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Overview

The **Journal of Banking and Financial Economics (JBFE)** is an open access journal. The submission of manuscripts in free of fee payment. This journal follows a double-blind reviewing procedure.

Aims and Scope

JBFE publishes high quality empirical and theoretical papers spanning all the major research fields in banking and financial economics. The aim of the journal is to provide an outlet for the increasing flow of scholarly research concerning banking, financial institutions and the money and capital markets within which they function. The journal also focuses on interrelations of financial variables, such as prices, interest rates and shares and concentrates on influences of real economic variables on financial ones and vice versa. Macro-financial policy issues, including comparative financial systems, the globalization of financial services, and the impact of these phenomena on economic growth and financial stability, are also within the *JBFE*'s scope of interest. The Journal seeks to promote research that enriches the profession's understanding of the above mentioned as well as to promote the formulation of sound public policies.

Main subjects covered include, e.g.: [1] *Valuation of assets*: Accounting and financial reporting; Asset pricing; Stochastic models for asset and instrument prices; [2] *Financial markets and instruments:* Alternative investments; Commodity and energy markets; Derivatives, stocks and bonds markets; Money markets and instruments; Currency markets; [3] *Financial institutions, services and regulation*: Banking efficiency; Banking regulation; Bank solvency and capital structure; Credit rating and scoring; Regulation of financial markets and institutions; Systemic risk; [4] *Corporate finance and governance*: Behavioral finance; Empirical finance; Financial applications of decision theory or game theory; Financial applications of simulation or numerical methods; Financial forecasting; Financial risk management and analysis; Portfolio optimization and trading.

Special Issues

JBFE welcomes publication of Special Issues, whose aim is to bring together and integrate work on a specific theme; open up a previously under-researched area; or bridge the gap between formerly rather separate research communities, who have been focusing on similar or related topics. Thematic issues are strongly preferred to a group of loosely connected papers.

Proposals of Special Issues should be submitted to at jbfe@wz.uw.edu.pl. All proposals are being reviewed by the Editorial Team on the basis of certain criteria that include e.g.: the novelty, importance and topicality of the theme; whether the papers will form an integrated whole; and the overall 'added value' of a Special Issue.

CONTENTS

Recent developments in corporate finance and corporate governance in post-transitional markets
(Scientific Editors' Note)

The amount of corporate governance and corporate finance research has increased dramatically during the last decade. A search of SCOPUS abstracts containing the term "corporate governance and finance" results in more than 5,400 published papers since the beginning of 2020. As this is a multidimensional topic, it attracts researchers from voluminous disciplines not only from finance but also economics and management. However, in this issue, we concentrate on studies from finance, accounting and financial economics. We realize that the topics that the Authors tackle reflect only some tendencies that can be identified in the field. Nonetheless, we believe that some important problems are shown, shedding some new light on the landscape of corporate finance and corporate governance research. The issue is composed of 7 papers covering 5 different threads of studies.

Marek Gruszczyński presents an important opinion in the debate within Polish academia on the development of empirical research within the accounting discipline. According to his analysis, Polish authors – especially those using quantitative methods – rarely publish in top accounting journals affiliated outside Poland. However, the corresponding percentage of quantitative papers is much higher in leading international accounting journals.

Another dimension of the finance research presented in this issue includes studies related to the capital market. Bing Anderson investigates a decrease in order execution time on US stock exchanges in the past two decades. His study shows that information diffusion from one stock to another occurs mainly via computers and algorithms rather than human insights and human analyses. Paweł Witkowski contributes to a better understanding of the impact of the EU ETS on the company market value. He finds a statistically significant relationship between emission allowances and excess rate of return (ERR). It implies that companies are able to pass on the cost of emission allowances to their counterparties.

The third thread of research concentrates on voluntary disclosure strategy and effective communication between issuers and investors on the Polish bond market Catalyst. Dominika Hadro, Marek Pauka, Kamil Gemra, Szymon Okoń and Justyna Fijałkowska claim that personal engagement of board members in preparing voluntary disclosure should be considered a proxy of a high disclosure strategy quality. According to them, in relatively smaller capital markets, companies use dialogue with investors in private rather than in public to understand their communication expectations.

The fourth area of investigation concentrates on the pattern in which operating cash flows are allocated between dividends and investment. Elżbieta Bukalska, Anna Maziarczyk and Kinga Ociesa, building on the free cash flow hypothesis and signalling theory of dividends, provide evidence on a positive relation between dividends and investment.

Last but not least are the papers dealing with manipulation and fraud. Marek Sylwestrzak investigates irregularities in financial statements by applying the Beneish and Roxas models. However, the results indicate that none of these models should be used for companies that have received an adverse or disclaimer opinion from auditors. The author claims that a modified M-Score model is more powerful as far as detection capacity is concerned than either the Beneish or Roxas model. Adam Adamczyk and Sławomir Franek focus on a relationship between earnings management and the market value of companies with different ownership structures. According to them, while there is a negative and statistically significant relationship between market value and the presence of a majority direct investor, there are no significant differences in earnings management between companies with different ownership structures.

Appropriate development of the relationship between the company and different stakeholders is supposed to promote improvements in firm performance as measured by valuation, operating performance, or stock returns. It has been established that cross-country differences in laws (statutory provisions, i.e., de jure protection) and their enforcement (i.e., de facto protection) affect the effectiveness of CG practices. While there are important organizational and behavioural differences between firms in post-transition markets and those in developed markets, with this issue we intend to instigate a scholarly discussion on developments in corporate finance and corporate governance specific to transitional economies from various perspectives. We hope that this issue will be of great interest to the readership of *Journal of Banking and Financial Economics*.

Katarzyna Byrka-Kita and *Michał Kałdoński*

Application of the Beneish Model on the Warsaw Stock Exchange

Marek Sylwestrzak

University of Warsaw, Faculty of Economic Sciences Poland
msylwestrzak@wne.uw.edu.pl
https://orcid.org/0000-0001-8962-8168

ABSTRACT

This paper investigates irregularities in financial statements by applying the Beneish and Roxas models to Polish firms listed on the Warsaw Stock Exchange from 2015 to 2020. The total sample included 110 observations. The sample comprised companies that had received an adverse or disclaimer opinion by the auditors, but had not been fined by the Polish Financial Supervision Authority (KNF Board). The control firms were selected based on the industry as selected by the standard industrial classification code and on the financial year, with minimizing the difference in the size of total assets. The results indicate that the Roxas model revealed greater accuracy than the Beneish model on the tested sample. The use of logistic regression allowed a modification of the Beneish model to align it with the conditions of the Polish market. The modified Beneish model showed greater accuracy for the tested sample and companies fined by the KNF Board.

JEL Classification: C46, G00, G30, M40, M42

Keywords: Beneish model, Roxas model, Warsaw Stock Exchange, logistic regression.

1. INTRODUCTION

Based on research conducted by the Association of Certified Fraud Examiners (ACFE) in 2020, the majority of fraud schemes involved asset misappropriation (86%), corruption (43%) and the least common instance was financial statement fraud (10%), although the latter is the most harmful and costliest category of occupational fraud. Financial statement fraud is a serious threat to market participants' confidence in financial information; it is estimated to cost corporations substantial money and is viewed as unacceptable, illegitimate and illegal corporate conduct (Rezaee, 2005). Financial statement fraud is an intentional distortion of financial statements, which can include reporting sales that did not happen, reporting income in the current year that belongs in the next year, capitalizing expenses improperly or reporting an expense in the next year that should be reported in the current year (Ata & Seyrek, 2009). Overall, financial statement fraud techniques work by improper revenue recognition and overstatement of assets or understatement of expenses and liabilities (Beasley et al., 2010).

Advances in technology have significantly improved the detection process for frauds and embezzlements. Auditors have access to many tools used in the audit of financial statements,

including Benford's Law, the financial statement ratio analysis or data mining techniques. These tools produce more relevant findings and identify the critical areas that should be further investigated by forensic accountants. Although it is a very new area, forensic accounting practices have played a prominent role in the detection and prevention of accounting frauds in recent years. The literature identifies various approaches to detecting fraud in corporate financial statements, and various techniques have been employed to analyze the likelihood of financial statement fraud, such as logistic regression or data mining techniques, which most often are decision trees, neural networks and Bayesian belief networks (Spathis et al., 2002; Gaganis, 2009; Gupta & Gill, 2012; Amara et al., 2013; Chen, 2016; Ozcan, 2016; Hajek & Henriques, 2017; Jan, 2019). Many researchers have used mathematical models to determine whether a company provides misleading information about assets, liabilities, revenues and costs with the help of probit and logistic regressions (Summers & Sweeney, 1998; Beneish, 1999; Spathis et al., 2002; Gaganis, 2009; Dechow et al., 2011; Amara et al., 2013; Kanapickiene & Grundiene, 2015; Sorkun & Toraman, 2017; Dong et al., 2018; Alfian & Triani, 2019; Yao et al., 2019). This study focuses on the Beneish model financial statement fraud detection tool as a cost-effective and efficient tool that should be utilized by auditors. The Beneish model is among the most used quantitative models in forensic accounting investigations, and it provides massive benefits to forensic accountants because it helps to fully examine financial statements disclosed by firms and analyze changes in the amounts of financial statement accounts from period to period.

This paper explores the potential of the Beneish model as an indicator of fraud in the Polish financial market. Therefore, two hypotheses were formulated: the 8-variable model will have greater accuracy than the 5-factor model on the sample of companies that have received an adverse or disclaimer opinion by the auditors (Hypothesis 1) and the modified M-Score model based on logistic regression results will be more accurate than the 8-variable (5-variable) M-Score model for companies fined by the KNF Board (Hypothesis 2). To test these hypotheses, the data were analyzed from the annual financial statements of companies listed on the main market of Warsaw Stock Exchange in the period 2015–2020 which have received an adverse or disclaimer opinion by the auditors but have not received a monetary fine from the Polish Financial Supervision Authority (KNF Board) for violation of IAS/IFRS principles related to the financial statements in the study period.

The rest of this paper is organized as follows. Section 2 contains a literature review. Section 3 describes the situation of the Polish financial market and research conducted using the Beneish model. Section 4 describes the data set and the hypotheses set in the analysis. Section 5 presents the results of the analysis, and Section 6 provides a summary and conclusion of the study.

2. LITERATURE REVIEW

The Beneish model (M-Score model) is one of the best-known methods for detecting accounting manipulations in the world. It is a mathematical model based on a probit regression method and indicates the perspectives concerning the tendency of companies to engage in fraudulent accounting processes. The M-Score model measures the level of earning management in various financial situations. The 8-variable M-Score model was conceived based on a sample of 74 U.S. manipulator companies that committed financial fraud according to the U.S. Securities and Exchange Commission (SEC) in the years 1982–1992 and 2,332 public non-manipulators. The Beneish model has a high accuracy rate (76%) in detecting potential financial statement fraud in the U.S. sample. The marginal value of M-Score is (-2.22), where a higher value indicates a probability that the company applied financial statement fraud techniques (Beneish, 1999); however, the relative cost function of Type I and Type II classification errors indicates that the marginal value of the Beneish model should equal (-1.78) (Beneish et al., 2013).

Several researchers prefer an alternative 5-variable M-Score model created by Roxas (2011) rather than the 8-variable Beneish model. The Roxas model omits the Sales, General, and Administrative Expenses Index (SGAI), Leverage Index (LEVI) and Total Accruals to Total Assets (TATA) indicators and changes the marginal value of M-Score to (−2.76). The research by Roxas showed that the 5-variable model correctly identified more companies than the 8-variable on a sample of U.S. companies, 62% versus 46% observations. Numerous studies have found the Roxas model more accurate than the Beneish model (Anning & Adusei, 2020; Lehenchuk et al., 2021), but some authors did not confirm these results (Buljubasic & Halilbegovic, 2017). Paolone and Magazzino (2014) have also drawn attention to the existence of many differences between U.S. and European accounting principles, so they reclassified the model with SGAI equal to one. Equation 1 and Equation 2 present the calculation of M-score models:

$$\text{M-Score (Beneish)} = -4.84 + 0.920*DSRI + 0.528*GMI + 0.404*AQI + 0.892*SGI + \\ + 0.115*DEPI - 0.172*SGAI + 4.679*TATA - 0.327*LEVI \tag{1}$$

$$\text{M-Score (Roxas)} = -6.065 + 0.823*DSRI + 0.906*GMI + 0.593*AQI + \\ + 0.717*SGI + 0.107*DEPI \tag{2}$$

where:
DSRI – Days Sales in Receivables Index
GMI – Gross Margin Index
AQI – Asset Quality Index
SGI   – Sales Growth Index
DEPI – Depreciation Index
SGAI – Sales, General, and Administrative Expenses Index
LEVI – Leverage Index
TATA – Total Accruals to Total Assets

Table 1 reports the method of calculating the individual ratios of the Beneish model.

Table 1
The M-Score model indicators

Ratio	Formula
DSRI	$(\text{Net receivables}_t / \text{Sales}_t) / (\text{Net receivables}_{t-1} / \text{Sales}_{t-1})$
GMI	$[(\text{Sales}_{t-1} - \text{Cost of goods sold}_{t-1}) / \text{Sales}_{t-1}] / [(\text{Sales}_t - \text{Cost of goods sold}_t) / \text{Sales}_t]$
AQI	$[1 - (\text{Current Assets}_t + \text{PPE}_t)/\text{Total Assets}_t] / [1 - (\text{Current Assets}_{t-1} + \text{PPE}_{t-1}) / \text{Total Assets}_{t-1}]$
SGI	$\text{Sales}_t / \text{Sales}_{t-1}$
DEPI	$[\text{Depreciation}_{t-1} / (\text{Depreciation}_{t-1} + \text{PPE}_{t-1})] / [\text{Depreciation}_t / (\text{Depreciation}_t + \text{PPE}_t)]$
SGAI	$(\text{SGA Cost}_t / \text{Sales}_t) / (\text{SGA Cost}_{t-1} / \text{Sales}_{t-1})$
LEVI	$[(\text{Current Liabilities}_t + \text{Total Long Term Debt}_t) / \text{Total Assets}_t] /$ $[(\text{Current Liabilities}_{t-1} + \text{Total Long Term Debt}_{t-1}) / \text{Total Assets}_{t-1}]$
TATA	$[(\text{Change in Current Assets} - \text{Change in Cash}) - (\text{Change in Current Liabilities} - \text{Change in Current maturities of Long Term Debt} - \text{Change in Income Tax payable}) - \text{Depreciation and Amortization}_t] / \text{Total Assets}_t]$

Source: Beneish (1999).

M-Score calculations and the calculations of the component indices provide a general benchmark that can be used to predict variance in financial statements. The TATA index is one of the elements of the Beneish M-Score model, which measures the ratio of total accruals to total assets for each period. Accruals provide information linking business activities unrelated to cash transactions or future costs incurred by the company. This is why accruals provide a playing field for potential financial manipulation and earnings management. TATA is not the only way to measure accruals; in the literature, are several models that analyze the relationship between firms' accruals and their net income or cash flows, e.g. Jones model, modified Jones model, Sloan model, Dechow-Dichev model, Dechow model (Mantone, 2013). These models are designed to detect the total value of discretionary accrual adjustments. In these models, the non-discretionary accruals adjustments are estimated as a linear function of the model's explanatory variables. The accruals models are typically estimated by industry and year, and the remainder of the model for the total accruals is used to estimate the discretionary accruals adjustments (Artienwicz et al., 2020). On the other hand, the Dechow model (F-Score model) requires the calculation of the index and then the probability value. The probability value is divided by the overall probability of fraud in a given population of companies. The result shows how many times a certain company has a greater probability of falsifying financial statements than a randomly selected company from the entire surveyed population (Wyrobek et al., 2020). However, the accrual models have a poor ability to actually measure the value of the discretionary accruals, because the information about which financial data was manipulated by directors is strictly confidential (Piasecki, 2015). Moreover, the M-Score models can use an overall benchmark of 1.78 or 2.76 to determine whether the financial statement suggests earnings manipulation or an attempt to conceal embezzlement funds. In addition, by decomposing the M-Score model into its components, a researcher can determine whether each calculation may contain unusual variances or anomalies that require further investigation (Mantone, 2013).

3. THE POLISH SCENARIO

In the Polish legal system, no legal acts refer to the definition of financial statement fraud. In such a case, the only clear evidence that the financial statements have been manipulated may be serious reservations of auditors or proceedings initiated by various regulators resulting in the imposition of penalties. The KNF Board is one of the bodies ensuring the proper functioning, stability, security, transparency and confidence in the financial market and ensures that the interests of market participants are protected. The KNF Board also imposes financial or legal sanctions in connection with non-compliance with the International Financial Reporting Standards (IFRS) guidelines.

