emissions 21% lower than in 2005. The post-2020 assumptions were revised in July 2015. It was agreed that the sectors covered by the scheme would have to reduce emissions by 43% by 2030, compared to 2005. On 14 July 2021, the European Commission presented the “Fit for 55” climate package. According to the Commission's predictions, the changes contained therein will result in an overall reduction of emissions from the sectors covered by the EU ETS of 61% by 2030 (compared to 2005). In addition, free allocation of allowances is gradually being phased out. In the initial clearing periods (2005-2012), most allowances were allocated to installations for free. Since 2013, the allocation of free allowances has been falling dramatically; in 2013, it was around 80%. In 2020, companies already received only 30% of allowances for free (Directive 2009/29/EC of the European Parliament and of the Council, Article 10a(11)). Ultimately, from 2027 there should be a complete elimination of free allocations (Directive 2018/410, point 14(k)).

The effect of, among others, the abovementioned changes is a rising price of emission allowances, which in 2021 reached a level exceeding EUR 100. With such high prices of emission allowances, the question of the impact of the EU ETS on the value of the companies covered by the scheme becomes justified. Such analyses can help recognize who bears the costs of reducing greenhouse gas emissions, as well as whether the European Union's goals in this regard are too ambitious. The conclusions of this study may be of interest to policymakers, investors, but also to the public.

## 2. LITERATURE REVIEW

In economics, many theories touch on the impact of regulations, not only environmental ones, on the economic and financial health of enterprises. Emphasizing the goal of the operation of enterprises, which is an increase in value, the conclusions of the mentioned theories can be applied to this financial category. This justifies the synthetic nature of enterprise value and its wide field of perception.

In classic terms, emission allowances represent a cost for companies. They are therefore expected to negatively affect their value. In the neoclassical view, however, it is emphasized that companies have the ability to pass on the cost of emission allowances to counterparties. As a result, the impact of regulation on the value of a company can be negative (incomplete or no ability to pass on costs), neutral (full ability to pass on), or even positive (excess passing on). The phenomenon of passing on the cost of emission allowances to consumers has been the subject of research. Studies have been conducted *ex ante* using simulations (see McKinsey&Company & Ecofys, 2006; Smale et al., 2006; Vivid Economics & Ecofys, 2013) or *ex post* using econometric tools, or surveys. The research conducted so far shows that in the first two EU ETS settlement periods (2005–2013), energy-intensive companies passed on a significant portion of the value of free emission allowances to the prices of their products and received windfall profits from this. A review of the literature further shows that the passing rate differed between the different subjects of activity. Sectoral estimates of this indicator also differed between studies (de Bruyn et al., 2015, p. 163).

Porter and Linde (1995) suggested a different perspective on the effects of introducing regulations. Environmental regulation can contribute to innovation, they said, which can improve the competitiveness of companies (the Porter hypothesis). As a result, it is reasonable to believe that the value of the company should increase. Hoffmann (2007) and Rogge et al. (2011) found, based on interviews with experts and managers of energy companies in Germany, that the EU ETS has contributed to innovation in specific electricity generation technologies, accelerated research in energy efficiency, as well as carbon capture and storage technologies. Similarly, Anderson et al. (2011), based on interviews with representatives of 27 companies in Ireland, concluded that the EU ETS stimulates companies to seek emission reduction opportunities. Borghesi et al. (2012), based on information on the innovation of 1,000 Italian companies, detected that participation in the EU ETS positively influences company innovation, as long as the “severity factor”, defined as the ratio of a sector’s emissions to the number of freely allocated allowances, is not too high (negative correlation). The opposite conclusion was reached by Löfgren et al. (2013), based on panel data of 700 Swedish companies (energy and energy-intensive). They compared data of companies that were «most likely to be covered by the EU ETS» with low-energy-intensive companies that were «most likely not covered by the EU ETS.» They detected no impact of the EU ETS on small and large investments, although their study only covers the first eight months of the second settlement period. Conclusions similar to those of Löfgren were reached by Martin et al. (2012) in a preliminary version of their study. Based on the managers’ responses in terms of clean process and product innovation, they rated companies on a scale of 1–5 and found no significant differences in the scores between EU ETS and non-EU ETS companies. However, when they considered in the survey that sectors deemed vulnerable to emissions leakage would continue to receive free allowances after 2012, their conclusions changed. They noted that companies in sectors that almost met the conditions for inclusion in the protection procedure innovated significantly more than those in protected sectors. In 2016, Caeli and Dechezlepretre published a study that analyzed patents filed between 1979 and 2009 in the field of low-CO<sub>2</sub> technologies. Controlling for differences between EU ETS companies and others, they detected a small positive but significant effect of the EU ETS on the number of low-carbon technology patents reported by ETS companies. They also noted that there had been a noticeable increase in this type of patenting in both groups of companies since 2005. Unfortunately, this study is flawed in that it did not take into account the significance of the innovations made. It seems that, in part, this shortcoming could be eliminated by controlling the amount of expenditures made. The cited studies show that the EU ETS has most likely influenced innovation in some companies. However, isolating all the gains from R&D investments is very troublesome. It is therefore difficult to assess how these innovations have affected the value of companies. It would be an oversimplification to say that since they made them, they must have gained from them.

Recalling the emission havens hypothesis, the impact of the introduction of environmental regulations on the value of companies depends largely on international competition and the tightness of regulations. If international competition is fierce and regulation is not tight, the value of regulated companies will fall and the value of unregulated ones will rise. However, the conclusions of the research are ambiguous (Temurshoev, 2006, p. 3). While there is frequent evidence of the so-called pollution haven effect<sup>2</sup>, so-called carbon leakage<sup>3</sup> was not observed during the first two periods of the EU ETS (Bolscher et al., 2013). This is probably due to the presence of safeguard mechanisms against the said phenomenon. However, a slightly different view is proposed by the Tiebout Hypothesis (Tiebout, 1956). As this theory implies, taxpayers choose a location where the combination of the amount of taxation and the public goods provided

<sup>2</sup> Increase in foreign investment in countries that have not introduced environmental regulations or have set environmental standards below their efficiency levels.