Due to the lack of an appropriate legal definition of financial statement fraud, a few studies have adopted one of the two possibilities of defining a company as a manipulator. Golec (2019) assumed that the companies that had received an adverse or disclaimer opinion by the auditors could be involved in earning management practices. In this way, the author identified 24 companies listed on Warsaw Stock Exchange (WSE) from 2014 to 2017. For each fraud company, a control company conducting as similar a type of activity as possible was assigned based on the sector. The M-Score model correctly identified 67% of manipulators and 75% of non-manipulators. The research showed that SGI, SGAI, LEVI and TATA were significant in detection of earnings management. Comporek (2020) analyzed 27 companies listed on the WSE that received a monetary fine from the KNF Board in the context of compliance with IFRS principles in the period 2006–2018. The author did not include a control sample to the analysis, because he noted that it is not always possible to choose a company similar enough to reflect all the features that may affect the scope of manipulation. The Beneish model correctly classified 41% observations in the year for which accounting manipulations were detected, and 63% in

the two previous years for which no accounting manipulations were detected. Hołda (2020) assumed that companies that been fined by the KNF Board for irregularities related to financial statements and received a disclaimer opinion by the auditors or notoriously qualified opinions due to irregularities identified in the statements could be classified as manipulators. Hołda used a sample of eight companies listed on the WSE in the period 2009–2010, in which four firms were identified as manipulators using the 5-variable and 8-variable M-Score models. The author chose only this period because he noticed that it was known what had happened with these companies, and based on their history, it was possible to correctly classify them as a group of manipulators and non-manipulators. The 5-variable model correctly identified only five firms; however, the 8-variable model correctly classified all companies.

4. DATA AND HYPOTHESES

The present empirical research on the Beneish model includes 55 companies listed on the main market of WSE that have received an adverse or disclaimer opinion by the auditors, are established in the territory of Poland and have not received a monetary fine from the KNF Board for violation of IAS/IFRS principles related to financial statements in the period 2015–2020. Table 2 shows the most important reasons for the company's receiving an adverse or disclaimer opinion by the auditors. A matched pair of samples were used in this study, whereby each company is matched with a corresponding control firm based on the industry (according to the Standard Industry Classification code) and financial year, with minimizing the difference in the size of total assets. Each control firm was required to have an unqualified opinion by the auditors. In addition, three companies that received a monetary fine from the KNF Board in the period 2015–2020 related to non-compliance with IAS 1, IAS 24, IAS 34, IAS 36, IAS 39, IFRS 3, IFRS 7 or IFRS 8 (in each case, it was a violation of four IAS/IFRS guidelines) and three control firms were included in the empirical research as a separate sample. The data were collected for these two samples from the annual reports of the companies. In some cases, the denominator of the variables was equal to zero. This study adopted two solutions: first, setting the value of the indicator equal to one, which is the solution used by Beneish (1999), Paolone and Magazzino (2014), Repousis (2016), Feruleva and Shtefan (2017), Golec (2019), Comporek (2020), and second, removing the observation from the sample.

Table 2
The most important reasons for receiving an adverse or disclaimer opinion by the auditors

Reason	No. of cases
Disclaimer regarding adoption of going concern principle by the company	40
related to:	
insufficient audit evidence to evaluate the assumptions made in the notes and financial statements	28
negative equity	11
negative net working capital	8
irregularities or lack of test fixed asset for impairment	5
Not all accounting documents/information are available to the auditor	17
The auditor's report was not made available	7
Tax and audit proceedings conducted against the company	6
Valuation of some of the company's assets in violation of the regulations	5

Note: The auditor could indicate more than one reason for receiving an adverse or disclaimer opinion.

Source: Author's own elaboration.

Several authors have used the 5- and 8-variable M-Score models in their research. To investigate which of these two models is better for the listed companies on the WSE, the first hypothesis was formulated as follows:

Hypothesis 1: *The 8-variable model will have greater accuracy than the 5-factor model on the sample of companies that have received an adverse or disclaimer opinion from the auditors.*

Several authors have adapted the Beneish model to the conditions of their own country (Paolone & Magazzino, 2014; Repousis, 2016; Feruleva & Shtefan, 2017; Hasan et al., 2017; Ozcan, 2018; Halilbegovic et al., 2020; Kramarova & Valaskova, 2020; Svabova et al., 2020; Vetoshkina et al., 2020; Shakouri et al., 2021; Sabău et al., 2021). This leads to the second hypothesis that:

Hypothesis 2: *The modified M-Score model based on logistic regression results will be more accurate than the 8-variable (5-variable) M-Score model for companies fined by the KNF Board.*

5. RESULTS

Table 3 shows the descriptive statistics for the M-Score variables for the sample of companies that received an adverse or disclaimer opinion by the auditors and have not received a monetary fine from the KNF Board and control firms. The Mann-Whitney U-test showed that there was a significant difference between the variables SGI, DEPI, SGAI, LEVI and TATA for companies that had received an adverse or disclaimer opinion compared to the control group firms. The high SGI ratio can raise expectations, many of which are not sustainable for the company's management but do not yet imply financial statement fraud. A high value of DEPI ratio indicates that fraudulent firms revise the useful life of their assets upwards or adopt a new depreciation method that boosts corporate earnings. The high SGAI ratio may signal deteriorating sales and administrative efficiency that may induce the firm's management to commit financial statement fraud. A high value for the LEVI ratio indicates that firms may become more prone to financial statement fraud. The high level of the TATA ratio may increase the likelihood of the manipulation of corporate earnings.

Table 3
Descriptive statistics

	Minimum		Maximum		Mean		Std deviation	
	Adverse	Control	Adverse	Control	Adverse	Control	Adverse	Control
DSRI	-0.58	0.00	3527.86	15.12	89.33	1.60	520.86	2.32
GMI	-18.87	-351.76	4.87	2.09	-0.10	-5.72	3.38	47.98
AQI	-0.63	0.00	19.86	5.60	1.74	1.03	3.24	0.72
SGI***	-0.72	0.22	1.59	257.43	0.51	5.83	0.45	34.89
DEPI**	0.10	0.04	9.42	4.43	1.03	1.13	1.34	0.68
SGAI**	-3.48	0.00	699.23	9.80	27.71	1.19	118.26	1.26
LEVI***	0.00	0.13	60.69	26.19	3.87	1.54	9.14	3.50
TATA***	-27.69	-25.61	8.33	0.32	-1.88	-0.51	5.00	3.45

Note: *** indicates Mann-Whitney U-test significant at the 1 percent level, ** at the 5 percent level and * at the 10 percent level.

Source: Author's own elaboration.

Table 4 illustrates the classification scheme of the full sample, where it is assumed that the value of the indicator is equal to one when the denominator is equal to zero. The results from the Beneish model reveal that 12 out of the 55 firms (27.9%) are found to have a total M-Score higher than (−1.78) and were classified as earnings manipulators, while 38 control firms (69.1%) are classified as non-manipulators. In contrast, using the Roxas model, the results showed that 23 firms with adverse or disclaimer opinions (41.8%) and 34 control companies (61.8%) are prone to financial statement fraud. The Roxas model approach increases accuracy by 6.3 percentage points.

Table 4
M-Score model results for the full sample

	Beneish model		
	Manipulator	**Non manipulator**	**Correct (Percentage)**
Adverse	12	43	27.9%
Control	17	38	69.1%
Overall			45.5%
	Roxas model		
	Manipulator	**Non manipulator**	**Correct (Percentage)**
Adverse	23	32	41.8%
Control	21	34	61.8%
Overall			51.8%

Source: Author's own elaboration.

Table 5 presents the classification scheme for the companies for which it was possible to calculate all M-Score ratios. Based on the estimations, the Beneish model correctly classified 7 adverse firms (16.7%) and 30 control firms (71.4%); the accuracy of the model was 44.0%. The Roxas model correctly classified 17 adverse companies (40.5%) and 29 control firms (69.0%); and the Roxas model had greater accuracy than the Beneish model by 10.8 percentage points.

Table 5
M-Score model results for the sample with enumerated variables

	Beneish model		
	Manipulator	**Non manipulator**	**Correct (Percentage)**
Adverse	7	35	16.7%
Control	12	30	71.4%
Overall			44.0%
	Roxas model		
	Manipulator	**Non manipulator**	**Correct (Percentage)**
Adverse	17	25	40.5%
Control	13	29	69.0%
Overall			54.8%

Source: Author's own elaboration.

Based on the results, Hypothesis 1 should be rejected. The Beneish model was less accurate than Roxas model. The goal of this research is not only to assess the differences between the two groups of companies but also to evaluate which of the eight ratios in the Beneish score individually influence the probability of identifying fraud for companies. Some authors have also modified the Beneish model to the conditions in their countries, primarily based on logistic regression (Ozcan, 2018; Erdogan & Erdogan, 2020; Papik & Papikova, 2020; Svabova et al., 2020). In this case, the logistic regression was used to analyze the interaction effects of the ratios in the Beneish model. The logistic regression model is selected to establish a model that can effectively predict the situation of firms with negative or adverse opinions. The results of estimating the research model by logistic regression and using data where it was possible to calculate all M-Score ratios are reported in Table 6.

Table 6
Logistic regression models for the sample with enumerated variables

	Beneish	Roxas	Modified
DSRI	-0.0126 (0.0285)	-0.0127 (0.0263)	
GMI	-0.5320 (0.2555)***	-0.8003 (0.2884)***	-0.4078 (0.2253)**
AQI	0.2892 (0.3463)	0.1896 (0.3142)	
SGI	-0.7401 (0.3513)***	-1.1068 (0.3967)***	-0.5693 (0.3101)**
DEPI	-0.7495 (0.5306)*	-0.9830 (0.5248)**	-0.8672 (0.6461)*
SGAI	-0.0045 (0.0050)		
LEVI	-1.0167 (0.6868)		
TATA	-2.2405 (1.4803)		-4.0402 (0.0023)***
Constant	2.1448 (1.0425)	2.2875 (0.9401)**	1.0181 (0.8805)
N	84	84	84
R-square	31.7%	22.1%	33.0%
Accuracy	75.0% (63)	76.2% (64)	79.8% (67)
Sensitivity	50.0% (21)	52.4% (22)	59.5% (25)
Specificity	100.0% (42)	100.0% (42)	100.0% (42)

Note: standard errors in parentheses: *** indicates variables significant at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Source: Author's own elaboration.

The results from the logistic regression indicate that the GMI, SGI and DEPI ratios are significant in both the Beneish and Roxas models. Based the regression results, the classification accuracy was 75.0% for the Beneish model and 76.2% for Roxas model. The GMI, SGI, DEPI and TATA have a direct and statistically significant effect on the Polish market in Table 6. The model correctly classified 59.5% of companies with adverse or negative opinions and 100% of

the control companies. These findings align with the results of other studies in the literature. Shakouri et al. (2021) confirmed that there is a significant relationship between GMI, SGI, DEPI and TATA with financial statement fraud. Herawati (2015) in the conducted research also confirmed that GMI, DEPI and TATA ratios have a direct influence on identifying the presence of financial fraud. Sabău et al. (2021) also showed that GMI, DEPI and TATA ratio can signal the presence of financial fraud. In their study for the ratio TATA and SGI, Halilbegovic et al. (2020) ran tests that also showed they have a significant influence in detecting financial fraud.

Based on the results of logistic regression analysis, Equation 3 presents the following linear equation for the M-Score model for companies listed on the WSE:

$$\text{M-Score (Modified)} = 1.0181 - 0.4078 * GMI - 0.5693 * SGI - 0.8672 * DEPI - 4.0402 * TATA \quad (3)$$

The red flag values for these ratios were computed as the probability cutoffs that would minimize the expected costs of misclassification with relative costs of Type I to Type II errors equal to 1:1. The threshold values are as follows:
- Less than 0.7218 for GMI,
- Less than 0.9443 for SGI,
- Less than 0.7801 for DEPI and
- Less than (−0.1079) for TATA.

The marginal value of the modified M-Score was calculated based on the linear equation and the threshold values for the indicators and is equal to (–0.0544). It means a higher value indicates a higher probability that the company applied financial statement fraud techniques.

Table 7 reports the classification results of the modified M-Score model for companies that have received a monetary fine from the KNF Board for violation of IAS/IFRS principles. Both the Beneish and Roxas models accurately classified one out of three fined firms and all control firms, while the adapted model incorrectly classified only one fined company. The use of red flag values indicates that attention should be paid to all fined companies. The value for TATA was exceeded for all fined companies, SGI for two companies and GMI for one firm; however, for control companies, the red flag value for GMI identified one company and SGI two firms for further analysis. The classification results suggest that the adapted model has superior performance in the detection of firms that have received an adverse or disclaimer opinion by the auditors and received a monetary fine from the KNF Board.

Table 7
Modified M-Score model results for companies that have received a monetary fine from the KNF Board

	Beneish / Roxas		Modified	
	Manipulator	Non manipulator	Manipulator	Non manipulator
Fraud	1	2	2	1
Control	0	3	0	3
SUM	1	5	2	4

Note: Identical results were obtained for Beneish and Roxas models, therefore they were not separated in the table.

Source: Author's own elaboration.

Based on the results, Hypothesis 2 cannot be rejected. The Modified M-Score model had better accuracy than the 8-variable (5-variable) M-Score models.

6. CONCLUSION

Detecting financial statement fraud is extremely difficult for forensic accountants, especially if the firm's management is involved, although the methods used in forensic accounting make key contributions to the detection of financial statement fraud. Past experiences have played a critical role in the development of forensic accounting methods, but the rapidly changing global financial environment leads to the introduction of new methods.

The research sought to detect financial statement manipulation among 110 listed companies in Poland analyzed during a six-year period (2015–2020) using the Beneish and Roxas models. Based on the results, the Roxas model was more accurate than the Beneish model, and Hypothesis 1 should be rejected. The overall accuracy of the Roxas model was 51.8%. It is crucial to mention that Beneish or Roxas models do not present the perfect evaluation for earning manipulation in companies. That is why it is significant to detect the level of accuracy in the case of manipulation within firms, based on the models.

Also the modified M-Score model, based on the logistic regression approach, with 79.8% overall accuracy, allowed for correct identification of each control company and nearly 60% of companies that had received an adverse or disclaimer opinion from the auditors. For the Polish market, there are four significant ratios: GMI, SGI, DEPI and TATA. Based on the results for companies that have received a monetary fine from the KNF Board, Hypothesis 2 cannot be rejected. Researchers should remember that a single irregularity is not a sign of financial statement manipulation.

The results indicate that the Beneish and Roxas models should not be used for companies that have received an adverse or disclaimer opinion from auditors for public companies listed on the WSE. The logistic regression based on indicators from these models had greater accuracy. This paper found that the modified M-Score model for companies listed on the WSE has more powerful detection capacity than either the Beneish or Roxas models. The modified M-Score model can be used as a predictor in determining the risk of a negative opinion by an auditor. The data sample was prepared based on which companies had received an adverse or disclaimer opinion from the auditors; however, not all adverse or disclaimer opinions are a sign of fraud. The weakness of this study is the small sample size, which was dictated by data availability constraints. Future studies should investigate the detection capacity of the proposed model in other countries, because the methods for reporting financial indicators may differ significantly by country.

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On the Use of Quantitative Methods
in Accounting Research in Poland

Marek Gruszczyński
SGH Warsaw School of Economics, Poland
marek.gruszczynski@sgh.waw.pl
https://orcid.org/0000-0001-8946-0713

ABSTRACT

This paper presents a review of published accounting research based on quantitative methods originating in Poland between 2010 and 2021. Twenty-one international and national journals were examined, all having "accounting" in their title, as well as the leading Polish journal on accounting research – *Zeszyty Teoretyczne Rachunkowości* (ZTR, *Theoretical Journal of Accounting*). The principal finding is that Polish authors – especially those using quantitative methods – rarely publish in top accounting journals outside of Poland. They most frequently publish quantitative papers in ZTR, although those papers account for just 5% of the total number of papers published there. The corresponding percentage of quantitative papers is much higher in leading international accounting journals. This paper is presented as a voice in the debate within Polish academia on the development of the accounting discipline.

1. INTRODUCTION

Accounting research is contemporarily defined very broadly, with many topics covered within other fields such as corporate finance or corporate governance. For example, in 2018, the *Journal of Accounting Research*, the leading journal in the field, composed the following list of research topics historically published in that journal (Gruszczyński, 2020):
– the impact of financial reporting and disclosure on stock prices,
– the economics of auditing, enforcement, and audit oversight,
– the use of accounting information in contracting in the debt, labour, supply, and other markets,
– the role of accounting in compensation and in corporate governance,
– the role of managerial accounting in internal decision-making such as budgeting, costing, and transfer pricing,
– the real effects of financial reporting and disclosure,
– the economics of the regulation of financial reporting and disclosure including bank regulation,
– international differences in financial reporting and the role of reporting standards in international capital markets,

– the political economy of accounting standard-setting,
– the use of accounting information in public finance,
– the impact of tax regulation on transaction structuring.

The above topics coincide with, encompass or are intertwined with typical topics of corporate finance research, as reflected in research published in corporate finance and other journals of finance. To narrow the scope of our survey, this paper concentrates on those journals that have "accounting" in their title.

This review is rooted in other reviews of accounting research. The examples of recent surveys include the paper by Lennox and Wu (2022) on Chinese accounting research over the past twenty-five years, the paper by Lopes (2015) on research methods in accounting, as well as two papers by Bromwich and Scapens (2010, 2016).

Polish research has been reviewed in the papers by Dobroszek and Michalak (2013) and Jaworski and Sokołowska (2014).

One incentive to undertake this review was the level of interest in the 2009 paper entitled "Quantitative Methods in Accounting Research" that has been read more than twenty thousand times via ResearchGate[1] (Gruszczyński, 2009).

This paper concentrates on published research that: (1) employs quantitative methods and (2) originated in Poland. Journals in accounting issued during the 2010–2022 period were reviewed, the period beginning after publication of the paper cited above.