<sup>3</sup> Relocation of activity or increase in production in branches operating outside the EU due to the introduction of EU ETS regulations.

in return maximizes their individual utility<sup>4</sup>. The value of a regulated enterprise may be higher than that of an identical enterprise located in an unregulated country if the ratio of public goods (which it receives in return) to the cost of environmental regulation is favorable. Continuing this line of thinking, countries also differ in their factor endowment. What matters, then, is the ratio of the benefits of factor endowments (which a company obtains) to the costs of regulation. This reasoning is supported by localization theories, as well as the factor endowment hypothesis, according to which, the reason for differences in the emissivity of countries is primarily due to differences in factor endowments.

Given the theories mentioned, as well as the results of the studies cited, it is difficult to assess how the introduction of the EU ETS has affected the value of companies. Some theories suggest that the impact should be negative, others that it should be positive, and still others that the introduction of the EU ETS will not affect the value of companies at all. What is more, research does not unequivocally confirm the validity of either theory. Moreover, there is no certainty that only one theory is correct. Knowledge from these studies is therefore piecemeal, and the research itself appears uncoordinated. Conclusions from studies directly analyzing the relationship between emission allowances and enterprise value are also ambiguous. Some authors have detected a positive impact on the value of companies in the first trading period (Veith et al., 2009). Others found that while allowance prices were positively correlated with the market value of firms in the first trading period, they were already negatively correlated in the second trading period (Mo et al., 2012). The opposite conclusions were reached by Pereira da Silva et al. (2016), who detected only a significant effect in the second settlement period and it was positive.

Without avoiding value judgments, it seems that the ability of a company to pass on the costs of these regulations is crucial. If a company can pass on the costs of the allowances, the regulation will not fulfill its incentive function and the stimulation of innovation, as predicted by Porter's hypothesis, will not occur. The ability of companies to pass on costs is highly dependent on the level of competition prevailing in the sector, including international competition, which also links it to location choice theories.

In recent years, the attention of researchers analyzing the impact of the EU ETS on the broader financial situation of companies has focused primarily on two financial categories: corporate profitability and the carbon premium (cost of capital). As will be shown later, these financial categories can, with several assumptions, be directly related to the value of the enterprise. Moreover, analyzing these financial categories can be linked to the theories described previously, which can help to create a framework for a broad and internally consistent study of the impact of emission allowances on the value of companies. The proof is in the work of Krzyzaniak and Musgrave (1963), in which they analyzed the phenomenon of income tax pass-through based on corporate profitability.

## 2.1. Impact of the EU ETS on corporate profitability

When studying the impact of the EU ETS on corporate profitability, the most commonly used method was the difference-in-differences method. In these models, the impact of the EU ETS was estimated using a binary variable that took the value of one (1) when a company was covered by the EU ETS in a given year. In addition to the companies covered by the scheme, the sample included companies not covered by the EU ETS (control group). The study used data from the years of EU ETS operation as well as from the period before the introduction of the system.

Commins et al. (2011) analyzed the impact of the introduction of the EU ETS on the logarithm of return on capital invested (ROCE) of 65,787 firms covered and not covered by the EU ETS over the period 1996–2007. Using OLS and FD (*first difference*) estimators, they found that the

<sup>4</sup> The mentioned theory applied to household choices, but as Fischel (1975) noted, it can also be used for mobile businesses.



EU ETS had a significantly negative impact on ROIC. However, it did not significantly affect employment, total factor productivity and investment.

Jaraite and Di Maria (2015) analyzed the impact of the EU ETS on the gross profit-turnover ratio of 353 Lithuanian companies (41 covered and 312 not covered by the EU ETS) between 2003 and 2010. Using the semi-parametric nearest neighbor estimator and the Kernel estimator, they detected only a slight increase in investment, but no significant differences in the area of profitability.

Marin et al. (2018), using Abadie's (2005) semiparametric estimator, analyzed the impact of the introduction of the EU ETS on a wide range of economic efficiency indicators of enterprises, including: turnover, margin, investment intensity, labor productivity and return on investment (ROI). The study was conducted on a sample consisting of three groups of companies: those covered by the EU ETS, for which a similar company was selected or differences were controlled (between 481 and 754 companies); those covered by the EU ETS, for which no similar companies were selected and differences were not controlled (between 167 and 297 companies); a control group of similar companies (between 1,935 and 2,919 companies). They concluded that the EU ETS had a positive effect on scale-related measures and a negative effect on the scale-free ones. In addition, emission-intensive firms and sectors had slightly worse economic performance. Two factors were the most important: the ability of firms to pass on costs to their consumers (increased margins and turnover) and improved labor productivity. However, as they noted, this may be due to the protective nature of the first two periods. The authors calculated that for industry, the free allocation between 2005 and 2012 was about 24% greater than actual emissions. In contrast, other sectors received on average 8% fewer allowances for free than they needed. This resulted in very low allowance prices. In relative terms, relative to the sectors not covered by the scheme, this improved their situation. As noted by the authors, companies that left the EU ETS but remained in the market significantly reduced their size (Marin et al., 2018, pp. 578-579).

Dechezlepretre et al. (2018) conducted a study on a sample of about 8,000 companies from France, Netherlands, Norway, and the United Kingdom (installations covered by the scheme accounted for 1,828 and those not covered for 5,258). They took their emissions data from EPER (later E-PRTR). Using, among others, the FE-OLS estimator and probit models, they found that the economic performance of regulated firms was not negatively affected by the introduction of the EU ETS. Moreover, it had a positive impact on firm profitability (ROA) and the size of fixed assets (logarithm of fixed assets). This means that it is likely that the EU ETS forced companies to make appropriate investments, which ultimately led to improved profitability.

## 2.2. Impact of the EU ETS on the cost of capital

Through the introduction of the EU ETS, companies were required to purchase emission allowances in a number equivalent to the greenhouse gases emitted (in tCO<sub>2</sub>e). As the free allocation of allowances decreased, the costs associated with this obligation became higher, potentially affecting companies' revenues and profitability. The rising price of allowances in recent years has further multiplied this effect. However, this is not the only channel for the impact of the introduction of the EU ETS on the value of companies. The form of regulation also matters. Emissions trading has become a source of risk in the price of allowances (market price), commonly referred to as carbon risk (Koch & Bassen, 2013, p. 431). The premium that investors expect in return for this risk is referred to as the carbon premium.

Studies on the impact of the EU ETS on the cost of capital can be divided into two types: those focusing on the beta carbon factor and the carbon premium. The papers in which the authors took the first steps to calculate the carbon beta coefficient should be considered as the publications by Oberndörfer (2009) and Veith et al. (2009). However, the work of Koch and Bassen (2013) should be considered as the first adequate attempt to estimate the carbon beta ratio at the firm level.

This was done for the first time for the second settlement period, which can be considered to be operating efficiently. Using data from 2005 to 2010, they calculated the carbon beta coefficient for 20 companies in the energy sector. They found that for most electricity generating companies, carbon risk is negligible, but for high-carbon companies, it is a significant risk factor, resulting in a higher cost of equity capital. Importantly, the authors included the determined beta factors in the calculation of the “carbon-adjusted weighted average capital cost”. Then, using the DCF (discounted cash flows) approach, they calculated the value of the company. Similarly to the previously cited studies (Veith et al., 2009; Oberndörfer, 2009), they did not refer to any specific theoretical concept when making their calculations. The authors merely stated that they developed the model in the spirit of multivariate models and those of Fama and French (Koch & Bassen, 2013, p. 433). However, their intention was not to test the asset pricing model on a full scale, but only to estimate the ‘systematic impact’ of emissions allowance price risk over and above the impact of the market factor (Koch & Bassen, 2013, p. 434).

Studies that attempted to estimate the carbon premium appeared in later years. They most often used the sorted portfolio technique. This was first done by Oestreich and Tsiakas (2015), who conducted very thorough analyses, but only on German companies. Taking into account the criterion of the size of the free allocation (a rough proxy for carbon risk exposure adopted by the authors), they divided 65 German listed companies into three portfolios: “DIRTY”, “CLEAN” and “MEDIUM”. According to their calculations, the carbon risk premium was between 11.8% and 16.8% in the German market during this period.

A different conclusion regarding the carbon premium was reached by Cheema-Fox et al. (2019) based on an analysis of US and European companies between June 2009 and December 2018, where a positive carbon premium was detected. However, the structure of the zero-investment portfolio was the opposite (CLEAN minus DIRTY) to Oestreich and Tsiakas (2015), so their results should be understood as a negative carbon premium.

An even different conclusion was reached by Görgen et al. (2020), who did not detect a significant carbon premium. They conducted their study on a very large sample of 1,600 companies from 43 countries. The sorting criterion was the author’s synthetic Brown-Green-Score benchmark which took into account more than 50 indicators related to carbon risk.

It is also worth mentioning the working papers that refer to the carbon premium but did not use the sorted portfolios technique. Bolton and Kacperczyk (2019) analyzed the carbon premium on very large samples of US companies and US, European and Asian companies (Bolton & Kacperczyk, 2020). In both studies, the authors used panel models with fixed effects. They detected a positive carbon premium. The study conducted on US companies showed that the detected premium was not explained by other risk factors (primarily known from the models of Fama and French) or the sale of „sinful” assets, which only applied to a few sectors (Bolton & Kacperczyk, 2019). Excluding „sinful” sectors from the study resulted in a significant high premium. The authors also noted that carbon risk is not related to emissions intensity (the ratio of emissions to revenues), but rather to the amount of emissions or change in emissions. In a study conducted on an enlarged sample, including European and Asian companies, they obtained similar results. They found that the carbon premium does not affect only a few countries, but occurs universally (Bolton & Kacperczyk, 2020).

Lemma et al. (2019) developed a simultaneous equation model system and analyzed data drawn from firms listed on the Johannesburg Securities Exchange (JSE), for the period 2010 to 2015, using the three-stage least squares procedure. They find that the capital market does not appear to incorporate a company’s individual exposure to carbon risk in the required cost of capital, but generally requires higher returns for companies operating in carbon-intensive sectors. They also find that voluntary carbon disclosure is associated with a lower overall (and equity) cost of capital, after controlling for corporate carbon risk.

Bui et al. (2020) reached similar conclusions about the importance of carbon disclosure for the cost of capital. They examined the relationship between GHG emission intensity and the so-called implied cost of equity operationalized according to the Easton's (2004) model. Based on 4,655 observations from firm-year in 34 countries (for the period 2010 to 2015), they find that firms' GHG emission intensity is positively related to the cost of capital. However, they also find that the penalty associated with a higher cost of capital is moderated by extensive disclosure of carbon emissions.

A positive relationship between issuance and cost of equity and a negative one between level of disclosure and cost of equity was also found by Garzón-Jiménez and Zorio-Grima (2021). The data panel they used included 5,328 observations from 929 companies (from 30 emerging countries) covering the period 2014 to 2019. Similarly to Bui et al. (2020), they used the Easton's (2004) model to calculate the cost of equity, which was the dependent variable in the Blundel and Bond's (1998) model.

### 2.3. Excess return concept

The literature review shows that companies were likely able to pass on the allowance costs, but at the same time, higher emissions were associated with higher carbon risk and, consequently, a higher cost of capital. Unfortunately, these conclusions come from separate studies, carried out on different companies and at different times, so there can be no certainty that they can be combined. Moreover, the impact on the cost of capital or on profitability does not necessarily indicate an impact on the value of the company. If the operation of the EU ETS reduces the profitability of companies but at the same time lowers their cost of capital, then there need not be a loss of value because the fall in profitability may be less than the cost of capital. This regularity also works in the opposite direction, if, as a result of the introduction of the EU ETS, the profitability of companies has improved, but the cost of capital has also increased, then there is not necessarily an increase in value. An analysis of the relationship between these two financial categories can therefore facilitate the assessment of the impact of the EU ETS on the value of companies. The concept linking these two determinants of value is the excess rate of return (ERR), which is the difference between profitability and the cost of capital.

Wishing to relate it to the value of the company, a single-phase growth model can be used. Assuming for simplicity that cash flow is represented by operating earnings EBIT after tax, and that growth is not free and depends on the rate of reinvestment, we can write the formula for value as follows:

$$V = EBIT_{t+1}(1 - T)(1 - RR) / (r - g) \quad (2.1)$$

where:

$V$  – value of the company,

$EBIT_{t+1}$  – profit before tax and interest deduction in period  $t + 1$ ,

$T$  – income tax rate,

$RR$  – reinvestment rate,

$r$  – cost of equity,

$g$  – growth rate.