Quantitative methods are in frequent use in today's accounting research as the preeminent methodological choice in cases with an abundance of data (e.g., corporate reports text mining) and provide a more rigorous approach in examining survey outcomes (e.g., structural equations modelling), among other undertakings.

We sought to uncover papers that use quantitative methods in accounting research and are presented by Polish academia in journals of accounting. The search concentrated on major international and European scientific journals that specialize in publishing accounting research. The vast majority of papers, however, came from a single Polish journal *Zeszyty Teoretyczne Rachunkowości.* (ZTR, *Theoretical Journal of Accounting*).

Section 2 presents the results of the search for papers published in leading international accounting journals authored by scholars affiliated in Poland. In section 3, papers are presented that use quantitative methods and are published in Poland in ZTR. Section 4 concludes the review.

It should be noted that our search does not purport to be comprehensive, and any omissions are not intentional. We apologize if a paper that meets the stated criteria has not been included here.

2. RESEARCH FROM POLAND PUBLISHED IN MAJOR INTERNATIONAL ACCOUNTING JOURNALS

The search focused on leading international accounting journals. Various sources publishing lists of highly rated journals were referenced, beginning with the Web of Science (Social Science Citation Index and Emerging Sources Citation Index). Also consulted was the Scopus list of major journals in the field of "Business, Management and Accounting," by countries, as published by Scimago.

The search was restricted to journals having the word "accounting" in their titles. Twenty-one publications were identified:
– *European Accounting Review*, *Accounting in Europe*; journals of the European Accounting Association (EAA)

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[1]   Score in May 2022.

– *The Accounting Review, Journal of Management Accounting Research*; journals of the American Accounting Association (AAA)
– *Contemporary Accounting Research*; journal of the Canadian Academic Accounting Association
– *Journal of Accounting Research*
– *Journal of Accounting and Economics*
– *Journal of Business Finance and Accounting*
– *Journal of International Financial Management and Accounting*
– *Review of Accounting Studies*
– *Journal of Accounting Literature*
– *Journal of Accounting Auditing and Finance*
– *International Journal of Accounting Information Systems*
– *Critical Perspectives on Accounting*
– *British Accounting Review*
– *Advances in Accounting*
– *Accounting Horizons*
– *Abacus-A Journal of Accounting Finance and Business Studies*
– *Accounting and Finance*
– *Comptabilité Contrôle Audit*; journal of the Francophone Association of Accounting
– *Revista de Contabilidad – Spanish Accounting Review*; journal of the Spanish Association of Accounting Academics

To find papers from Poland, we searched, when possible, for the word "Poland" in the author's affiliation or within the content of the papers. In accordance with this paper topic, we concentrated on finding articles on accounting research that employ any type of quantitative methods. Some of the authors from Poland are not affiliated with accounting research units but with finance, management and other university departments or institutions.

Table 1 presents the results of our search, by journal, indicating the type of indexing in the Web of Science, the number of ministerial points in the current classification of scientific journals in Poland, and the number of published papers using quantitative methods by authors affiliated in Poland. The journals were searched in May 2022, with results including papers published online until that time.

Table 1
Accounting journals examined in the paper for the period January 2010–May 2022

Journal title	Web of Science	Polish score	No. of papers
European Accounting Review	SSCI	100	0
Accounting in Europe	ESCI	70	2
The Accounting Review	SSCI	200	0
Journal of Management Accounting Research	ESCI	100	0
Contemporary Accounting Research	SSCI	140	0
Journal of Accounting Research	SSCI	200	0
Journal of Accounting and Economics	SSCI	200	0
Journal of Business Finance and Accounting	SSCI	100	0
Journal of International Financial Management and Accounting	SSCI	100	2
Review of Accounting Studies	SSCI	100	0
Journal of Accounting Literature	ESCI	70	0

Table 1 – continued

Journal title	Web of Science	Polish score	No. of papers
Journal of Accounting Auditing and Finance	ESCI	70	0
International Journal of Accounting Information Systems	SSCI	100	1
Critical Perspectives on Accounting	SSCI	100	0
The British Accounting Review	SSCI	140	1
Advances in Accounting	ESCI	20	0
Accounting Horizons	SSCI	100	0
Abacus-A Journal of Accounting Finance and Business Studies	SSCI	70	0
Accounting and Finance	SSCI	70	0
Comptabilité Contrôle Audit	SSCI	40	0
Revista de Contabilidad – Spanish Accounting Review	SSCI	70	1

SSCI = Social Sciences Citation Index; ESCI = Emerging Sources Citation Index; Polish score = the score in the classification of journals in Poland published by the Ministry of Science and Education (November 2021), Polish scores ranged between 20 and 200; No. of papers = the number of papers that use quantitative methods published by Polish authors in that journal.

The survey of these accounting journals showed that only seven papers by authors from Poland employing various quantitative methods had been published. In addition to identifying each paper and journal, the following list presents the title of each, the method(s) used, and the number of citations in the Web of Science (WoS) and Google Scholar[2] (GS) or journal website (JW).

1. Panfilo and Krasodomska (2022). Published in *Accounting in Europe*.

    Title: Climate change risk disclosure in Europe: The role of cultural-cognitive, regulative, and normative factors.

    Method: **ordinal probit** explaining CDP (Carbon Disclosure Project) climate change ratings for a sample of European companies, linear **regression** for explaining CDP climate change disclosure quality score.

    Citations: 1 (WoS), 2 (GS).

2. Hadro, Klimczak and Pauka (2017). Published in *Accounting in Europe*.

    Title: Impression management in letters to shareholders: Evidence from Poland.

    Method: content analysis of impression management techniques in a sample of letters to shareholders for companies listed on the Warsaw Stock Exchange (WSE), **clustering method of *k*-means** for identifying groups of similar mix of impression management techniques, linear **regression** for the length of letters, **logit** regression for assigning letters to clusters.

    Citations: 12 (WoS), 30 (GS).

3. Grabiński and Wójtowicz (2022). Published in *Journal of International Financial Management and Accounting*.

    Title: The impact of Catholic religion on earnings management: A case of Poland.

    Method: for a sample of WSE-listed companies, linear **regression** of discretionary accruals on religiosity in the diocese where the headquarters of the company are located and on company financials; the religiosity proxy is the share of Catholics receiving Holy Communion during the Sunday Eucharist.

    Citations: 3 (WoS), 3 (JW).

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2   Via Publish or Perish (retrieved July 6, 2022).

4. Altman, Iwanicz-Drozdowska, Laitinen and Suvas (2017). Published in *Journal of International Financial Management and Accounting*.

    Title: Financial distress prediction in an international context: A review and empirical analysis of Altman's Z-Score model.

    Method: for a sample of European and non-European companies, re-estimation of the original Altman's *Z"* score (using linear **discriminant analysis**), **logit** regression version of *Z"* score, both with the effect of the year of bankruptcy.

    Citations: 185 (WoS), 203 (JW).

5. Monteiro, Vale, Leite, Lis and Kurowska-Pysz (2022). Published in *International Journal of Accounting Information Systems*.

    Title: The impact of information systems and non-financial information on company success.

    Method: **structural equations model** (SEM) applied to a survey questionnaire of managers in Portuguese companies; SEM is applied to analyse causal relationships between constructs representing accounting information system quality, internal control system quality, non-financial information quality, decision-making success, and non-financial performance.

    Citations: 0 (WoS), 1 (GS).

6. Roszkowska, Langer and Langer (2021). Published in *The British Accounting Review*.

    Title: Pension funds and IPO pricing. Evidence from a quasi-experiment.

    Methodology: **quasi-experiment** involving Polish pension funds' government-forced changes; IPO underpricing and long-term underperformance due to rapid changes in pension funds presence on the stock market is tested with cross-sectional **regression**, test of pre- and post-treatment mean returns, **diff-in-diff** estimation, **event study**.

    Citations: 0 (WoS), 1 (GS).

7. Hadro, Klimczak and Pauka (2021). Published in *Revista de Contabilidad – Spanish Accounting Review*.

    Title: Management's choice of tone in letters to shareholders: Sincerity, bias and incentives.

    Methodology: **ordered logit** regression to model linguistic tone of letters to shareholders, from negative to positive, with information from the IFRS financial statement for a sample of companies listed at the Warsaw Stock Exchange and Vienna Stock Exchange.

    Citations: 3 (WoS), 3 (GS).

The choice of accounting journals from outside Poland was restricted here to those that are indexed in the Web of Science. Our search identified a journal from Czechia: *European Financial Accounting Journal*[3], which also publishes papers of authors with affiliation in Poland. This journal is not indexed in the WoS and has no score in the classification of journals in Poland published by the Ministry of Science and Education.

In summary, although we recognize that authors from Poland rarely appear in the identified accounting journals, these infrequent papers must present a very high quality of research design and performance to be accepted for publication. The methods used are up to date and thoroughly applied.

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[3] *European Financial Accounting Journal* has been published by the Faculty of Finance and Accounting, Prague University of Economics and Business, since 2006.

3. RESEARCH PUBLISHED IN *ZESZYTY TEORETYCZNE RACHUNKOWOŚCI*

Zeszyty Teoretyczne Rachunkowości (*Theoretical Journal of Accounting*) or ZTR is the leading journal publishing accounting research in Poland. ZTR has a score of 70 in the classification of journals in Poland published by the Ministry of Science and Education. The journal publishes papers in Polish and in English.

For this review on quantitative methods in accounting research, we have selected all suitable papers published in ZTR in the period between January 2010 and December 2021. There are forty papers that utilize some type of quantitative methodology. Our ZTR list is by no means comprehensive.

In the list below, we present the forty papers, identifying each paper's topic, the data used, the type of quantitative method(s), the author(s) and year of publication, and the number of citations in Google Scholar[4].

1. Bankruptcy modelling perspectives. Review article. No own research. Hołda (2010). Citations: 9.
2. Effectiveness of higher education in Poland. Data on higher education institutions. Method: data envelopment analysis (DEA). Ćwiąkała-Małys (2010). Citations: 2.
3. Determinants of asset accounting write-offs. Data on WSE-listed companies. Methods: linear regression, binomial logit. Piosik and Rówińska (2010). Citations: 14.
4. Bankruptcy study: stability of cash flows for bankrupt and non-bankrupt companies. Data on Polish bankrupt and non-bankrupt companies (choice-based sample). Methods: McNemar's test, Yule coefficient, canonical correlation. Wędzki (2010). Citations: 4.
5. Classification of companies with the use of *k*-means clustering. Data on WSE-listed construction companies. Method: *k*-means clustering for partitioning companies into groups in terms of financial distress. Dyczkowska (2010). Citations: 0.
6. Disclosure and investor protection. Data on selected WSE-listed companies. Method: design of the corporate disclosure index for Poland, correlation. Świderska, Pielaszek and Borowski (2010). Citations: 2.
7. Portfolio analysis and accounts receivable. Proposal of a method for categorizing company clients with the use of graphical (Lorenz curve) and mathematical approach, taking into account sales and accounts receivable. Wędzki (2011). Citations: 3.
8. Earnings management and economic situation. Time-series cross-section data on WSE-listed companies. Method: statistical tests. Wójtowicz (2012). Citations: 13.
9. Financial condition of food industry in Poland. Time-series cross-section data on WSE-listed food companies. Method: classification of companies into clusters with the use of TOPSIS and *k*-means methods. Bieniasz, Gołaś and Łuczak (2012). Citations: 5.
10. Debt ratios in European manufacturing companies. Time-series cross-section data on selected companies in selected countries. Method: graphical analysis of ratios, cluster analysis. Kędzior (2012). Citations: 0.
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17. Upward revaluation of fixed assets and information value of financial statement. Time-series cross-section data on WSE-listed companies. Method: regression. Piosik, Kumor, and Sulik--Górecka (2013). Citations: 0.

18. Financial condition of merging companies. Data on merged companies in one region of Poland. Method: new data are substituted into several "canonical" bankruptcy models for Poland that use discriminant analysis and have been estimated on another data sets. Luty (2014). Citations: 0.

19. Provisions and the balance sheet and income statement. Data on WSE-listed companies. Method: Mann-Whitney U-test, correlation. Chraścina (2015). Citations: 0.

20. Capital structure and its determinants. Review article. No own research. Białek-Jaworska and Nehrebecka (2015). Citations: 6.

21. Non-controlling interests and financial performance versus the equity of groups. Data on groups whose parents are registered in Poland and whose securities are traded on the WSE. Method: statistical tests, correlation. Ignatowski and Zatoń (2015). Citations: 1.

22. Determinants of capital budgeting methods. Data: sample of companies operating in Poland. Method: rank correlation, statistical tests. Wnuk-Pel (2015). Citations: 3.

23. Economic crisis and earnings management. Time-series cross-section data on companies from selected European countries. Method: panel regression. Grabiński (2016). Citations: 7.

24. Book-tax conformity. Time-series cross-section data on accounting and taxable results of selected non-public companies in Poland. Method: ANOVA, panel regression. Białek-Jaworska (2016). Citations: 4.

25. Bankruptcy prediction in the time of economic crisis. Time-series cross-section data on WSE-listed companies. Method: new data are substituted into several "canonical" bankruptcy models for Poland and other models that use discriminant analysis and have been estimated on another data sets. Kopczyński (2017). Citations: 2.

26. Determinants of earnings per share in the companies from Central and Eastern European countries. Data on companies from CEE countries. Method: statistical tests, correlation, regression. Kędzior (2017). Citations: 1.

27. R&D investments and company profitability. Time-series cross-section data on US companies. Method: panel regression. Grabińska and Grabiński (2018). Citations: 6.

28. Appropriateness of Altman type model of discriminant analysis for predicting bankruptcy. Data on bankrupt and non-bankrupt companies from a regional court in Poland. Method: new data are substituted into Altman model several "canonical" bankruptcy models for Poland. Iwanowicz (2018). Citations: 6.

29. Non-audit fee and the auditee's failure risk. Data on listed and unlisted Polish companies. Method: linear regression, logit regression. Staszkiewicz and Górska (2018). Citations: 0.

30. ACCA accreditation and the quality of academic accounting education. Data from a survey questionnaire of university students in Poland. Method: regression. Zarzycka, Krasodomska, Biernacki (2018). Citations: 4.

31. Timeliness of financial reporting. Data on selected WSE-listed companies. Method: statistical test. Grzybek (2018). Citations: 0.

32. Comprehensive income, net income, and market value of equity. Time-series cross-section data on WSE-listed companies. Method: rank correlation, regression. Sajnóg (2018). Citations: 2.

33. Determinants of non-financial information disclosure. Data on selected joint-stock companies in Poland. Method: correlation, regression, Tobit model. Szadziewska, Spigarska, Majerowska (2018). Citations: 2.
34. Financial disclosures and culture. Hofstede's cultural dimensions and financial data on companies from selected countries. Method: statistical tests, rank correlation. Gierusz and Koleśnik (2019). Citations: 3.
35. Intra-group loans and earnings management. Data on financial statements of listed and unlisted Polish companies. Method: regression, propensity score matching. Białek-Jaworska and Dec (2019). Citations: 6.
36. Earnings forecasts and actual returns. Time-series cross-section data of selected WSE-listed companies. Method: correlation, regression. Jakubowski and Wójtowicz (2019). Citations: 2.
37. Value relevance and predictive value of comprehensive income. Time-series cross-section data on selected WSE-listed companies. Method: regression. Bareja, Giedrojć and Wrzosek (2019). Citations: 2.
38. Determinants of impairment losses on net fixed assets. Time-series cross-section data on selected WSE-listed companies. Method: statistical tests, analysis of variance. Hołda and Staszel (2020). Citations: 0.
39. Bankruptcy prediction. Time-series cross-section data on WSE-listed companies. Method: new data are substituted into several "canonical" bankruptcy models for Poland and other models that use discriminant analysis and have been estimated on another data sets. Kopczyński (2020). [new version of paper 25]. Citations: 0.
40. Non-financial reporting standard and company's orientation towards employees in large public interest entities in Poland. Data on large public interest entities in Poland. Method: logit regression. Krasodomska, Zarzycka and Dobija (2021). Citations: 0.

Table 2 presents the summary of methods that prevail in our selection of quantitative papers published in *Zeszyty Teoretyczne Rachunkowości*.

Table 2
Quantitative methods employed in papers published in ZTR in 2010–2021

Method(s)	Number of papers	Number in the list of paper(s) employing the method(s)
discriminant analysis and binomial logit regression (for bankruptcy models)	7	1,4,11,18,25,28,39
clustering methods, *k*-means, TOPSIS, and others	4	5,9,10,12
binomial logit regression	4	3,15,29,40
panel regression	3	23,24,27
regression analysis (also in cases of time series or panel data)	7	13,17,26,30,32,36,37
statistical testing and correlation	9	6,8,16,19,21,22,31,34,38
propensity score matching	1	35
tobit model	1	33
DEA method	1	2
theoretical papers	2	7,14
review paper	1	20
Total	40	–

These are principal findings:

a) The leading Polish accounting research journal rarely presents papers with research outcomes based on quantitative approaches.
b) Predominant quantitative method is statistical testing and correlation.
c) Linear regression is used frequently, also in cases of time series data.
d) Discriminant analysis applied to modelling financial distress and bankruptcy is also common.
e) Binomial logit (logistic) regression is also used, sometimes in addition to discriminant analysis.
f) The clustering methods (*k*-means, TOPSIS) are relatively frequent.
g) There are few instances of the use of more advanced econometric methods, like panel regression or tobit regression.