The reinvestments made make the cash flow lower (which is reflected in the numerator). However, thanks to the investments made, the growth rate can be higher. The condition, though, is to obtain an adequate profitability of the reinvested funds. Taking this observation into account, we can write the growth rate as a function of the reinvestment rate and profitability:



$$g = RR * ROC \quad (2.2)$$

where:

$RR$  – reinvestment rate,

$ROC$  – return on invested capital.

If we assume that the return on capital is equal to the cost of that capital ( $ROC = r$ ), the formula for the value of an enterprise reduces to perpetuity, where the fixed payment represents the EBIT value after taxes, which we can write as:

$$V = EBIT_{t+1}(1 - T)(1 - RR) / (r - RR * r) = EBIT_{t+1}(1 - T) / r \quad (2.3)$$

As the evidence shows, profitability at the level of the cost of capital nullifies the effect of growth, and only the appropriate quality of profits (profits in excess of the cost of capital), makes it possible to increase the value of the company under growth conditions. Crucial to the above considerations is the assumption that the growth rate depends on the reinvestment rate and the profitability of capital. This assumption derives from the belief that the value of a company is equal to the capital invested in existing assets and the present value of all excess returns on current assets and future investments, which in turn is the core of the DCF convention (Damodaran, 2007, p. 5).

There are many concepts in economic theory that are based on the reasoning behind the excess rate of return. Examples are economic value added (EVA<sup>®</sup>), the first condition for positive financial leverage, the condition for the profitability of investments in the case of simple and accounting rates of return, but also the internal rate of return (IRR). To the author's knowledge, this paper is the first attempt to create an econometric model explaining this financial category.

Of course, examining excess returns alone does not provide a comprehensive assessment of the impact of the EU ETS on the value of enterprises, but it is the next step (after assessing the impact on profitability and the cost of capital) in such an analysis.

Since this study is the first attempt to apply the presented concept in this field, it will be limited to the excess rate in the version for shareholders. Carrying out analyzes for the value for all capital providers would require calculating (in addition to the cost of equity) the cost of debt and using ROA or ROC as a measure of profitability. For the owner variant, it can be expressed as follows:

$$ERR = ROE - r_e \quad (2.4)$$

where:

$ROE$  – return on equity,

$r_e$  – cost of equity.

It is worth mentioning that the analysis of association between carbon emissions and the cost of debt financing has recently gained popularity (see Kleimeier & Viehs, 2018; Palea & Drogo, 2020; Wang et al., 2021). Additionally, future research should be expanded to include the analysis of the impact of emission allowances on the amount of invested capital, as illustrated by the concept of economic value added. In the presented theoretical evidence, this issue is hidden in the assumption that the growth rate depends on profitability and the reinvestment rate. The analysis of the impact of allowances on the capital will verify Porter's hypothesis and institutional theory's view of regulation.

### 3. MODEL SPECIFICATION AND DATA

The need for the use of models with individual effects is confirmed by the decomposition of the variance of profitability, a component of ERR. Individual (idiosyncratic) effects represent a significant part of the variance of the profitability variable (see Hirsch et al., 2014; Schiefer & Hartman, 2013; Goddar et al., 2009). As a result, it was decided to make the estimation using several classes of models for panel data, including pooled regression (P-OLS), with fixed effects (FE-OLS), with random effects (RE-GLS) and with between-group effects (BE-OLS). The studies conducted so far on corporate profitability also reveal a kind of consensus on the presence of autocorrelation in the case of this variable, which justifies the use of dynamic models. Taking into account the mentioned consensus, the Arellano and Bond model will be used (DIFF-GMM; Arellano and Bond, 1991)<sup>5</sup>.

Summarizing the considerations carried out, the proposed regression model can be expressed as follows:

$$y_{it} = x'_{it} \beta + u_i + e_{it} \quad (3.1)$$

$$i = 1, \dots, N; t = 1, \dots, T$$

where:

$y_{it}$  – dependent variable (ERR or ROE) for every  $i$ -th enterprise at time  $t$ ,  
 $x_{it}$  – vector of covariates (which may contain delayed dependent variables  $y_{it}$ ),  
 $u_i$  – unobserved, constant over time, enterprise-specific heterogeneity,  
 $e_{it}$  – idiosyncratic random error,  
 $\beta$  – the vector of the slope of the estimation.

If the lagged dependent variable is not part of  $x_{it}$ , the model is static and the directional coefficients can be explained as long-term effects; however, if the lagged dependent variable  $y_{it}$  is included in  $x_{it}$ , the model is dynamic and the directional coefficients can be explained as short-term effects (Verbeek, 2012).

In order to determine the list of dependent variables, analyses were used in which the dependent variable was the profitability of enterprises. The use of previous studies on the relationship between emission allowances and profitability was limited by the fact that they were difference-in-differences analyses. In this study, the variable will be continuous rather than zero-one, as in the aforementioned studies. It would also be inappropriate to use the previously mentioned work of Krzyzaniak and Musgrave (1963), since the subject of their analysis was income tax incidence. One of the most numerous groups of studies on corporate profitability is research in the area of resource-based organization theory. It has been considered that these studies will be the basis in terms of the selection of explanatory variables, as well as provide a benchmark for assessing the validity of the models built. The selection of explanatory variables was guided by the consensus found in the studies regarding the computational form and the transformation performed. Thanks to this procedure, the probability of the appearance of irrelevant variables was limited and the controversial nature of the transformation process was reduced. In addition, the adopted formula makes it possible to verify the resulting model with studies in terms of variable distributions, obtained coefficients, and reduces the risk of endogeneity (except inevitable, as endogeneity is inevitable in economics), heteroskedasticity or collinearity of variables (especially since the variables used often appear together in studies). The list of variables (dependent and independent) together with their computational form is presented in the table.

<sup>5</sup> Some studies indicate that the relationship between emissions and profitability may be non-linear (Broadstock et al., 2018). It was decided not to verify the non-linear relationship between the materiality index of missing allowances (*co2*) and corporate profitability (*roe*) at this stage of the study. These models would further complicate the study, which is sufficiently elaborate in the form adopted.

**Table 1**

Designation and analytical form of the variables used in the study on the relationship between emission allowances and corporate profitability or excess rate of return

Variable name	Variable abbreviation	Analytical (computational) form	References
Dependent variables			
Profitability	<i>roe</i>	$\text{net profit}_{i,t} / \text{equity}_{i,t}$	Ruggiero and Lehkonen (2017)
Excess rate of return	<i>err</i>	$ROE_{i,t} - r_{e,i,t}$	
Independent variables			
Company size	<i>lna</i>	$\ln(\text{total assets}_{i,t})$	Hirsch (2014), Pattitoni (2014)
Enterprise growth rate	<i>gs</i>	$\text{sale}_{i,t} / \text{sale}_{i,t-1} - 1$	Yazdanfar (2013)
Financial leverage	<i>fin_lev</i>	$\text{total liabilities}_{i,t} / \text{total assets}_{i,t}$	Nunes (2009)
Operational leverage	<i>op_lev</i>	$\text{fixed assets}_{i,t} / \text{total assets}_{i,t}$	Nunes (2009)
Liquidity ratio	<i>liq_rat</i>	$\text{current liabilities}_{i,t} / \text{current assets}_{i,t}$	Hirsch (2014)
Productivity	<i>prod</i>	$\text{value added}_{i,t} / (\text{salary}_{i,t} \text{ amortization}_{i,t} + \text{depreciation}_{i,t} + \text{interest}_{i,t})$	Yazdanfar (2013)
Economic growth	<i>ggdp</i>	$GDP_{i,t} / GDP_{i,t-1} - 1$	Pattitoni (2014)
Significance factor of cost of missing CO <sub>2</sub> emission allowances	<i>co2</i>	$(\text{total emission}_{i,t} - \text{allocation}_{i,t}) / \text{total assets}_{i,t}$	
Year	<i>Year</i>	dummy variables	Dechezlepretre et al. (2018)

The variables selected are also intended to help assess the mechanism for possibly neutralizing the impact of the cost of allowances on corporate profitability. Previous studies have focused a lot on passing on costs to consumers. The change in sales revenue (*gs*) will be used to verify this assumption. If passing on costs to consumers is the sole and most important mechanism, then including this variable in the model should make the significance factor of missing emission allowances (*co2*) no longer statistically significant. However, companies can deal with the cost of allowances in a number of other ways. Firstly, they can pass the costs on to employees or suppliers as well. Secondly, they can improve production processes, for example by increasing energy efficiency. Thirdly, they can make investments to reduce emissions (e.g., replacing outdated machinery, placing filters on chimneys). Modeling the mentioned mechanisms is quite difficult. An additional limitation is the ability to control the results obtained (reference studies). In previous studies, there has been a variable that is largely capable of capturing these mechanisms. Productivity (*prod*) was considered such a variable. Wage costs appear in the structure of this variable, thus it controls the possibility of passing on allowance costs to employees. It also takes into account third-party services and material and energy costs, so it captures the possibility of optimization in the field of production processes (e.g., energy efficiency) and passing them on to contractors. This variable also takes into account, in part, the effect of green investments made by including the amount of depreciation in the denominator. However, this mechanism will be further controlled by the inclusion of operating leverage (*op\_lev*) in the model. This variable will act as a control for the results obtained.

Considering the impact of the EU ETS on the value of a company through the prism of the excess rate of return involves a practical drawback. The research sample cannot be large because it is necessary to calculate the cost of capital, which practically means limiting the sample to listed companies. It is true that one can use models that allow the cost of equity capital to be calculated for non-listed companies (e.g. using the Hamada model), but such a procedure would always be quite disputable. Even methods of estimating the cost of equity capital for listed companies, although widely used, are not accepted uncritically. Therefore, it is justified to conduct the study in its simplest form, on listed companies. Due to the novel nature of the study, an analysis of the relationship between emission allowances and the excess rate calculated on the basis of ROE and the cost of equity capital was carried out. The CAPM model was used to calculate the cost of equity. The reason for not including the carbon risk index in the study is the volatility of the carbon premium. However, it should be noted that when calculating the cost of equity using the CAPM, the carbon risk premium is included, but the CAPM may underestimate it. The necessary information to calculate the cost of equity (market rate, risk-free rate) was taken from French's website for the European market. The beta factor was calculated using the weekly stock returns of each company, in each year of the 2008–2016 period.

Financial data for companies were sourced from ORBIS, company stock quotes from the Equity RT database, while information on allowances and emissions came from the database of the European Commission's Directorate-General for the Environment. The original number of identified companies covered by the EU ETS was 8,711 (90% of all installations were linked to companies), but as only publicly listed companies could be surveyed, the sample size turned out to be much smaller.

The structure of the sample does not correspond to that of the companies covered by the EU ETS (see Appendix 1), moreover, the sample is not random. The results obtained should therefore not be directly extrapolated to the population. The sample included 91 very large companies from EU countries. Only 35% of the companies covered by the EU ETS are very large companies. Consequently, benefits related to the size of the enterprise may affect the results obtained. This error will be controlled to some extent by the company size variable (*lna*). In addition, there are far too few companies in the "Gas, water, electricity" and "Chemicals, rubber, plastics, non-metallic products" sectors in the sample. Companies in these sectors accounted for 50% of all companies covered by the EU ETS. At the same time, the sample contained significantly more companies from the "Machinery, equipment, furniture, recycling" sector than the population. Companies in the "Gas, water, electricity" sector are characterized by a greater ability to pass costs on to consumers. As a result, the potentially detected association of emission allowances with profitability and the surplus rate may actually be smoother. In addition, the sample includes many more companies located in developed countries (especially Germany) than the population. This is due to the fact that the sample could only include companies listed on the stock market, and the development of the capital market accompanies economic development. There is a concern that effects related to the country's development level may occur. However, it is difficult to assess what this effect will be. On the one hand, this may result in the underestimation of the impact on the cost of capital, as the capital market is more efficient in developed countries. On the other hand, investors in less developed countries may not pay as much attention to the environmental issues. Additionally, developing countries, legitimately, receive more support (more allowances for free) than developed countries. This raises the question of whether the benefits outweigh the costs (factor endowment theory and location theory).

The sample is also unbalanced, meaning that there are missing values of variables for some periods. However, this does not mean that the study is free from survival bias, i.e. drawing conclusions on a sample of surviving companies. All the companies in the sample operated throughout the period 2008–2016. Almost all the companies are still operating in the market. The results obtained should therefore be considered from the perspective of surviving companies.