More general observations include the following:

– Time-series cross-section data on WSE-listed companies are frequently used with methodology not related to time series or panel econometrics.
– The use of "canonical" bankruptcy models with unchanged coefficient estimates. These models, typically discriminant analysis or logit models, are used in papers with new data sets. Such a procedure appears incorrect according to the paper by Altman et al. (2017) presented in Section 2.
– The scope of the research selected from ZTR is not confined to major accounting research questions. This is also the case for other accounting journals, as indicated in Section 1. For example, financial distress and bankruptcy topics may be relevant to any journal on corporate finance. Nevertheless, the main body of ZTR comprehensively covers topics dedicated to accounting.

Among the forty papers, the majority undertakes strictly accounting topics:

– asset accounting write-offs,
– financial disclosure,
– non-financial disclosure,
– earnings management,
– upward revaluation of fixed assets,
– provisions and the balance sheet and income statement,
– book-tax conformity,
– non-audit fee,
– comprehensive income, net income, and market value,
– impairment losses on net fixed assets,
– non-financial reporting standard.

Our research identified attempts to use quantitative methods in papers published in the leading Polish journal of accounting, although it is not clear how these attempts should be assessed. The presence of Polish entries in the leading international journals presented in Section 1, however, demonstrates that the level of sophistication in methodological approaches is high. This perhaps indicates the direction of the future development of accounting research in Poland. The number of papers that use some type of quantitative method in ZTR averages 3 to 4 annually, representing approximately 5% of all entries published there: forty papers out of the 754 papers published in the 12-year period of 2010–2021.

Quantitative papers in ZTR are less frequent than in other international accounting journals. For example, *The British Accounting Journal* (2022 Impact Factor = 5.577) published 8 quantitative papers in 2010 out of 18 (44% of the total) and 20 quantitative papers in 2021 out of 40 (50%). In *The Journal of Accounting Research* (2022 Impact Factor = 4.364), this proportion is higher: 34 quantitative papers in 2010 out of 34 (100%) and 40 quantitative papers in 2021 out of 40 (100%).

4. CONCLUSION

The review presented in this paper concentrates on articles with a quantitative edge published by researchers with an affiliation in Poland between 2010 and mid-2022. The search covered leading international journals in accounting and one Polish journal.

There is not a singular outcome of our research. It has been shown that Polish researchers in accounting rarely publish papers employing quantitative methods in international journals as presented in Section 2. However, many more attempts are published in Poland's leading accounting journal as shown in Section 3, although the occurrence of quantitative papers in ZTR is very rare (only 5% of papers published during the 12-year period), and their methodological complexity varies.

The most popular topics that appear in the selected papers are bankruptcy and financial distress, financial and nonfinancial disclosure, classification of companies, earnings management, and comprehensive income. The primary methods used are discriminant analysis, logit regression, multiple regression, *k*-means, correlation, and statistical testing.

To narrow the scope of the survey, our review focused on journals having the word "accounting" in their title. Obviously, such a survey could be extended to journals that publish papers in corporate finance and accounting – but without "accounting" in their titles. However, based on the findings of this paper, in the near term, it is difficult to foresee any major increase in the number of publications that could be the subject of such a review. A broader orientation toward quantitative methods in Polish accounting research may come in the more distant future.

Possible changes might begin with accounting programmes offered in institutions of higher education. For example, the Master's Programme in Accounting at Aalto University School of Business includes a "Big Data Analysis in Accounting" course. Such classes are offered at business schools in Poland but are not necessarily attached to the core accounting curriculum. At SGH (Warsaw School of Economics), the field of study in Finance and Accounting at the master level offers no quantitative classes in the list of major courses. The course "Financial Econometrics" is offered as an elective. Another example is the MSc Accounting and Data Analytics Master's degree offered at the University of Portsmouth. The core courses there include "Statistics and Data Modelling" and "Data Analysis and Visualization." Such courses seem to fit well within the contemporary curriculum of accounting majors. Along with introducing data analytic subjects in advanced degree studies, doctoral tracks in accounting could also include courses on quantitative methods in research.

We hope this paper shows the current state of the use of quantitative methods in accounting research in Poland and may play a part in discussions in academia about the development of the accounting discipline in the country.

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Voluntary Disclosure and Relational Connectivity – The Case of the Polish Bond Market

Dominika Hadro[1]
Wroclaw University of Economics and Business, Poland
dominika.hadro@ue.wroc.pl
https://orcid.org/0000-0001-7904-7685

Marek Pauka
Wroclaw University of Economics and Business, Poland
marek.pauka@ue.wroc.pl
https://orcid.org/0000-0001-8148-4438

Kamil Gemra
Warsaw School of Economics, Poland
kgemra@sgh.waw.pl
https://orcid.org/0000-0001-5292-2362

Szymon Okoń
Warsaw School of Economics, Poland
sokon@sgh.waw.pl
https://orcid.org/0000-0001-7214-3981

Justyna Fijałkowska
University of Lodz, Poland
justyna.fijalkowska@uni.lodz.pl
https://orcid.org/0000-0002-4236-1491

ABSTRACT

The purpose of our research is to evaluate the voluntary disclosure strategy and effective communication between issuers and investors on the Polish bond market Catalyst. We conducted a questionnaire among issuers on the Catalyst. To evaluate the data and find answers to the research questions, we used the Qualitative Comparative Analysis. As our analysis shows that management board engagement seems crucial for effective communication, we claim that in relatively smaller capital markets, personal engagement of board members in preparing voluntary disclosure should be considered a proxy of a high disclosure strategy quality. We prove that companies use dialogue with investors in private rather than in public to understand their communication expectations. This finding indicates the essential limitations of previous research

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[1] Corresponding author: Dominika Hadro, tel. no 00 48 71 36 80 212, address Komandorska 118/120, 53-345 Wroclaw, Poland.

evaluating relational connectivity through social media. We point out the existence of many paths to achieve a high level of companies' perception of investors' voluntary disclosure needs and companies' relational connectivity regarding voluntary disclosure. We developed a new approach to measuring relational connectivity, which can be successfully applied to other markets and stock exchanges, allowing verification of previous findings and the development of a new approach to conducting research. We claim that it is necessary to put more pressure on the management board's engagement in preparing the financial report as it is crucial for understanding investors' voluntary disclosure needs. Our conclusions question the growing societal pressure on engaging in activity in social media as a key concept of effective communication.

JEL Classification: G14, G23, D82

Keywords: voluntary disclosure, relational connectivity, bond market, Poland, corporate communication.

1. INTRODUCTION

Information is crucial for effective financial markets and their development (Bebczuk, 2003; Goldstein & Yang, 2017; Stiglitz, 1989). Nevertheless, only information that is useful for investors' valuation models in a decision-making process fulfils its function (Blankespoor et al., 2020). Nowadays, managers of listed companies recognise the corporate communication and disclosure strategy as an essential part of firms' strategic management, allowing them to keep effective relationships with their key stakeholders (Frandsen & Johansen, 2018). One of the crucial elements of disclosure strategy lies in the non-mandatory information disclosure decision. For decades, managers of public companies paid little attention to the disclosure strategy and their stakeholders' information needs. Still in the 1980s, the main focus was on publishing mandatory information, underestimating the significant and long-lasting effects of voluntary disclosures for companies and their stakeholders (Lev, 1992).

Voluntary disclosure and its quality can be seen as exogenous, i.e. used to mitigate information asymmetry, or as exogenous, i.e. reflecting the underlying information environment (He et al., 2018). Both perspectives, theoretical and empirical, confirm that under certain conditions publishing non-mandatory information and fulfilling stakeholders' information expectations influence companies' financial and market ratios positively in the long run. As a consequence, nowadays, much of public information is in the form of voluntary disclosure (Beyer & Guttman, 2012).

Despite the fact that since the 1990s, there has been a growing body of empirical research trying to find patterns and logical explanations for different levels of voluntary disclosure, the discussion is still open and clear answers have not been delivered yet (He et al., 2019). The legal environment is constantly changing to improve transparency in financial markets, new channels of dissemination are appearing with growing awareness and pressures of different groups of stakeholders to disclose non-mandatory information. However, at the same time, all those factors have influenced dramatically the length of periodic reports decreasing their specificity, readability, and the relative amount of hard information (Dyer et al., 2017). It seems, though, that the only way to find a balance in voluntary disclosure, understood as effective communication, is the continuous dialogue with stakeholders followed by companies' reactions to match their needs (Blankespoor et al., 2018; Blankespoor et al., 2020, Hadro et al., 2022). Dialogue, feedback, and customisation between companies and their audiences are the reflection of relational connectivity in corporate communication (Brennan & Merkl-Davis, 2018, p. 561).

Companies' uncertainty about stakeholders' information needs usually results in either very limited or exaggerated extent of voluntary disclosure (Beyer et al., 2010). Relational connectivity seems crucial for voluntary disclosure to match stakeholders' needs and information environment obligations that change over time. At the same time, the aim is not to produce an excessively large amount of information, negatively influencing investors' decision-making process and obfuscating the company picture.

In the great majority of academic publications in the area of voluntary disclosure, periodic reports and other sources of companies' written and spoken information are investigated. Researchers usually use textual analysis or financial and market indices as proxies of the voluntary disclosure level and quality (Hassan & Marston, 2019).

In contrast to that approach, we conducted a questionnaire with listed companies. Our research aims to indicate the determinants of the voluntary disclosure strategy and relational connectivity between issuers and investors on the Polish bond market Catalyst. To achieve our goal, focusing on empirical research, we conduct a literature review and indicate variables that potentially can significantly influence companies' disclosure strategy, and as a consequence, we implement appropriate questions into our survey.

Our research also differs from the others in terms of the market that has been analysed. We focused on listed companies from the Polish bond market called Catalyst, which is a part of the Warsaw Stock Exchange (WSE). To give a new insight into the literature, we decided to peer at the public debt market of non-financial companies as it is considered less risky than the equity market. At the same time, it usually suffers from low liquidity, which causes a higher level of information asymmetry (Bardos, 2011). In this situation, companies' investors should demonstrate greater needs for voluntary disclosure (Beyer et al., 2010), and better companies should be more willing to understand those information needs using the concept of relational connectivity and deliver non-mandatory information that is of interest to their investors.

To analyse the questionnaire, we used the Qualitative Comparative Analysis (QCA) tool infrequently applied in financial qualitative research. The method was first presented by Ragin (1987) and was initially predominately used in sociology and political science. Lately, it has also become explored in business and management studies (Cucari, 2019; Wagemann et al., 2016), developing a new wave of «neo-configurational» research (Greckhamer et al., 2018).

Through QCA, our results show the different sets of companies' characteristics that convey voluntary disclosure strategies. In general, CEO engagement seems to be crucial for effective communication. With that result, we answered the call of Bamber et al. (2010) to explore the role of individual managers in reporting choices. We claim that, especially in relatively smaller capital markets, the CEO's personal engagement in preparing voluntary information can be seen as a proxy for a high-quality disclosure strategy. We suggest that concentrating the investigation more on the CEO's personal role and not only on the board of directors' characteristics, which is the most frequent approach in the literature, can give new answers to effective communication. We also confirm the results of a stream of previous research (like Gomez-Carrasco & Michelon, 2017; Jung et al., 2017; She & Michelon, 2019) on social media's limited role in effective corporate communication and fulfilment of the investors' information needs. We prove that companies use private rather than public dialogue to understand investors' communication expectations. That finding indicates the essential limitations of previous research evaluating relational connectivity through social media.

The study may be of interest to researchers, practitioners, policymakers, and society as it implies that how the disclosure occurs is equally important as the content of the information disclosed. Our paper contributes to the debate on effective corporate communication in financial markets; specifically, it sheds new light on both strategies regarding voluntary disclosure and disclosure dissemination. Finally, we developed a new approach to measuring relational

connectivity, which can be successfully applied to other markets and stock exchanges, allowing verification of previous findings and the development of a new approach in research.

Our paper is structured as follows: in Section 2, we present a literature review that brings us to the development of two research questions; in the third section, the questionnaire process, methodology, and variables are described, which is followed by the research results in Section 4. The final section (number 5) consists of the conclusions and suggestions for future research.

2. LITERATURE REVIEW AND RESEARCH QUESTIONS DEVELOPMENT

2.1. Voluntary disclosure

Financial reporting plays a crucial information role in the capital market; however, even in an efficient capital market, managers have superior information to outside investors on their firms' future performance (Healy & Palepu, 2001). Therefore, voluntary disclosures allow managers to convey their private information to the marketplace. "Disclosure" refers to a specific signal from a firm report or communication (Blankespoor et al., 2020). Consistent with Healy & Palepu (2001), corporate disclosure includes both regulated financial reports (e.g., financial statements) and voluntary communication (e.g., management forecasts and public earnings conference calls). In the case of mandatory disclosure, the firm is required by regulators to disclose its information to the general public (Goldstein & Yang, 2019).

According to current legal regulations, depending on whether the bonds are listed on a regulated market or in an alternative trading system, the issuer is obliged to publish periodic financial reports. Even if they are adequately prepared and follow the accounting requirements, they do not always explain all the material issues sufficiently. For this reason, issuers often decide to provide additional disclosures and thus allow stakeholders to get more informed. According to the Financial Accounting Standards Board (FASB, 2001), the term voluntary disclosure describes disclosures, primarily outside financial statements, that are not explicitly required by generally accepted accounting principles (GAAP) or specific national rules (García-Meca & Sánchez--Ballesta, 2010). Firms use disclosure as a mechanism to communicate with their stakeholders, reduce information asymmetries between managers and investors, reduce firms' capital costs, increase stock prices, and ultimately increase shareholders' wealth (Enache & Hussainey, 2020).

Disclosure is a potential governance tool to manage conflicts of interest between different parts by reducing asymmetries in information; therefore, it may be a useful tool for managing the agent-principal problem (Richards & Safari, 2021). Managers have incentives to voluntarily provide more information than mandated by regulation. Khlif et al. (2017) underline that corporate voluntary disclosure is an important means for management to communicate firm performance and governance to outside stakeholders and has remained a significant field of empirical and theoretical studies since the 1970s. Until today, voluntary disclosures represent one of the most widely studied topics in finance and accounting research (Hales et al., 2018). Previous literature shows that voluntary disclosures reduce the cost of capital (Glosten & Milgrom, 1985, Barry & Brown, 1985; Botosan 1997; Sengupta, 1998; Easley & O'Hara, 2004; Hughes et al., 2007; Lambert et al., 2007, He et al., 2019), improve firm performance and stock liquidity (Diamond & Verrecchia 1991; Kim & Verrecchia 1994; Healy et al. 1999), and increase information intermediation (Lang & Lundholm 1993; Francis et al. 2008).

Voluntary disclosure is also a mechanism for improving managers' accountability (Enache & Hussainey, 2020). It also gives a greater opportunity to reduce information asymmetry between informed and uninformed investors, a far-reaching determinant of stock liquidity (Grossman, 1981; Diamond, 1985; Diamond & Verrecchia, 1991; Balakrishnan et al., 2014, Schoenfeld, 2017). Voluntary disclosure also improves the credibility of financial statements and enhances the

perceptions of market participants of future corporate performance (Athanasakou & Hussainey, 2014). In effect, voluntary disclosure is simultaneously a mechanism of greater accountability. Managers voluntarily disclose their private information because rational market participants would otherwise interpret nondisclosure as unfavourable news and consequently discount the value of the firm's assets (Grossman & Hart, 1980, Milgrom, 1981, Verrecchia, 1983). Francis et al. (2008) focus on the extent of voluntary disclosure and financial reporting quality and conclude that higher quality in reports is significantly related to a higher level of voluntary disclosure.

The potential benefits of voluntary disclosure are a vast area of research; however, the type and content of the information expected by investors are still not thoroughly investigated. Already in 1971, Rawls (1971) underlined that investors demand information about the performance and prospects of the firm in the capital market. This is, however, a very general statement. Previous research confirms that investors monitor bad and good news disclosed by companies. However, voluntary disclosures with favourable news can increase stock liquidity to a greater extent than those with unfavourable news (Cho & Kim, 2021).

Voluntary disclosure could reveal information that the firm would otherwise not reveal to competitors, potential entrants, regulators, customers, and suppliers (Enache & Hussainey, 2020). Several studies underline the interest of stakeholders in voluntary disclosure. Ajinkya et al. (2005) argued that institutional investors desire and demand more voluntary disclosures and that such disclosures, especially earnings forecasts, are closely watched by market participants. Zahller et al. (2015) provide evidence that investors perceive companies' legitimacy to be higher with a high level of disclosure. Capital market participants benefit when a firm provides transparent and adequate information to assess the firm's future performance (Enache & Hussainey, 2020). Therefore, managers must trade benefits from reduced information asymmetry and other benefits of voluntary disclosure against the costs of reducing competitive advantage (Wagenhofer, 1990; Hayes & Lundholm, 1996).

Because of the voluntary disclosure's nature, they may freely and arbitrarily choose the subject matter, scope, and depth of the issues described. In their communication strategies, companies should satisfy the information needs of their stakeholders, primarily investors. While preparing the voluntary disclosure content, companies try to understand and meet those needs. Therefore, our research question no. 1 (RQ1) is formulated as follows:

RQ1: What influences companies' perception of investors' voluntary disclosure needs?