The temporal structure of the panel shows that for more than half of the companies in the sample all the necessary information from the full period of analysis is available (47 entities); in this part the panel would be balanced. In addition, more recent observations are available more frequently, which is typical for databases.

#### 4. EMPIRICAL RESULTS

Before analyzing the relationship between the EU ETS operation and the excess rate, it was necessary to first investigate the relationship between the EU ETS and equity returns. This sequence is necessary from the point of view of drawing conclusions. By knowing the relationship between EU ETS and ROE, more accurate conclusions can be drawn regarding the relationship with ERR.

Moving on to the analysis of the estimated models (Table 2), it should first be noted that the FE-OLS models failed the heteroskedasticity test, but the P-OLS models passed it. As a result, robust standard errors were applied in all cases. Time effects did not prove to be statistically significant and were therefore not included in the basic configurations. In models where time effects were controlled for, the relationship of the study variables with *roe* remained unchanged (as illustrated in model 7). The *lna* variable was also not included in the baseline configuration, as its inclusion caused a significant disparity in explaining within-group and between-group variability (model 6). The *lna* variable resulted in a significant reduction in  $R^2$  within group, with a marginal increase in  $R^2$  between groups. The correlation table shows that this variable is significantly correlated with almost all independent variables. Not including this variable in the model, however, did not affect the significance and direction of influence of *co2\_neg* and *co2\_pos*.

The following conclusions emerge from the analyses. The ratio of missing allowances to assets plays a significant role in the development of the *roe* coefficient, but only when individual effects are not controlled (cf. models 1 and 2, 5–8). When individual fixed effects, productivity (*prod*), change in sales revenue (*gs*) and economic growth (*ggdp*) are controlled, the relationship of the ratio of missing allowances to return on equity (*co2\_pos* and *co2\_neg*) is not statistically significant (model 2). Such a relationship may be due to the fact that the ability to pass on costs is a firm-specific feature. If individual effects are allowed to vary (model 3), the variables *co2\_neg* and *co2\_pos* are again statistically significant. However, this model does not pass the Sargan-Hansen test, with a significance level of 5%, which may mean that the explanatory variables are correlated with individual effects. Also for this reason, the studied variables are not statistically significant in the model with fixed individual effects, but significant in the model with random individual effects. Nevertheless, a model with fixed individual effects is more appropriate in this situation, as these models are robust to the assumption of uncorrelated individual effects with explanatory variables. It should therefore be concluded that the effect of the study variables on *roe* is statistically insignificant. This relationship remains statistically insignificant when also the financial leverage (*fin\_lev*), operating leverage (*op\_lev*) and liquidity ratio (model 5), as well as company size (model 6), or time effects (model 7) are controlled.



**Table 2**Analysis of the relationship between return on equity (ROE) and the ratio of missing allowances to assets (*co2*)

Model	1	2	3	4	5	6	7	8
Variables	P-OLS	FE-OLS	RE-GLS	BE-OLS	FE-OLS	FE-OLS	FE-OLS	RE-GLS
$a_0$	−0.2405***	−0.3033***	−0.2863***	−0.2427***	−0.4559***	0.5906**	−0.4428***	0.1618
prod	0.2504***	0.2993***	0.2829***	0.2329***	0.3098***	0.3158***	0.3106***	
gs	0.0026	−0.0016	0.0012	0.0298	−0.0019	0.0046	−0.0092	
ggdp	0.2331**	0.0762	0.1208	0.8462*	0.0955	0.0994	−0.0281	0.4344***
fin_lev					0.2013**	0.2087**	0.2062**	−0.0573
op_lev					0.0407	0.0427	0.0192	−0.068
liq_rat					−0.011	−0.0114	−0.0095	−0.0136
lna						−0.0692***		
co2_pos	−0.1787***	−0.0508	−0.1011*	−0.2112**	−0.0162	−0.0015	−0.0707	−0.0563
co2_neg	0.1272***	0.1427	0.1242*	0.0317	0.0802	0.0838	0.0955	0.1161
Year $F/\chi^2$							0.92	
$F/\chi^2$ statistic of the model	142.2***	54.14***	369.43***	28.81	31.91***	28.11***	20.1***	15.03**
R <sup>2</sup> within		0.6509	0.6498	0.5621	0.6645	0.6836	0.6711	0.0243
R <sup>2</sup> between		0.5988	0.6057	0.6289	0.5877	0.0708	0.5988	0.0579
R <sup>2</sup> overall		0.6239	0.6276	0.6029	0.6316	0.1404	0.6407	0.0423
Adj. R <sup>2</sup>	0.6275	0.648		0.6071		0.6788	0.6622	
No. observation	607							
Fixed effect		6.73***			5.86***	6.48***	5.89***	
$\Theta$			0.4222					0.6401
Breusch-Pagan	4.68**		359.72***					
Sargan-Hansen			14.376**		19.511**	25.44***	42.46***	6.042

P-OLS – pooled model; FE-OLS – fixed effects model; RE-GLS random effects models; BE – between effects model; OLS – ordinary least squares; GLS – generalized least squares.

Significance levels are based on robust standard errors and are indicated by \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Source: Author's calculation.

As can be seen, the inclusion of the above variables does not significantly improve the model, only the variables *fin\_lev* and *lna* are statistically significant. The variables *co2\_neg* and *co2\_pos* remain statistically insignificant, even when productivity and sales revenue changes are not controlled for in the model (model 8). The aforementioned model passed the Sargen-Hansen test, so individual effect variable estimators were used. In all configurations, the directional coefficient on the variables *co2\_neg* and *co2\_pos* did not change sign and was consistent with the Pearson correlation coefficient. As a control study, an estimation using ROA (in the form of EBIT/Asset) was also carried out, but again no significant relationship was found between the ratio of missing allowances to assets and the operating return on assets. However, it is worth mentioning that in these models significantly more explanatory variables turned out to be statistically significant.

This is probably due to the fact that net profit, which includes other spheres of the company's operation besides operations, was used to calculate ROE.

The absence of a statistically significant relationship between the ratio of missing allowances to assets (*co2\_pos* and *co2\_neg*) and ROE in the studied sample is the starting point for investigating the effect on the excess rate. The potential detection of a significant effect of the variable under study on the excess rate will therefore have to come from adjusting ROE by the cost of equity capital. As with the relationship between the EU ETS and profitability, the correlation coefficients of the independent variables with the excess rate (the dependent variable) were analyzed first. The analysis of Pearson correlation coefficients shows that the association of the excess rate with these variables is not statistically significant. However, after splitting the *co2* variable into observations when it took positive and negative values, it turns out that negative values are statistically significantly correlated with the excess rate (*ERR*). This shows that if companies emitted below allocation (*co2\_neg*), greater emission reductions were associated with lower excess rates. For emissions above allocation (*co2\_pos*), the correlation is not statistically significant, although negative. The directions of the correlation are therefore consistent with the predictions. The excess rate is also statistically significantly correlated with productivity (*prod*), change in sales revenue (*gs*) and economic growth (*ggdp*). In contrast, it is not statistically significantly correlated with financial leverage (*fin\_lev*), operating leverage (*op\_lev*), and liquidity ratio (*liq\_rat*). The insignificance of the association of these variables with the excess rate may be due to the fact that the sample includes companies from different sectors. Moreover, it is not appropriate to draw conclusions about the relationship of variables solely on the basis of correlation. By doing so, the effect of time, individual effects as well as the influence of other factors are not taken into account. The analysis of correlation coefficients should serve as a check on the direction of possible influence and as an indication of which variables should be used in the model. It should not, however, be the basis for selection. The theoretical basis and conclusions of the research conducted so far are more important. For each of the variables presented, there are theoretical grounds that their relationship with the explanatory variable is significant. However, given that the study is novel in nature, variables whose correlation is statistically significant were used in the model first. Binary variables representing individual years were considered in the study. The validity of this procedure is confirmed by tests of joint significance, these variables in each configuration are statistically significant.

The estimation results are presented in Table 3. The generalized/combined regression model (9) passed the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity (variance constancy), while the fixed individual effects models (10 and 13) failed the modified Wald test for fixed individual effects models for group heteroskedasticity. In both the P-OLS and FE-OLS models, it was decided to report results using robust statistics. In each configuration, fixed individual effects (models 10 and 13) as well as random individual effects were found to be statistically significant (model 11). This means that the pooled regression model is biased (model 9). The Sargan-Hansen test, on the other hand, shows (model 11) that individual effects are related to the explanatory variables and, as a result, the random effects estimator is biased. The fixed effects estimator is therefore preferred because it is also consistent but is unbiased (models 10 and 13). Fixed-effects models (models 10 and 13) will therefore be the basis for drawing conclusions about the relationships under study. The remaining models have primarily a control function.

**Table 3**

Analysis of the relationship between the excess rate of return (*ERR*) and the ratio of missing allowances to assets (*co2*)

Model	9	10	11	12	13	14
Variables	P-OLS	FE-OLS	RE-GLS	BE-OLS	FE-OLS	FE-OLS
$a_0$	−0.1009***	−0.1516***	−0.1175**	−0.3672***	−0.8336***	1.2134
prod	0.3179***	0.3572***	0.3284***	0.3093***	0.3707***	0.3856***
gs	0.0285	0.014	0.0246	0.089	0.0492**	0.0122
ggdp	0.5633**	0.513	0.5269	0.8652	3.0214	0.5745*
fin_lev					0.3917**	0.3789**
op_lev					0.0886	0.0789
liq_rat					0.0751	0.0015
lna						−0.111**
co2_pos	−0.2497***	−0.3106*	−0.2589***	−0.1935	−0.3956**	−0.3192*
co2_neg	0.0915	0.1066	0.0434	−0.0907	−0.0503	0.0318
Year $F/\chi^2$	42.22**	32.46***	239.25***			33.68***
$F/\chi^2$ statistic of the model	15.77***	38.79***	514.04***	20.8***	30.13***	31.35***
R2 within		0.6917	0.6906	0.2859	0.3623	0.7060
R2 between		0.5685	0.5748	0.5502	0.3957	0.0666
R2 overall		0.6557	0.6579	0.3561	0.3728	0.2463
Adj. R2	0.6508	0.6849		0.5238	0.4423	0.6976
No. observation	607					
Fixed effect		2.86***	11.36***		1.37**	2.71***
$\Theta$			0.4222			
Breusch–Pagan	5.34**		101.09***			
Sargan–Hansen			38.130***			41.405***

P-OLS – pooled model; FE-OLS – fixed effects model; RE-GLS random effects models; BE – between effects model; OLS – ordinary least squares; GLS – generalized least squares.

Significance levels are based on robust standard errors and are indicated by \*  $p < 0.1$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$ .

Source: Author's calculation.

As the study shows, the variable *co2\_pos* explains the evolution of the excess rate of return in a statistically significant way (cf. models 9–14). When controlling for productivity, change in sales revenue, economic growth and time and individual effects (model 10), the more (relative to assets) allowances firms have to buy (*co2\_pos*), the lower the excess rate. Presumably, investors assume that cost pass-through has limits and they expect a premium for this risk, resulting in a higher cost of capital. This result is highly significant because adjusting ROE for the cost of equity makes the relationship statistically significant, and in almost every configuration (compare models 2 and 5–7 with 10 and 13–14). The exception is the model with between-group effects (model 12), which also confirms that the relationship is within-group.

Despite a statistically significant correlation between the *ERR* variable and *co2\_neg*, no significant statistical relationship was detected. GHG emissions below the allocation may be due to either reducing production or making investments to reduce emissions. In the first

situation, the lack of significance of the variable could be due to the inclusion in the model of the variables productivity and change in sales revenue. The entire impact of this variable would be “absorbed” by the change in sales revenue (*gs*) and productivity (*prod*). However, repeating the analyses without these variables contradicts such conclusions; the variable remains statistically insignificant. It would follow that the reason for the insignificance of this variable must be emission reductions. Presumably, companies have managed to reduce emissions by making cost-effective environmentally friendly investments, and their cost was comparable to the savings. The emission reductions limited their carbon risk and, overall, the introduction of the EU ETS did not affect *ERR*.

Including other variables in the model, such as financial leverage, operating leverage and liquidity ratio, did not change the conclusions (model 13). It is puzzling that the estimators with all additional variables have the opposite sign to the correlation coefficient. This is probably an effect of controlling for individual effects and the time dimension. The reason for this is not the variables under study, as removing *co2\_neg* and *co2\_pos* from the model did not result in a variation in the sign of the directional coefficient with the other variables. Including the company size variable (*lna*) in the model also does not change the conclusions (model 14), although it is worth noting that it completely changed the model fit ( $R^2$  within and between).