2.2. Connectivity between investors' information needs and issuers' disclosure strategy

In the financial market, while voluntarily communicating with their audience, companies try to meet investors' disclosure expectations (Blankespoor, 2018; Blankespoor et al., 2020) and consequently, they create and maintain relations based on the conversation with investors, which is known as connectivity. According to Brennan and Merkl-Davis (2018), meaningful and effective communication can only be present when connectivity exists.

The notion of connectivity contrasts with the approach that sees corporate communication as reporting only. Reporting implies a monologic view and one-directional process, meaning that companies provide and disseminate information and the audience is a passive recipient. Unlike reporting, connectivity is seen as corporate communication: a two-way, dialogic process with information flowing in both directions (Brennan & Merkl-Davis, 2018, p. 554). Connectivity consists of three components: textual connectivity, intertextual connectivity, and relational connectivity. As the first concept refers to the text cohesion and coherence (textual connectivity) and the second one to the stakeholders' ability to interpret the text (intertextual connectivity), in our research and following Masiero et al. (2019), we focus on the broadest view of connectivity, represented by the third concept. Relational connectivity is defined there as connecting firms to

audiences by creating opportunities for feedback, dialogue, and customisation (Brennan & Merkl-Davis, 2018, p. 561).

The manifestation of relational connectivity can also be understood as signals that investors communicate by contacting the issuer (reporting information through public or private channels) and/or acting on the securities, which has an impact, among other things, on securities liquidity, turnover, and rates of return. Usually, investors send signals when the disclosure processing costs are high, thus making it impossible for them to use publicly available information for the pricing models and the decision-making process regarding trading securities (Blankespoor et al., 2019). High disclosure processing costs (awareness, acquisition, and integration costs) usually indicate that companies prepare biased information with only selective facts that are hard to interpret. In relational connectivity, issuers should react to signals and adapt the manner and content of the information provided to meet investors' expectations (Blankespoor, 2018; Blankespoor et al., 2020).

Relational connectivity relates to an earlier approach linking voluntary disclosure with the stakeholders theory. Following this theory, a stakeholder is any group or individual who can affect, or is affected by, the achievement of a corporation's purpose (Freeman, 1984). The stakeholder theory was developed by management theorists to provide a framework for analysing how large corporations interact and manage their relationships with various parties who are involved in or affected by the activities of the corporation. Based on this theory, non-mandatory information published by companies is the response to stakeholders' pressure (Farneti et al., 2019; Krasodomska & Zarzycka, 2020). However, it sticks to the concept of effective dialogic communication (Masiero et al., 2019) as relational connectivity is seen as co-creation engaging all stakeholder groups and not as the manifestation of influential stakeholders' behaviours.

Although the concept of two-way corporate communication is not new, empirical research investigating relational connectivity is very limited. In the most recent decade, we can observe an increasing number of new academic publications in the area of corporate communication and its role in financial markets (Hamilton & Winchel, 2018) as the use of social media gives us more possibilities to directly observe stakeholders signals on disclosed information and companies' reactions to that (see, for example, Bryl et al., 2021). The analyses of social media disclosure gives inconsistent results. Some show that companies selectively satisfy stakeholders' information needs even if stakeholders' signals are unambiguous (Cade, 2018; Gómez-Carrasco et al., 2020; Jung et al., 2017; Manetti & Bellucci, 2016; She & Michelon, 2019). However, single studies suggest that direct dialogue between a company and its stakeholders significantly improves the effectiveness of corporate communication (Castelló et al., 2016; Grant et al., 2018; Saxton et al., 2019). Therefore, our second research question (RQ2) is as follows:

RQ2: What influences the company's relational connectivity regarding voluntary disclosure?

2.3. Factors that influence voluntary disclosure and relational connectivity
Monologic vs. dialogic communication/openness

As most previous research analysing connectivity focuses on the information (voluntary information) disclosed on social media, we looked closer at the types of dissemination channels a company uses. Companies may decide to use or not to use social media and other interactive, less traditional channels to publish information. The dissemination choices are seen as an important part of the disclosure strategy, potentially influencing a firm's value by increasing its visibility (Jung et al., 2017). Empirical research highlights that a greater number of dissemination channels influences investors' decisions, observed as a decrease in information asymmetry (Blankespoor et al., 2014), an increase in market liquidity (Blankespoor et al., 2014) and trading volume (Gomez-Carrasco & Michelon, 2017), changes in stock prices (Gómez-Carrasco et al., 2020;

Gomez-Carrasco & Michelon, 2017; Lee et al., 2015) and their formation process (Drake et al., 2017; Twedt, 2015).

We follow the approach presented in Brennan and Merkl-Davies (2018), where corporate communication has two perspectives: monologic and dialogic. Companies that use traditional dissemination channels with few feedback opportunities, conducting their communication through routine and ad-hoc mandatory and voluntary corporate reporting are labelled as monologic. In contrast, dialogic companies use social media where there is room for comment and criticism, consequently conducting a continuous exchange of ideas with stakeholders leading to mutual understanding. That perspective is critical for building effective communication and, as a result, connectivity between companies and their stakeholders (Brennan & Merkl-Davies, 2018).

2.3.1. CEO engagement

Following Garcia Osma and Grande Herrera (2021), we understand CEO engagement as the CEO's actions taken to influence corporate reporting. For many decades, CEO engagement in corporate choices such as voluntary disclosure was recognised as insignificant (Bamber et al., 2010). In contrast to previous publications, the results of Bamber et al. (2010) indicate that CEOs play a critical role in shaping voluntary disclosure and personal managerial attributes explain systematic variations in the disclosure policy among companies. More recent research confirms that CEO characteristics influence firms' likelihood to voluntarily disclose information and affect this information (Huang, 2013, Lewis et al., 2014, Bochkay et al., 2019). In particular, further research confirms the importance of CEOs' personal engagement in increasing the credibility of financial disclosure (Asay et al., 2018) and market participants' willingness to invest in a company (Elliott et al., 2018). One of the latest studies in this field highlights that CEOs that are more able in the field of firms' disclosure policies are at the same time more willing to disclose comparable and useful non-financial information that favours stakeholder commitment (García-Sánchez et al., 2020). We expect, therefore, that CEO engagement plays a crucial role in the perception of stakeholders' voluntary disclosure needs and connectivity between them and a company.

2.3.2. Self-confidence

Strategic decisions like those regarding voluntary disclosure may also depend on a company's perception regarding its ability to deliver a good quality of reporting (Hribar & Yang, 2016). Numerous investigations in psychology prove that people tend to be biased in evaluating their own abilities, resulting in self-confidence (overconfidence) (Charness et al., 2018). Self-confidence enhances motivation for continuous improvement, but also it manifests itself in actions influencing the decisions of others (Benabou & Tirole, 2002). Therefore, we believe that how companies rate their competencies in delivering information to stakeholders may impact the awareness of their investors' non-mandatory information needs and at the level of relational connectivity.

2.3.3. Individual investors

Especially to individual investors, effective corporate communication is essential (Lawrence, 2013), as their information costs resulting from using financial disclosure in a trading decision are very high (Blankespoor et al., 2019). Individuals invest more in firms with clear and concise financial disclosures (Lawrance, 2013). Usually, they are considered unsophisticated investors with preferences for clear and more concise disclosures that are easy to process and to infer in the firm value (Fishman & Hagerty, 2003; Lawrence, 2013). On average, individual investors choose companies whose disclosure information costs are lower than investment benefits (Blankespoor et al., 2019; Lawrence, 2013). The study of Naveed et al. (2020) confirms the role of financial and non-financial information in shaping the trading behaviour of individual investors and indicates that, on average, retail investors invest in firms with detailed financial and non-financial

disclosures. They also indicate that improved financial and non-financial disclosure practices support retail investors in making sound stock investment decisions.

Moreover, the disclosure form is important while considering individual investors; less readable and longer reports require more time and energy to extract relevant information (e.g., Bloomfield, 2002). It is imperative to consider limited attention among individual investors (e.g., Hirshleifer & Teoh, 2003). We expect that the high fraction of individual investors will result in a low level of investors' non-mandatory information needs and a low level of relational connectivity.

3. METHODOLOGY AND DATA

3.1. Data and sample selection

As the first step, we sent an online questionnaire to all bond issuers listed on the Catalyst market, excluding financial sector companies. In March 2020, when we conducted our research, there were 95 issuers listed on the Catalyst, 27 of which were commercial banks and insurance companies. Finally, we sent our online questionnaire to 68 companies. In return, we received 20 questionnaires filled correctly and completely. It constitutes 29.41% of all companies that met our initial criteria, forming a sample for further analysis.

3.1.1 Catalyst – bond market on the WSE

The Catalyst bond market started on September 30, 2009. Until the foundation of the Catalyst, the public bond trading market in Poland was practically insignificant. The separation of the debt securities market from the main market of the WSE increased the interest in these instruments; however, the turnover on the secondary market remained at a low level all the time. The crisis in the financial markets was the moment of the Catalyst market establishment and consequently, there was a decline in the issuers' credibility, which caused communication with investors to be a key factor that allowed building investors' confidence in the market itself and among individual issuers. This market is also characterised by a fairly high default rate. The first debt default case occurred in 2011 (by issuer Anti S.A.). The default rate index at the end of 2014 was 7%; in the following years, its value decreased significantly, reaching the lowest level (1%) in the second quarter of 2017. However, the highest level of this indicator was recorded at the end of 2020 (over 8%). On the one hand, the drop in interest rates increased interest in debt as a source of financing, but on the other hand, the introduction of new regulations related to information obligations, i.e. the MAR / MAD directives, which tightened, among other things, penalties for the management boards of listed companies resulted in a decrease in the number of issuers since 2016 and, in particular, in the number of IPOs.

The Catalyst bond market consists of four platforms: two operated as a regulated market and two operated as the so-called Alternative Investment Market (AIM) as Multilateral Trading Facility (MTF). In the regulated market, when going public, the Act on Public Offering requires an Issue Prospectus (with a few exceptions, Okoń & Gemra 2020). It is different at the AIM, where the WSE Internal Regulations impose publication of the so-called Information Document. Despite the different regulations acts, there is no substantial difference in current and periodic disclosure obligations.

3.2. Questionnaire

To find drivers influencing bond issuers' willingness to publish non-mandatory information and answer our RQs, we formulated 51 closed-ended questions divided into four sections. The first section included five questions regarding organisation of investor relations and valuation

of issuers' communication with investors. We asked companies to indicate: who is responsible for investor relations, how companies value different investors' communication channels, who is responsible for preparing Management Discussion and Analysis (MDA) in the annual report, what causes the most significant difficulties in fulfilling disclosure obligations, which elements of the MDA are the most important from the management perspective.

In the second section, there were three questions about the companies' events and activities which are of investors' interests: in companies' opinion, what is the important information for individual investors in their decision-making process, what investors most often ask while contracting with the company, what kind of collateral is expected by individual investors. The third section dealt with companies' opinions on the importance of the events explained in the MDA. We asked four questions regarding the importance of companies' activities context, whether bad news is more important than the good ones, whether opinions and interpretations of the management board are relevant to investors, or whether forward-looking statements are relevant to investors. The last section, including six questions, covered companies' demographic information and control variables: size, type of investor, planning of new bonds' issuance, and type of debut on the Catalyst market.

3.3. Research variables

For RQ1, we developed four dependent variables representing types of voluntary disclosure that are most widely investigated in the literature: Context, Bad News, Forward-Looking--Statements (FLS), and CEO Opinion. Table 1 explains the definition and calculation methods of dependent variables for RQ1.

Table 1
Dependent variables for RQ1

Name	Description	Questionnaire	Calculation
Context	Expressing the respondents' opinion about additional information concerning MDA report.	The companies indicated whether they agree that investors need additional information explaining the context of events, not just the presentation of the results themselves ("bare facts").	The Likert scale was used here, where 5 means that the company fully agrees that it is necessary to show the context and 1 means that the company believes that it is not necessary to show context.
Bad News	Expressing the respondents' opinion about additional information concerning MDA report.	The companies indicated whether they agreed that investors needed additional information explaining negative events rather than explaining positive events.	The Likert scale was used here, where 5 means that the company fully agrees that explanations for negative events are needed more than for positive events. A 1 means that the company does not agree with this approach.
Forward Looking Statement (FLS)	Expressing the respondents' opinion about additional information regarding MDA report.	The companies expressed their opinion that investors expect the management board to present its own expectations as to future results and the situation in the environment.	The Likert scale was used here, where 5 means that the company entirely agrees that the presentation of the management board's expectations as to the results and situation is desired by investors. A 1 means that the company does not agree with this approach.

Table 1 – continued

Name	Description	Questionnaire	Calculation
CEO Opinion	Expressing the respondents' opinion about the need to include additional information in the MDA report.	The companies assessed whether they agreed that the management board should not present their opinions and interpretations of events in the report.	A 1 means that the company believes it does not agree with this approach. The variable prepared in this way was transformed into a variable expressing a positive attitude. A CEO op with a value of 5 means positive recognition that the management board should present its opinion and interpretations in the financial statements. Value 1 – that it shouldn't do this.

Source: own elaboration.

For RQ2, we use one variable – Connectivity, which is an indicator that was created by comparing the respondents' answers to two groups of questions:

- the first concerned the importance of factors which, in the opinion of the respondents (i.e. IR representatives), are important for individual investors in making a decision to invest in bonds (IO, *investors' opinions*),
- in the second, the respondents indicated which areas in the MDA report are the most important to describe (DO, *directors' opinions*).

In both groups, there were questions concerning three areas (*A*): future, history and risk. We checked the consistency between the assessments of importance within these three areas by calculating the connectivity as:

$$Connectivity = \sum_{A=1}^{3} (IO_A - DO_A)^2.$$

The higher the value of the indicator, the greater the diversity of opinions about what is important for managers and what is important for investors according to managers. In the "future" group, the credibility of the management board, the financial forecasts, the future factors influencing the financial results and the strategy were assessed. The group relating to the "historical analysis" encompassed the opinions about the importance of the factors explaining the historical results and the historical financial results. In the "risk" group, we analysed the importance of presence of covenants, risk description and the level of security.

Next, we calculated four independent variables (Table 2): Openness, CEO engagement (CEO) and Self-confidence and type of majority investors (Individual Investors).

Table 2
Independent variables for RQ1 and RQ2

Name	Description	Questionnaire	Calculation
Openness	Indicates if dialogic communication channels are used within corporate communication.	Five-point Likert scales ranging from 1 (totally disagree) to 5 (totally agree) 9 questions about communication channels, where 5 questions are related to the monologic approach, and 4 to the dialogic approach.	A measure of a company's openness based on calculating the mean value for the set of answers regarding dialogic corporate communication.

Table 2 – continued

Name	Description	Questionnaire	Calculation
CEO (CEO engagement)	Indicates whether CEO is (also) responsible for investor relations.	Respondents could indicate more than one of the following answers: CEO, Public Relations Agency, one of the departments, Nominated Advisor.	It equals 1 if the CEO is engaged and 0 otherwise.
Self-confidence	Indicates that a company assesses obligations regarding investor relations and corporate communication with low difficulty.	Respondents could indicate the following answers: • preparation of periodic reports, • preparation of current reports, • identification of events causing the need to prepare a report, • technical publication of reports, • dialogue with the supervisor (correspondence, explanations).	The arithmetic mean for the ratings of these five measures was taken as the difficulty rating index. The self-confidence index was taken as 5 – the difficulty index, with 5 being the highest degree of difficulty. The higher the self-confidence index, the lower the company's assessment of the difficulty of its obligations related to investor relations.
Individual Investors	Indicates that the main group of investors are individual investors.	Respondents could indicate, whether the main group of investors are individual or institutional ones.	It equals 1 if respondents indicated individual investors as the main group and 0 otherwise.

Source: own elaboration.

We also added three control variables (Table 3) that indicate: company size (Size), planning of bonds new issuance (New Issuance), and type of debut (Public First Issuance).

Table 3
Control variables for RQ1 and RQ2

Name	Description	Measure
Size	Indicates the size of a company measured by the value of annual revenues	It equals 1 if a company generates revenues above PLN 100 million and 0 otherwise.
New Issuance	Expresses the respondents' opinion on the plans for new bond issues in the next 12 months.	It equals 1 if the company intended to issue new bonds in the next 12 months and 0 otherwise.
Public First Issuance	Informs about the legal formula according to which the company obtained capital from the issue of bonds.	If the issue was a private one, the value of the variable is 0. If there was a public offering without a prospectus, then the index has a value of 0.5. Ultimately, if the offer was public with a prospectus, the value of the variable is 1.

Source: own elaboration.

3.4. Methods

To overcome the limitation of a small sample and to find the answer to our research questions, we used QCA, which lately has been more widely used in management and finance studies also as a method to analyse the questionnaire research (Cheng et al., 2013; Mastrangelo et al., 2019). QCA is a set-theoretic method that uses sets and searches for set relations to form concepts and formulate casual relations between social phenomena applying Boolean algebra rules (Schneider & Wagemann, 2012).