The subject of the study is the long-term relationship, but it was decided to additionally verify the results in the short term using dynamic models. The closest to meeting the required tests was a model in which all explanatory variables were considered exogenous. This is counterintuitive. The model also failed the test for restriction redundancy but passed the test for first-degree autocorrelation. As a consequence, the results were not presented. The sign of the relationship was retained, although only the original variable was found to be statistically significant (*co2*).

## 5. CONCLUSIONS

The literature review shows that companies were likely able to pass on the allowance costs, but at the same time, higher emissions were associated with higher carbon risk and, consequently, a higher cost of capital. Unfortunately, these conclusions come from separate studies, carried out on different companies and at different times, so there can be no certainty that they can be combined. In the author’s opinion, the analysis of the excess rate of return may help to verify the above-mentioned conclusions. Moreover, the excess rate of return can be directly related to the value of the enterprise, which may contribute to the creation of a comprehensive method of assessing the relationship between environmental regulations and this financial category.

No statistically significant effect of emission allowances on return on equity was detected. However, a statistically significant effect of emission allowances on the excess rate of return (*ERR*), i.e. ROE adjusted for the cost of equity capital, was found. The lack of a significant effect on profitability may mean that companies were able to pass on the cost of allowances or optimize production and thus deal with the problem of purchasing missing allowances. However, higher emissions entail greater exposure to the risk of the price of allowances that investors expect to pay for. If this risk is not diversifiable, it should be reflected in an increase in the cost of equity, which explains the statistically significant relationship between emission allowances and excess returns.

As the conducted study shows, if companies were not able to reduce their emissions below the allocation (*co2\_pos*), their excess rate eventually decreased, which can be equated with a decrease in value. However, if they were able to reduce emissions, through for example investments made, the introduction of the EU ETS did not change their excess rate and consequently their value. This would imply that the relationship between the EU ETS and the value of companies is not symmetric. This conclusion is very important as it undermines the corrective nature of emission allowances. However, it should be noted that the research sample was significantly limited and not random.

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## APPENDIX 1

Comparison of the structure of enterprises in the sample with the structure of the population according to their geographical location

Country (ISO code)	% of all enterprises in the sample	% of all enterprises in the entire base (population*)
AT	2%	2%
BE	5%	3%
BG	1%	2%
CY	1%	0%
CZ	1%	4%
DE	26%	14%
DK	4%	3%
EE	.	0%
ES	5%	12%
FI	4%	2%
FR	5%	9%
GB	5%	7%
GR	.	1%
HR	2%	0%
HU	2%	2%
IE	1%	1%
IT	12%	11%
LT	.	1%
LU	.	0%
LV	2%	1%
NL	.	4%
NO	1%	1%
PL	12%	7%
PT	1%	3%
RO	1%	3%
SE	.	3%
SI	.	1%
SK	2%	2%
SUM	100%	100%

\* Almost 90% of all installations covered by EU ETS have been associated with companies from the ORBIS database and approximately 99.3% after excluding airline operators and public agencies (schools, hospitals, etc.).

Source: Author's calculation.

Comparison of the sectoral structure of enterprises from the sample with the population

Major sector (Bureau van Dijk classification)	% of all enterprises in the sample	% of all enterprises in the entire base (population*)
Chemicals, rubber, plastics, non-metallic products	34%	28%
Machinery, equipment, furniture, recycling	18%	4%
Gas, Water, Electricity	12%	23%
Wood, cork, paper	11%	10%
Food, beverages, tobacco	9%	8%
Primary sector	8%	4%
Metals & metal products	4%	6%
Hotels & restaurants	1%	0%
Publishing, printing	1%	0%
Transport	1%	2%
Wholesale & retail trade	1%	3%
Other services	.	6%
Textiles, clothing, leather	.	2%
Other sectors (less than 1% share)	.	5%
SUM	100%	95%

\* Almost 90% of all installations covered by EU ETS have been associated with companies from the ORBIS database and approximately 99.3% after excluding airline operators and public agencies (schools, hospitals, etc.).

Source: Author's calculation.

## APPENDIX 2

Descriptive statistics of variables

Variable	Mean	Median	SD
<i>err</i>	0.0764	0.0857	0.1998
<i>roe</i>	0.09	0.0936	0.1002
<i>prod</i>	1.3218	1.2891	0.3106
<i>op_lev</i>	0.619	0.6284	0.1344
<i>lna</i>	15.33	15.4	2.035
<i>co2</i>	0.0009	−0.00008	0.0792
<i>gs</i>	0.0739	0.0408	0.2139
<i>liq_rat</i>	0.762	0.7294	0.2369
<i>fin_lev</i>	0.5928	0.5905	0.1456
<i>ggdp</i>	0.0265	0.0272	0.0238

Source: Author's calculation.

## APPENDIX 3

Correlation coefficients

	roe	ERR	lna	gs	fin_lev	liq_rat	op_lev	prod	ggdp	co2	co2_pos
roe	1										
ERR	0.6819*	1									
lna	0.1611*	0.0832	1								
gs	0.1570*	0.1885*	0.0843	1							
fin_lev	−0.0523	−0.0254	0.3533*	−0.0377	1						
liq_rat	−0.0925*	−0.0213	0.1189*	0.0503	0.4479*	1					
op_lev	−0.0918*	−0.0468	0.2082*	0.0888	−0.1261*	0.3245*	1				
prod	0.7852*	0.5362*	0.1809*	0.1851*	−0.2690*	−0.1275*	0.0786	1			
ggdp	0.1220*	0.3541*	0.0266	0.1211*	−0.0897	−0.0119	−0.0103	0.0848	1		
co2	0.0822*	0.0374	0.0325	0.0809	−0.0501	0.0945	0.0929	0.1413*	0.1393*	1	
co2_pos	−0.0308	−0.0392	−0.1634*	0.0422	−0.1520*	0.0644	0.1915*	0.0660	0.0823	0.8099*	1
co2_neg	0.1733*	0.1083*	0.2446*	0.0862	0.0932	0.0831	−0.0674	0.1597*	0.1373*	0.7306*	0.1912*

Significance levels \*  $p < 0.01$ .

Source: Author's calculation.