QCA, based on configuration analyses (also referring to conjunctural causation in the set theory), assumes that combinations (configurations) of factors (variables) which form patterns or profiles rather than individual independent variables lead to an outcome (Schneider & Wagemann, 2012). This view is consistent with the systemic and holistic approach to organisations, where structures, activities and environment interpenetrate and interact defining different configurations (Fiss, 2007). Also, QCA distinguishes between necessary and sufficient conditions for an outcome. A sufficient but not necessary condition allows the existence of other sufficient conditions for the same outcome. It means that the set-theoretic perspective assumes the existence of equifinality understood as alternative factors that can produce the same outcome (Schneider & Wagemann, 2012). Usually, statistical analysis is uni-finally oriented (Wagemann et al., 2016), which contrasts with organisational reality, where more than one causal condition often explain a specific outcome (Fainshmidt et al., 2020). Finally, the set theory also encompasses the asymmetry of concept and causal relations. The asymmetry indicates that the same configurations of factors rarely explain at the same time both negative and positive outcomes (Seny Kan et al., 2016). In other words, the causal explanation of asymmetry says that different conditions can cause the occurrence and absence of an outcome (Greckhamer et al., 2018). That is often the case in management practices, where the knowledge about the paths that explain a phenomenon's existence does not influence the understanding of its absence (Seny Kan et al., 2016).

Set-theoretic methods operate on membership scores of elements in sets (Schneider & Wagemann, 2012). In the QCA technique, there are two types of variables – crisp sets variables and fuzzy sets variables. Crisp sets have dichotomies variables, where 1 stands for full membership in a set and 0 for full non-membership in a set. If a variable is a dichotomy by its nature, it belongs to a crisp set. In the case of non-dichotomy, continuous variables, the first step in QCA analysis is a calibration of the degree of membership in a set. To calibrate continuous variables from our sample, we use the Fuzzy Set Direct Calibration Method described by Ragin (Ragin, 2007).

Once all variables are calibrated, we use fs/QCA software (downloaded from http://compasss. org/software/) to run the QCA analysis. fs/QCA uses the Quine-McCluskey algorithm with the simplification rules of Boolean expressions to determine configurations that are sufficient or necessary conditions for specific levels of an outcome (Fiss, 2007; Schneider & Wagemann, 2012). Finally, the QCA analysis results for each outcome are presented as models of sufficient and necessary conditions configurations separately, along with the degree of consistency and coverage.

The consistency and coverage are evaluated for each configuration (solution) as well as for each model as a whole. They are similar metrics to correlations and coefficient of determinations for a symmetric test (Cuadrado-Ballesteros et al., 2017). Consistency is defined as the degree to which empirical evidence is consistent with the set-theoretic relation in question (Rihoux & Ragin, 2008). At the same time, coverage can be interpreted as a numeric expression for the empirical importance (sufficiency) and relevance (necessity) of a given condition (or a combination) for producing an outcome (Schneider & Wagemann, 2012). The formulas expressing consistency and coverage are as follows (Rihoux & Ragin, 2008):

$$Consistency(X_i \leq Y_i) = \frac{\sum(\min(X_i, Y_i))}{\sum(X_i)} \tag{1}$$

$$Coverage(X_i \leq Y_i) = \frac{\sum(\min(X_i, Y_i))}{\sum(Y_i)} \tag{2}$$

Where min indicates the selection of the lower of two values, X_i represents membership scores in a combination of conditions, and Y_i represents membership scores in the outcome.

To apply QCA analysis with our data, we used models described by the following equation:

$$y = f(x_1, x_2, x_3, x_4, x_5, x_6, x_7) \tag{3}$$

We ran five models with the same seven conditions (x_1, …, x_7). As outcomes (y), we defined five dependent variables (Context, Bad News, Forward-Looking-Statements (FLS), CEO Opinion and Connectivity). As conditions, in each model four explanatory variables (Openness, CEO engagement (CEO), type of majority investors (Individual Investors) and Self-confidence and three control variables were included (company size (Size), planning of bonds new issuance (New Issuance), and type of debut (Public First Issuance)).

4. RESULTS

Table 4 presents sufficient conditions for the five outcomes (models): a high level of companies' awareness of stakeholders' voluntary disclosure information needs (for each type of information, we ran a separate model, in total, four models) and a high level of relational connectivity between companies and their stakeholders (one model). Except for the FLS model, where we have only one solution, all other models give two solutions with different sets of co-occurring conditions.

Table 4
High level of companies' awareness of stakeholders' voluntary disclosure information needs and high level of relational connectivity between companies and their stakeholders – QCA results

Model	Context		Bad News		FLS	CEO Opinion		Connectivity	
Solution	S1	S2	S1	S2	S1	S1	S2	S1	S2
Dialogue (openness)		~	~	~			~	●	~
CEO	●	●	●	●	●	●	●	●	●
Self-confidence				●		●	●	●	~
Individual Investor	~	●	●	●	~	~	~	~	~
Size	●	●	●	●	●	●	●		
New Issuance	~	~	~	●	~	~	●	~	~
Public Debut	~	●	●	●	~	~	●	~	~
Raw Coverage	0.34	0.09	0.11	0.11	0.42	0.22	0.08	0.17	0.14
Unique Coverage	0.34	0.09	0.11	0.11	0.42	0.22	0.08	0.08	0.05
Consistency	0.80	1	0.77	1	0.81	0.91	1	0.88	0.88
Solution Coverage	0.48		0.22		0.42	0.30		0.28	
Solution Consistency	0.97		0.86		0.81	0.93		0.89	

Where: ● indicates the presence of a condition, ~ indicates the absence of a condition, and a blank cell means that a condition is not relevant for the particular solution.

Source: own elaboration with fs/QCA software.

Looking at the single conditions (variables), the CEO is present in all models and solutions. While Size is present in all solutions regarding awareness of stakeholders' voluntary disclosure information needs, it is not relevant to the presence of relational connectivity between companies and their stakeholders. Relevant conditions (both as being present or absent) for each solution

are Individual Investor, New Issuance and IPO. In contrast to our expectations, the Dialogue condition seems to be indecisive for the appearance/high level of companies' awareness of stakeholders' voluntary disclosure information needs. In three solutions, that variable is not relevant to the outcome, whereas in four paths, we observe its absence. Dialogue is relevant for both solutions in the Connectivity model, but its presence in one solution and the second is absent.

To answer RQ1, we look at the four models for the Context, Bad News, FLS and CEO Opinion outcomes. Where the main investors are individual investors, solution paths include similar sets of conditions. In those companies, only two types of voluntary information (one solution for Context and two solutions for Bad News) are recognised as of high importance for investors. These companies are also users of traditional communication channels (close companies); they entered the public debt market through public placement and, in two solutions, do not plan a new issuance.

Where the main investors are institutional investors, also solution paths include similar sets of conditions. For that group of companies, we find configurations for three types of voluntary information: Context (one solution), FLS (one solution) and CEO Opinion (two solutions). In all models (except for one solution for CEO Opinion), whether companies use social media to contact their investors is irrelevant to the outcomes. Contrary to the first group, those companies entered the debt public market through private placement but did not plan any new issuance. Solution 2 for CEO Opinion presents the unique set of conditions where companies are planning new issuances are self-confidence and entered public debt market through public placement.

The connectivity model with two solutions allows answering RQ2. In both solutions, the main investors are institutional investors, companies' size is irrelevant, they entered public debt market through public placement and did not plan any new issuance. The solutions differ for open and closed companies. For companies that use more interactive communication channels (open), self--confidence seems crucial for a high level of connectivity, while in close companies, the lack of self-confidence leads to the same result.

As the QCA permits to analyse sets of conditions that lead to opposite outcomes, Table 5 presents models representing a low level of companies' awareness of stakeholders' voluntary disclosure information needs and a low level of connectivity with investors. Looking at the first group of models, we did not obtain any solution for the CEO Opinion variable, which gives us three models for RQ1. For the variable ~ Context, there is only one path that leads to the outcome, which overlaps with one solution (S2) for ~ Bad News and one (S2) for ~ FLS. Companies which are unaware of stakeholders' voluntary disclosure information needs regarding discussion about context, bad news and future (forecasts) share the same characteristics: they choose traditional communication channels, the CEO is not involved in the preparation of the financial report but is self-confident with the majority of individual investors. These companies are small, not planning new issuances and entered the public debt market under private placement. Solutions 3 (S3) for ~ Bad News and ~ FLS also share the same set of conditions, which indicates that open companies where the CEO participates in financial reports preparation can also be unconscious about investors' information needs if the latter are insecure, can have a majority of institutional investors, can be small, but entered the debt public market within the public offer.

Table 5
Low level of companies' awareness of stakeholders' voluntary disclosure information needs and low level of relational connectivity between companies and their stakeholders – QCA results

Model	~Context	~Bad News			~FLS			~Connectivity
Solution	S1	S1	S2	S3	S1	S2	S3	S1
Dialogue (openness)	~		~	●	~	~	●	●
CEO	~	●	~	●	●	~	●	●
Self-confidence	●		●	~	●	●	~	~
Individual Investor	●	~	●	~	●	●	~	~
Size	~	●	~	~		~	~	~
New Issuance	~	~	~	~	~	~	~	~
IPO	~	~	~	●	●	~	●	●
Raw Coverage	0.28	0.44	0.10	0.08	0.17	0.11	0.09	0.09
Consistency	1	0.68	1	1	0.95	1	1	0.90
Solution Coverage	0.28	0.71			0.37			0.09
Solution Consistency	1	0.76			0.98			0.90

Where: ● indicates the presence of a condition, ~ indicates the absence of a condition, a blank cell means that a condition is not relevant for the particular solution.

Source: own elaboration with fs/QCA software.

The third paths (S1) have only two common conditions: CEO presence and lack of planning for new issuance. For ~ Bad News Openness and Self-confidence are irrelevant, but being a big company and having institutional investors is important. In the case of ~ FLS, solution 1 indicates that closeness with self-confidence and individual investors are the conditions that lead to the low awareness of the necessity to publish forward-looking statements.

To answer RQ2 extensively, we look at the model for the ~ Connectivity variable, which has only one solution. Companies that present a low level of connectivity with their investors share the openness and CEO engagement, but they are insecure, small, have the majority of institutional investors and entered the public debt market within the public offer.

CONCLUSIONS

The scope of our research was to indicate the determinants of the voluntary disclosure strategy and relational connectivity between issuers and investors on the Polish bond market Catalyst. Even though voluntary disclosures represent one of the most widely studied topics in finance and accounting research (Hales et al., 2018), we deliver new insight into academic discussion. Generally, we show that what influences companies' perception of investors' voluntary disclosure needs differs from what influences the company's relational connectivity regarding voluntary disclosure. We also point out that there are many paths to gain a high level of companies' perception of investors' voluntary disclosure needs and the company's relational connectivity regarding voluntary disclosure. We obtain equifinality (alternative factors that can produce the same outcome) in our models thanks to QCA, which indicates that more than one set of variables explains a specific outcome (Fainshmidt et al., 2020). These results could partially explain the contradictory results of previous research where traditional analysis tools were applied.

Remarkably, our results show that the management board's engagement in preparing reports is crucial for understanding investors' voluntary disclosure needs. It can indicate that involvement stays together with the management board's professional knowledge of practical implications and mandatory information disclosure limitations. To date, management involvement in the preparation of reports has not been discussed in depth and was frequently taken for granted in the academic literature. In our research, we point out that this is not the case in the public bond market in Poland. Therefore, we call for considering that issue as one of the avenues for future research, looking also at the institutional determinates that can have an impact on the management board's engagement in corporate communication.

We also found out that active communication, mainly through social media (openness), based on dialogue with investors, did not turn out to be a critical factor that influences companies' perception of investors' voluntary disclosure needs. It seems that companies use dialogue in private rather than in public to understand investors' information needs. That conclusion puts into question the growing societal pressure on engaging in activity in social media as a critical concept of effective communication of companies.

Additionally, we confirm the necessity of the management board's engagement in reporting to maintain relational connectivity. Strong relational connectivity appears together with open communication channels only if a company is self-confident regarding reporting obligations. That observation indicates the essential limitations of previous research evaluating relational connectivity through social media. Accordingly, we consider our research as one possible way to verify effective communication conceptual models presented in Brennan and Merkl-Davis (2018), Blankespoor (2018) and Blankespoor et al. (2020) regarding voluntary disclosure.

This work contributes to the enrichment of existing literature on the determinants of the voluntary disclosure strategy on the Polish bond market Catalyst. It also focuses on the relational connectivity between issuers and investors and its impact on disclosure. It is an important topic that is scarcely researched. With our study, we try to contribute to filling this research niche. Our paper also contributes to the debate on effective corporate communication in financial markets; specifically, it sheds new light on both strategies regarding voluntary disclosure and disclosure dissemination. This study also broadens the field of application of the stakeholder theory. Our analysis enriches the list of determinants of voluntary disclosure beyond those frequently analysed in the existing research.

Furthermore, this work presents a unique tool of analysis, the QCA, still rarely used by researchers, notwithstanding its considerable merits. Furthermore, this work stimulates reflections on the applications of analytical tools as the results obtained in our work derived from the application of QCA approach not always confirm the results of previous research. This demonstrates the contribution of our work to the critical international debate on the determinants of voluntary disclosure.

This study has limitations that must be considered in the context of formulating conclusions and their generalisation. The first is that it analyses limited determinants of voluntary disclosure. The second is connected with exclusively one-country analysis. Further studies could focus on more factors impacting voluntary disclosure and might consider other countries and diverse markets. Still, the proposed approach and tool is universal and applicable in a broad context.

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How Do the Lengths of the Lead Lag Time between Stocks Evolve? Tick-by-tick Level Measurements across Two Decades

Bing Anderson

California Polytechnic State University, USA
bianders@calpoly.edu
https://orcid.org/0000-0003-1870-1000

ABSTRACT

There has been an extraordinary decrease in order execution time on stock exchanges in the past two decades. A related question is whether there has been a similar reduction in orders of magnitude for the lengths of the lead lag time between stocks. If the answer is affirmative, and the lengths of the lead lag time have long fallen below the human reaction time, algorithms have taken over information diffusion from one stock to another. Otherwise, humans continue to be in authority. In this study, the lengths of the lead lag time within pairs of stocks of large US companies are estimated using the Hayashi-Yoshida estimator, for each year from 2000 to 2022. We first construct stock pairs, with each pair containing two stocks from the same industrial sector. The median length of the lead lag time for each year shows a general trend of decline over time. From 2000 to 2005, the median lengths are a few seconds. By 2021 and 2022, they are less than 10 milliseconds. We also study a second construct in which stock pairs are randomly formed, but each pair contains stocks from two different sectors. The median length of the lead lag time for each year shows a decline over time, similar to the first construct. Overall, the lengths of the lead lag time in the second construct are not remarkably longer than those in the first construct. This shows that being in the same sector, at the tick-by-tick level, is not an important factor in determining the length of the lead lag time between stocks.

JEL Classification: G12; G14; G19

Keywords: Hayashi-Yoshida estimator, price discovery, cross-correlation, statistical arbitrage, high-frequency trading.

1. INTRODUCTION

The past two decades have seen a phenomenal increase in order execution speed, and a decrease in order execution time, on stock exchanges. In 2000, the average execution time was approximately 20 seconds on the New York Stock Exchange, whereas by 2010, it reduced to around 1 second (Haldane, 2011). It is now represented in microseconds on the fastest exchanges.

The question is whether there has been a similar reduction in orders of magnitude for the lengths of the lead lag time between stocks. For example, a short time after news on Chevron Corporation impacts its stock price, investors may realize that the news has repercussions on other stocks in the energy sector. Therefore, the length of the lead lag time between stock prices is a reflection of the time required to digest information. However, the duration of the lead lag time could potentially shed light on the nature of the information processing mechanism. If we indeed see orders of magnitude of lead lag time length reduction over the past two decades, the information is processed via automation by computers and algorithms. Alternatively, this process likely involves human decision making by traders and investors.

In this study, we use tick-by-tick data on eight pairs of significant US stocks from eight distinct industrial sectors and quantify the length of the lead lag time within each pair for each year between 2000 and 2022 in order to examine the evolution of lead lag periods between individual stocks over the past two decades. To study the impact of being in the same sector on the length of the lead lag time, we also randomly reassign the stocks into pairs from different sectors and remeasure the lengths of the lead lag time across the two decades.

This work provides substantial additions to the body of knowledge that already exists. The majority of lead lag literature focuses on the direction of the lead lag connection rather than the lengths of the lead lag period. How long is the lead lag duration on average for big liquid U.S. stocks? To the best of our knowledge, there has been no answer to this question in the current literature prior to this paper.

This research provided an answer for each year from 2000 until 2022. We are not aware of any prior investigation utilizing tick-by-tick data throughout such a wide time span. As it turns out, lead lag durations have a tendency to decrease with time. This finding has practical implications for academics who compare the outcomes of lead lag studies conducted over different time periods.

Eventually, this paper also answered the question posed above on whether the magnitude of the lead lag time points to information processing via humans versus via computers. Computers dominate, but occasionally humans may still play a role. This and other findings in this study have practical implications for practitioners. For instance, when a mutual fund wishes to liquidate a big position, does employing human traders optimize the net liquidation proceeds, or does this approach leave money on the table for high-frequency trading algorithms? When a hedge fund employs high-frequency lead lag statistical arbitrage algorithms, how frequently may it discover "anomalies" that represent potential profit opportunities? A peek at the three tables in this article and a count of the frequencies of "anomalies" in the tables may provide a general notion. Additionally, should these lead lag arbitrage algorithms focus on stock pairings from the same sector or from different sectors? In this paper, we have studied both the intra-sector and inter-sector cases.

The rest of the paper is organized as follows. Section 2 provides a review of the literature on lead lag studies. Section 3 introduces the data and the research methodology based on the Hayashi-Yoshida estimator. Section 4 presents and discusses the results. Section 5 concludes.

2. LITERATURE REVIEW

The lead lag relationship has been examined for different parts of the financial markets.

Hasbrouck (2003) analyzes the correlation between futures and exchange-traded funds (ETF) for stock indices and finds that the E-mini NASDAQ 100 and S&P 500 index futures have the highest price discovery. Price discovery is "the impounding of new information into the security price" (Hasbrouck, 1995). Most of the price discovery studies point out the direction of the lead lag relationship, but they rarely assess the exact lead lag duration. This is not surprising given that neither of the two primary approaches for price discovery research, the information share

methodology of Hasbrouck (1995) and the common factor component share methodology of Gonzalo and Granger (1995), is designed to measure the length of the lead lag time.

There is an extensive body of literature on lead lag research from the perspective of price discovery. Sapp (2002) studies price discovery in the spot foreign exchange market. Chakravarty, Gulen, and Mayhew (2004) investigate the role of option markets in stock price discovery. Mizrach and Neely (2008) examine how the futures markets contribute to the US Treasury price discoveries. There is also work on whether New York or London leads in the discovery of gold prices (Lucey, Larkin, & O'Connor, 2013) and on the stock price co-movements between Europe and the United States (Ben Ameur et al., 2018). More recently, Chen et al. (2021) find that regular index futures in Taiwan contribute more to price discovery than the mini index futures.

Recently, cryptocurrencies have become a focus of lead lag research. For example, Ji et al. (2019) examine six large cryptocurrencies, and conclude that return shocks from Bitcoin and Litecoin affect the rest the most. Using a wavelet approach, Mensi et al. (2019) find that Bitcoin leads Dash, Monero, and Ripple in the time frequency space. Corbet et al. (2018) conclude that "Bitcoin prices affect both Ripple (28.37%) and Lite (42.3%), but Ripple and Lite have limited influence on Bitcoin", and that Bitcoin clearly leads other cryptocurrencies in price movements. Ciaian, Rajcaniova, and Kancs (2018) investigate Bitcoin and 16 alternative cryptocurrencies, and find that Bitcoin price shocks impact the prices of 15 out of the 16 alternative cryptocurrencies in the short run. Using the VAR-based approach of Diebold and Yilmaz (2009), Koutmos (2018) analyzes 18 major cryptocurrencies and concludes that Bitcoin is the leader of return spillover to the rest. Most of the cryptocurrency lead lag studies use daily data.

Wang et al. (2022) investigate the lead lag link between the VIXs of individual stocks and the S&P 500 VIX. Xu and Yin (2017) probe stock market index volatility and how it relates to the index ETF volumes. Tolikas (2018) study the lead lag connection between the stock and the bond markets. Ballester and González-Urteaga (2020) examine the lead lag relationship between the sovereign credit default swap market and the stock market.

There are a few distinguishing factors between this study and the previous literature. In the bulk of existing studies, the lengths of the lead lag time are not measured. This paper is intended to quantify the lengths of the lead lag time. The majority of published works utilize daily or other low-frequency data. This study utilizes tick-by-tick data, sometimes known as ultra-high-frequency data, as there is no higher frequency than tick-by-tick data. The final distinctive feature of this study is that it analyzes the evolution of the lengths of the lead lag time over a period of 23 years.

3. DATA AND METHODOLOGY

Tick-by-tick data are purchased from Tick Data LLC, an authorized distributor of the New York Stock Exchange (NYSE) TAQ data. In comparable research, it is typical to utilize quotes rather than trade prices (see, for example, Huth & Abergel, 2014; Anderson, 2016). As explained in Anderson (2016), the possibility of the bid-ask bounce effect in trade prices is one argument for using quotes. According to Blume and Goldstein (1997), the NYSE dominates other U.S. exchanges in terms of initiating quote revisions and displaying the best quote prices. Only quotes from the NYSE during its regular trading hours are utilized in this study. The average of the bid and ask prices, or the mid-quote, is used as the observed price. When multiple quotes arrive exactly at the same time, their average is utilized.

Due to the vast amount of data involved, it is common for market microstructure research employing tick data to focus on a period of a few months. Hasbrouck (2003), for instance, examines the sample period between March 2000 and May 2000. Huth and Abergel (2014), for example, utilize data from March 2010 to May 2010 for their research. We use the month of May

in each year from 2000 to 2022. We pick 16 large liquid US stocks in eight different sectors to form eight pairs, with each pair being two stocks in the same sector: Coca-Cola (ticker symbol: KO) and Pepsi (PEP), Verizon (VZ) and AT&T (T), IBM (IBM) and HP (HPQ), Walmart (WMT) and Home Depot (HD), Raytheon (RTX) and Boeing (BA), JPMorgan (JPM) and Morgan Stanley (MS), Chevron (CVX) and Exxon Mobile (XOM), Pfizer (PFE) and Merck(MRK).

Using tick data for a study, a massive volume of data to work with is only a small portion of the difficulty. The fundamental issue is the asynchronous arrival of observations. The majority of time series econometrics tools deal with data that arrives at regularly spaced time intervals: each month, each day, each hour, etc. Casting high frequency asynchronous tick data into regularly spaced time intervals causes problems in measuring the lengths of the lead lag time (Finucane, 1999; Zhang, 2011).

Although it is possible to integrate the two asynchronous time series using a regression-based method (Finucane, 1999), we opt to employ a technique based on the cross-correlation estimator of Hayashi and Yoshida (2005). A significant advantage of the Hayashi-Yoshida estimator is that it reveals unambiguously the direction of the lead lag relationship as well as the length of the lead lag time.

In lead lag research, Huth and Abergel (2014), Dao, McGroarty, and Urquhart (2018), and Schei (2019) have utilized the Hayashi-Yoshida estimator. In 2018, bitcoin transactions on Bitfinex were 12 seconds ahead of those on Kraken, according to one of Schei's (2019) findings. To validate our implementation of the Hayashi-Yoshida estimator, we conduct the same analysis on the 2018 data and are able to duplicate Schei's findings to the second.

Below is a summary of how the length of the lead lag time is estimated. Consider stochastic differential equations to characterize the price dynamics of stocks P and Q:

$$dP_t = \mu_t^P dt + \sigma_t^P dB_t^P \tag{1}$$

$$dQ_t = \mu_t^Q dt + \sigma_t^Q dB_t^Q \tag{2}$$

where B_t^P and B_t^Q are standard Brownian motions with $d\langle B^P, B^Q \rangle_t = \rho_t dt$.

The stock price processes P_t and Q_t are observed at asynchronous sampling times, at $0 = t_0^P \leq t_1^P \leq \cdots \leq t_{m-1}^P \leq t_m^P = T$ for P and $0 = t_0^Q \leq t_1^Q \leq \cdots \leq t_{n-1}^Q \leq t_n^Q = T$ for Q. The sampling times should be independent of the prices P_t and Q_t.

Hayashi and Yoshida (2005) prove that a consistent estimator of the covariance between P and Q is

$$\sum_{i,j} \delta_i^P \delta_j^Q 1_{\{C_{ij} \neq \varnothing\}} \tag{3}$$

with $C_{ij} = \left(t_{i-1}^P, t_i^P \right] \cap \left(t_{j-1}^Q, t_j^Q \right]$, $\delta_i^P = P_{t_i^P} - P_{t_{i-1}^P}$, $\delta_j^Q = Q_{t_j^Q} - Q_{t_{j-1}^Q}$. The indicator function $1_{\{C_{ij} \neq \varnothing\}}$ takes the value of 1 whenever the sampling intervals of P and Q, $\left(t_{i-1}^P, t_i^P \right]$ and $\left(t_{j-1}^Q, t_j^Q \right]$, have any overlap. Given the covariance estimator, the correlation ρ can be estimated as

$$\hat{\rho}(P,Q) = \frac{\sum_{i,j} \delta_i^P \delta_j^Q 1_{\{C_{ij} \neq \varnothing\}}}{\sqrt{\sum_i \left(\delta_i^P \right)^2 \sum_j \left(\delta_j^Q \right)^2}} \tag{4}.$$

Hoffmann, Rosenbaum, and Yoshida (2014) demonstrate that a lag time can be introduced to the time stamps of Q. The lagged Q can be correlated with the original P. Among all the different

lengths of the lag time, the one that maximizes the correlation is the actual length of the lead lag time between the two stocks.

Mathematically, let

$$Q_t^*(\nu) = Q_{t+\nu} \tag{5}.$$

Then, P leads Q by

$$\text{argmax}_{-T < \nu < T} \hat{\rho}(P, Q^*(\nu)) \tag{6}.$$

In our implementation, we test every second between -120 and 120 seconds for the lead lag duration. The time stamps of the original data are expressed in seconds from 2000 to 2005, milliseconds from 2006 to 2015 , microseconds from 2016 to 2018, and nanoseconds from 2019 to 2022. When the estimated length of the lead lag time is small, and the time stamp provides sufficient resolution, we repeat the estimation process with a step size of one order of magnitude finer. For example, when the time stamps are in units of milliseconds, and the first round of estimation with the [-120, 120] window yields 1 second for the length of the lead lag time, we run the estimation again from -12 seconds to 12 seconds with a smaller step size of 0.1 seconds. Similarly, if the situation warrants, we could run another round from -1.2 seconds to 1.2 seconds with a step size of 0.01 seconds, and so on.

4. RESULTS

Table 1 displays the estimation outcomes. For example, the cell in the very first row and the first column indicates that WMT leads HD by -8 seconds in May 2000, which means that HD actually leads WMT by 8 seconds.

There are significant variations in the lead lag duration both across different years and across different stock pairs. In the first column of Table 1, for instance, the lengths of the lead lag time between WMT and HD exhibit a general downward trend from 2000 to 2022. For both 2009 and 2011, the lengths of the lead lag time are measured in tens of milliseconds. Nonetheless, for the intervening year, 2010, the length of the lead lag time is a stunning 23 seconds.

Table 1
The lengths of the lead lag time between stocks within the same sector

Year	WMT leads HD	CVX leads XOM	MRK leads PFE	PEP leads KO	RTX leads BA	MS leads JPM	HPQ leads IBM	VZ leads T	Median of |Time|
2000	-8s	1s	8s	-2s	-7s	-3s	9s	2s	5s
2001	5s	-9s	6s	1s	-39s	6s	-4s	3s	5.5s
2002	-4s	-4s	3s	-2s	-1s	0s	-17s	0s	2.5s
2003	-2s	-4s	0s	1s	-3s	1s	4s	0s	1.5s
2004	1s	1s	0s	0s	0s	1s	1s	1s	1s
2005	1s	1s	-2s	0s	1s	2s	1s	0s	1s
2006	300ms	550ms	240ms	115ms	520ms	29ms	1.3s	570ms	410ms
2007	-90ms	70ms	-74ms	-100ms	-120ms	0ms	-70ms	-140ms	82ms
2008	-41ms	16ms	100ms	95ms	23ms	-6ms	-85ms	80ms	60.5ms

Table 1 – continued

Year	WMT leads HD	CVX leads XOM	MRK leads PFE	PEP leads KO	RTX leads BA	MS leads JPM	HPQ leads IBM	VZ leads T	Median of |Time|
2009	23ms	0ms	140ms	104ms	-22ms	56ms	38ms	140ms	47ms
2010	23s	-9ms	-10s	9ms	7ms	-16ms	-39ms	-9ms	12.5ms
2011	-49ms	1ms	85ms	37ms	-5ms	25ms	-70ms	8ms	31ms
2012	2ms	2ms	31ms	28ms	-12ms	33ms	-390ms	70ms	29.5ms
2013	-1ms	2ms	97ms	23ms	0ms	2ms	-58ms	-3ms	2.5ms
2014	5ms	0ms	11ms	4ms	1ms	1ms	-630ms	-1ms	2.5ms
2015	0ms	1ms	1ms	1ms	-5ms	-1ms	-22ms	0ms	1ms
2016	-3ms	1.3ms	2.8ms	16ms	-2.6ms	-3.2ms	-210ms	2.2ms	2.9ms
2017	-3ms	2ms	14ms	5ms	-2.3ms	-1.2ms	-1.05s	-2.8ms	2.55ms
2018	42ms	2.1ms	7ms	-680ms	8ms	-2.3ms	-120ms	5.3ms	7.5ms
2019	-0.6ms	8ms	9.8ms	300ms	-1.6ms	-1.3ms	-130ms	5.1ms	6.55ms
2020	2.3ms	7ms	29ms	130ms	-1.8ms	-1.3ms	-54ms	4ms	5.5ms
2021	1.2ms	0.4ms	1.9ms	13ms	0.1ms	-0.9ms	-43ms	-1.1ms	1.15ms
2022	-8.3ms	0.9ms	1.1ms	18ms	-0.7ms	-0.1ms	-9ms	-0.3ms	1ms

Note: The length of each lead lag time is measured in seconds(s) or milliseconds (ms).

Source: Author's own calculation.

Table 2
The lengths of the lead lag time between stocks in different sectors

Year	WMT leads IBM	CVX leads PFE	MRK leads JPM	KO leads XOM	RTX leads HD	MS leads T	HPQ leads PEP	VZ leads BA	Median of |Time|
2000	0s	17s	3s	-3s	18s	2s	-3s	11s	3s
2001	0s	3s	2s	6s	-3s	5s	-16s	-1s	3s
2002	9s	2s	-4s	6s	-3s	-2s	-5s	2s	3.5s
2003	2s	1s	1s	0s	0s	0s	1s	-1s	1s
2004	1s	1s	1s	1s	1s	0s	1s	1s	1s
2005	1s	2s	0s	2s	1s	1s	0s	0s	1s
2006	63ms	810ms	105ms	1.7s	720ms	1.3s	390ms	60ms	555ms
2007	-10ms	-230ms	-99ms	24ms	27ms	0ms	130ms	-18ms	25.5ms
2008	-170ms	27ms	-9ms	-54ms	180ms	52ms	-68ms	12ms	53ms
2009	0ms	380ms	80ms	-35ms	8ms	46ms	-59ms	-1ms	40.5ms
2010	-62ms	-49ms	-10ms	-3ms	44ms	17ms	13ms	6ms	15ms
2011	-60ms	93ms	9ms	13ms	11ms	69ms	-64ms	-55ms	57.5ms
2012	-80ms	220ms	52ms	-8ms	60ms	55ms	-41ms	-78ms	57.5ms
2013	-8ms	28ms	35ms	-32ms	1ms	12ms	-87ms	-19ms	3.5ms

Table 2 – continued

Year	WMT leads IBM	CVX leads PFE	MRK leads JPM	KO leads XOM	RTX leads HD	MS leads T	HPQ leads PEP	VZ leads BA	Median of |Time|
2014	-9ms	15ms	6ms	-11ms	14ms	-22ms	-47ms	-41ms	14.5ms
2015	-25ms	4ms	0ms	-1ms	1ms	-1ms	0ms	-16ms	1ms
2016	-31ms	29ms	2.4ms	-7.9ms	1.5ms	-1.9ms	-15ms	-130ms	11.45ms
2017	-18ms	58ms	0.52ms	1.2ms	0.12ms	62s	-0.8s	-24ms	21ms
2018	1.2ms	49ms	-3.3ms	-1.4ms	51ms	9.2ms	-64s	-5ms	7.1ms
2019	-1ms	29ms	-0.97ms	-11ms	1.6ms	12ms	-110s	-26ms	11.5ms
2020	-1.1ms	60ms	-0.76ms	0.8ms	-20ms	1.5ms	-0.5s	-5.4ms	3.45ms
2021	1.3ms	7.4ms	1.3ms	0.47ms	-1.2ms	0.39ms	-30s	-7.2ms	1.3ms
2022	0.028ms	5.1ms	-1.9ms	1.3ms	-14ms	28ms	-29ms	-17ms	9.55ms

Note: The length of each lead lag time is measured in seconds(s) or milliseconds (ms).

Source: Author's own calculation.

One scenario that could explain why this occurs is that when a large mutual fund or hedge fund wants to acquire or sell a substantial position in a stock, the process must often take at least a few months. If a large fund wants to acquire HD and employs human traders to do so, and if WMT is one of the stocks the human traders monitor, WMT can easily lead HD by 23 seconds for the month. The volume data may provide some evidence to support this claim. For May 2009, there are 1,629,219 WMT observations and 1,380,688 HD observations. For the month of May 2011, WMT has 2,331,075 and HD has 2,754,698. In May 2010, however, the amount of observations for WMT is 4,314,827 and for HD it is 5,400,357, significantly more than in either 2009 or 2011.

The median length of each year's lead lag times provides a more accurate depiction of the evolution of the length of the lead lag time between stocks throughout the years, considering the large variations in lead lag lengths between different years and different stock pairs. For each year, we calculate the median of the absolute values of the eight lead lag durations for the eight stock pairs. This median is displayed in the final column of Table 1.

It is evident by inspecting the median column that the lengths of the lead lag time reduce over time. From 2000 to 2005, they are a few seconds. In both 2004 and 2005, the median lead lag duration is just 1 second. Before that, in 2003, a mere 1.5 seconds. In 2006, it is a few hundred milliseconds. After that, from 2007 to 2012, tens of milliseconds. The median lengths of the lead lag time for all of the years after 2012 are less than 10 milliseconds.

To answer the question posed at the beginning of this paper, the decline of the median lengths of the lead lag time below the human reaction time over the years demonstrates that information is primarily processed by computers and that trades placed by algorithms are the most influential factors in determining the lead lag duration. Some may question the extent to which algorithms can interpret and process news. Scholtus, van Dijk, and Frijns (2014) examine high-frequency trading following the release of US macroeconomic news. They discover that a delay of just 0.3 seconds can already have a major impact. Humans are incapable of reading the news and executing a trade in 0.3 seconds. Clearly, computers are automatically processing and understanding the news and trading appropriately. What they investigate is not the length of the lead lag time between individual stocks per se, but the 300 milliseconds they found using data from 2009–2011 are not discordant with those provided in Table 1 in terms of magnitude.

Next, we analyze to what extent the lengths of the lead lag time depend on the two stocks in a pair belonging to the same industrial sector. According to Hou (2007), the lead lag effect is predominant within the same industry. Hou (2007) did not utilize tick level data, however. Will the length of the lead lag time grow considerably if two stocks in a pair are not from the same industry? To answer this question, we re-assign the stock pairs at random, ensuring that no two stocks in a given pair belong to the same industrial sector.

Table 3
The lengths of the lead lag time between stocks within the financial sector

Year	GS leads AIG	WFC leads PGR	MS leads TRV	BAC leads ALL	AXP leads BK	C leads PNC	JPM leads STT	COF leads USB	Median of |Time|
2000	-87s	4s	-3s	-6s	-1s	10s	39s	29s	8s
2001	10s	16s	38s	-11s	3s	10s	5s	-50s	10.5s
2002	-2s	58s	13s	10s	-3s	-5s	1s	-1s	4s
2003	1s	1s	25s	-1s	0s	1s	2s	-5s	1s
2004	-1s	0s	0s	1s	0s	0s	2s	5s	0.5s
2005	0s	-1s	-1s	0s	0s	1s	1s	2s	1s
2006	-1.02s	-240ms	-630ms	-2s	-18ms	-490ms	-1.6s	-390ms	560ms
2007	109ms	-110ms	-340ms	-320ms	110ms	22ms	2ms	800ms	110ms
2008	52ms	-160ms	-89ms	-200ms	74ms	-220ms	-77ms	24ms	83ms
2009	15s	-20ms	59ms	-270ms	-66ms	-24ms	-40ms	52ms	55.5ms
2010	-9ms	-19ms	2ms	-110ms	6ms	-27ms	-8ms	12ms	10.5ms
2011	13ms	-87ms	-104ms	-120ms	9ms	-73ms	-50ms	52ms	62.5ms
2012	8ms	-23ms	-74ms	-1.09s	53ms	-37ms	-34ms	46ms	41.5ms
2013	14ms	-33ms	0ms	-14ms	38ms	-20ms	-12ms	1ms	14ms
2014	61ms	3ms	-11ms	-19ms	12ms	-47ms	-24ms	-1ms	15.5ms
2015	1ms	-2ms	-1ms	-740ms	1ms	-1ms	-4ms	1ms	1ms
2016	15ms	-1.5ms	-49ms	88s	0.4ms	-15ms	-5.2ms	9.3ms	12.15ms
2017	-4.3ms	-10.5ms	-34ms	-220ms	59ms	-3.5ms	-20ms	2.1ms	15.25ms
2018	-2.7ms	-8.3ms	-1.5ms	-190ms	1.5ms	-2.7ms	-0.2ms	1.8ms	2.25ms
2019	-0.3ms	-18ms	-17ms	-130ms	3.6ms	-19ms	0ms	0.8ms	10.3ms
2020	9.7ms	-5.1ms	-33ms	-21ms	14ms	-14ms	-5.7ms	18ms	14ms
2021	10.7ms	8.5ms	-0.7ms	-11ms	-1.3ms	-13ms	3.4ms	0.9ms	5.95ms
2022	-0.4ms	-9ms	-2.1ms	-12ms	10.1ms	-7.1ms	-1ms	3.1ms	5.1ms

Note: Each length of the lead lag time is measured in seconds(s) or milliseconds (ms).

Source: Author's own calculation.

The results are displayed in Table 2. From 2000 to 2005, the median lengths of the lead lag time are a few seconds. In particular, in 2003, 2004, and 2005, the median lengths of the lead lag time are just 1 second. In 2006, it is a few hundred milliseconds, just like in Table 1. After that, there are a greater number of years in which the lead lag durations are tens of milliseconds compared to Table 1. Eventually, the median lengths of the lead lag time fall below 10 milliseconds. However,

the first instance of this occurs in 2015, as opposed to 2013 in Table 1. The overall declining trend is identical to that shown in Table 1.

In 3 of the 23 years examined, Tables 1 and 2 have the same median lengths of the lead lag time. In 8 years, Table 2's median length of the lead lag time is less than Table 1. In 12 years, Table 2's median length of the lead lag time is more than Table 1. In general, the length of the lead lag time between two stocks from different sectors is not significantly longer than that between two stocks from the same sector.

To further validate the results presented in Table 1 and Table 2, we next focus on a particular sector. Sixteen large, liquid stocks are chosen from the financial sector: American International Group (AIG), Allstate (ALL), American Express (AXP), Bank of America (BAC), Bank of New York Mellon (BK), Citigroup (C), Capital One (COF), Goldman Sachs (GS), JPMorgan (JPM), Morgan Stanley (MS), Progressive (PGR), PNC Financial Services (PNC), State Street (STT), Travelers (TRV), US Bancorp (USB), and Wells Fargo (WFC). The stocks are randomly divided into 8 pairs for lead lag analyses. The results are presented in Table 3. Table 3 confirms the findings from Tables 1 and 2. The median lengths of the lead lag time have a similar decline over the years. They are in seconds from 2000 to 2005, in hundreds of milliseconds for 2006 and 2007, in tens of milliseconds after that, till eventually in a few milliseconds for the most recent years.

5. CONCLUSION

For large liquid US stocks, the median length of the lead lag time within a pair, whether the pair is from the same sector or not, is at a few seconds even as back as the year 2000. As the years progress, the median lead lag duration drops to eventually a few milliseconds by 2022.

This demonstrates that the information diffusion from one stock to another occurs, mainly via computers and algorithms, rather than human insights and human analyses. As the trade execution times on stock exchanges decrease, computers become faster, and algorithms become more sophisticated, even a few hundred milliseconds are eventually too long to prevent statistical arbitrage from taking advantage of the lead lag connection. That is why the length of the lead lag time has to continue to drop, and eventually drops to a few milliseconds by 2022.

As seen by the evolution of the median length of the lead lag time throughout the years, the efficient market hypothesis is alive and largely accurate, notwithstanding the possibility of local or brief deviations. According to Easley, de Prado, and O'Hara (2012), by 2009, high-frequency trading accounts for nearly two-thirds of the US stock trading volume. The findings of this article undoubtedly support this conclusion. Any breach of the efficient market hypothesis that is not local nor transitory will be identified by computers, exploited for profit, and finally eradicated since all possible gains from the inefficiency have been harvested.

In investigating the length of the lead lag time between an equity index and its futures, a 1987 study revealed a lead lag duration of up to 45 minutes (Kawaller, Koch, & Koch, 1987), but a 1992 study discovered a length of the lead lag time of 15 minutes or less (Chan, 1992). We are convinced that the days of measuring the length of the lead lag time in minutes are forever gone, and we now understand that research on the length of the lead lag time undertaken for different eras cannot be directly compared, because lead lag duration tends to decrease as the years progress.

As stated in the literature review, cryptocurrencies have attracted the interest of scholars in recent years. The bulk of previous research on cryptocurrency lead lag relationship focuses on the direction of the connection as opposed to the length of the lead lag time. Most rely on daily or other low-frequency data. A direction for future research is to measure the lengths of cryptocurrency lead lag time and how they evolve over the years using tick-by-tick data.

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The Impact of Earnings Management on the Value of Companies – The Role of Ownership Structure

Adam Adamczyk[1]

University of Szczecin, Institute of Economics and Finance, Poland
adam.adamczyk@usz.edu.pl
ORCID: 0000-0002-0491-5502

Sławomir Franek

University of Szczecin, Institute of Economics and Finance, Poland
slawomir.franek@usz.edu.pl
ORCID: 0000-0002-9698-4918

ABSTRACT

The aim of our paper is to test whether there is a relationship between earnings management and the market value of companies with different ownership structures. Additionally, we examined whether ownership control determines earnings management. Our study was conducted on 632 non-financial companies listed on the Warsaw Stock Exchange between 2013 and 2020. We have assessed panel data models showing that there is no relationship between earnings management and company value. However, there is a negative and statistically significant relationship for companies without a majority direct investor. We also showed that, despite the different impact of manipulation on company value, there are no statistically significant differences in earnings management between companies with different ownership structures. The originality of our study lies in conducting an analysis of earnings management taking into account the degree of ownership control.

JEL Classification: G10, G30, M42

Keywords: earnings management, M-score, market value, corporate finance.

INTRODUCTION

Financial statements are the primary source of information on the financial standing of companies. They are used by investors to make decisions on the capital market. There is therefore a temptation for managers to use earnings management (Kukreja et al., 2020). The key determinant of earnings management is stock market pressure (Dechow & Skinner, 2000). There is solid evidence that managers manipulate earnings to meet financial analysts' expectations

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[1] Corresponding author.

(Burgstahler & Dichev, 1997; Degeorge, Patel, & Zeckhauser, 1999) because negative earnings surprises lead to substantial negative price reactions, especially for growth firms (Skinner & Sloan, 2002). Chu et al. (2019) suggest that the pressure to maintain a reputation for beating analysts' expectations can encourage aggressive accounting and, ultimately, earnings manipulation. There is no clear answer as to whether earnings management has a positive or negative impact on the market valuation of companies. Magrath and Weld (2002), Yaping (2006), and Jiraporn et al. (2008) find that earnings management benefits the firm. The rationale behind this point of view is that earnings management reduces the volatility of earnings, which in turn, will lower the level of firm risks perceived by investors and increase the value of the firm. In this way, earnings management is a method of income smoothing. On the other hand, Beneish et al. (2013) provide empirical evidence that companies with a higher probability of accounting fraud earn lower returns on every decile portfolio sorted by size, book-to-market, momentum, accruals, and short interest. The explanation for this may be that fraudulent financial reporting imposes huge costs on financial markets. These accounting misrepresentations increase transaction costs by eroding investor confidence in the integrity of the capital markets. Interesting conclusions regarding earnings management are provided by the results of a study by Kałdoński & Jewartowski (2017) conducted on 356 non-financial companies listed on the Warsaw Stock Exchange in the period 2005-2015. These researchers indicate, based on Jensen's (2005) hypothesis, that companies whose stocks are overvalued have a greater tendency to manage earnings. Among the factors influencing the use of earnings management, great attention is paid to the ownership structure (Habib et al., 2022). Some studies provide evidence for a negative and significant impact of institutional investors on earnings management (Susanto et al., 2021). Other studies indicate that the presence of large investors favors earnings management (Dong et al., 2020). Kałdoński et al. (2020) note that the link between shareholder structure and earnings management is not clear-cut. However, institutional investors holding stable equity stakes play an important monitoring role in reducing real earnings management by managers pressured by capital market forces to 'meet or beat' earnings targets (Kałdoński et al., 2020).

Therefore, the aim of our paper is to answer the question of whether there is a relationship between shareholder structure and earnings management. We also test whether the relationship between earnings management and the market value of a company depends on the ownership structure. To achieve this objective, two research hypotheses were formulated. The first assumes that there is a negative relationship between earnings management and market value. The second one states that shareholding structure determines earnings management.

Our study covers non-financial companies listed on the Warsaw Stock Exchange (WSE). In the study, we used data for the years 2013–2020, which were sourced from the BvD ORBIS database. The original sample included 632 companies.

2. LITERATURE REVIEW

Earnings management essentially consists in the improvement of reporting data (Dalnial et al., 2014), which is reflected in the overstatement of assets, sales, and profits or the understatement of liabilities, expenses, or losses (Charalambos, 2002). Manipulation within financial statements is not necessarily related to accounting fraud. Fraud involves deliberate misrepresentation or omission of values or information in the financial statements, i.e. illegal actions. In the case of practices the essence of which is not a violation of accounting standards, but actions based on principles derived from accounting standards to conceal the economic content of the actual results, one can speak of earnings management (Rezaee, 2005). The level of earnings management in Poland compared to other countries is high, as is evident from both Kliestik et al.'s (2021) study

for the V4 group of countries (Poland, Slovakia, Czechia, Hungary) and He et al.'s (2017) results for 29 developed countries and emerging markets.

Managers manipulate revenues using 'accounting choices' that are reflected in discretionary (unexpected) accruals that typically inflate current earnings without affecting current cash flows (changing the depreciation rate of assets, delaying asset write-offs, or (under)provisioning for bad debt expenses may underlie non-cash income-increasing/decreasing strategies). This form of manipulation is known as accrual-based earnings management. They also can make real 'operational decisions' (involving cuts in R&D spending, price discounts accelerating sales, changes in credit policy, overproduction decreasing the cost of goods sold) that typically affect both earnings and cash flows. This practice is known as real earnings management (Kałdoński et al., 2020).

According to many researchers (Badertscher, 2011; Cohen & Zarowin, 2010; Roychowdhury, 2006; Schipper, 1989), real earnings management is more value destroying than the accrual-based earnings management. Most researchers agree that real earnings management can destroy a company's long-term ability to generate earnings because it is a departure from optimal operational decisions (Badertscher, 2011; Cohen & Zarowin, 2010; Roychowdhury, 2006; Sakaki et al., 2017). Badertscher (2011) analyzes the US overvalued firms' choices of different earnings management types (mechanisms). He presents evidence that the longer the firm is overvalued, the greater is the amount of total earnings management, which supports Jensen's theory (Jensen, 2005). Jensen (2005) predicts that equity overvaluation could induce managers to engage in activities that can sustain the inflated stock price in the short run but can destroy shareholder value in the long run. Studies conducted before Jensen's also support his theory, though indirectly, at least in terms of the pressure that managers are under when trying to meet (or beat) capital market participants' expectations reflected in analysts' forecasts (Kałdoński & Jewartowski, 2017). Liao (2014) has shown that stock crash is often preceded by earnings management due to overvaluation of company stock.

There is an ongoing debate on whether earnings management affects long-term operating performance and firm value, but the majority of academics treat it mostly as detrimental because it helps managers obtain some private gains at the cost of shareholders (Schipper, 1989). On the other hand, earnings management can be valuable when it conveys forward-looking, value-relevant information, by removing some of the noise in a truth-telling report of short-term earnings (Ronen & Yaari, 2008). Research results (Shan, 2015) show that the negative impact of value relevance for the companies engaged in earnings management is greater than for the companies without earnings management. The research results reported for the Polish capital market suggest that the difference between abnormal returns between firms with lower and higher discretionary accruals was not immense in many investment periods (Lizińska & Czapiewski, 2018).

Considering the results of this research, we want to demonstrate what is the relationship between earnings management and the value of companies listed on the WSE. In accordance with previous research, we formulate the following hypothesis: there is a negative relationship between earnings management and company value.

Among the factors influencing the use of earnings management, a crucial role is played by the ownership structure (Habib et al., 2022). Kałdoński and Jewartowski (2017) provide consistent evidence that institutional shareholders holding a large amount of stock mitigate real earnings management behavior, which suggests that these institutions are interested in long-term performance and act as a monitor. While the desire to attract external financing at a low cost is an important motivator for earnings manipulation (Dechow et al., 1996), Beneish (1999) argued that the cost of external financing is a weaker incentive to manage earnings than the managers' desire to sell their equity at higher prices. A study (Campa, 2019) conducted on 6,407 French non-financial companies for the period 2009–2016 shows that the stimulus for earnings management is the

deterioration of the financial situation of companies, with these practices being more prevalent among listed companies than among non-listed entities.

Darmawan et al. (2019) showed for Indonesia Stock Exchange during the period of 2013 to 2017 that accrual earnings management measured by discretionary accruals did not affect the value of the firm. Real earnings management was found to have a negative effect on firm value. Abbas and Usman (2019) investigated the behavior of earnings management for Pakistani non-financial listed firms for the period of 15 years for 2003–2017 and found a positive relation between aspects of real and accrual earnings management and firm value variables.

In contrast, the results of research conducted for French companies for the period 2008–2012 indicate that earnings management has a negative impact on market quotations (Bouaziz et al., 2020). This means that the market value of companies decreases when managers undertake earnings management. These studies also reveal that the relationship between shareholder activism and earnings management has no effect on market performance. Thus, shareholder activism turns out to be an ineffective mechanism that does not change accounting choices, particularly in relation to earnings management. This research points to the inability of activist shareholders to define and implement strategies within their proposals, namely 'lack of monitoring competence'.

The value effect, operationalized as the ratio of market value to book value of shares, has a significant impact on a firm's earnings management practices. In the earnings management literature, it is used to operationalize a firm's growth potential. Research has shown that high-growth firms are more likely to engage in earnings management in order to maintain their profit stream (Lee et al., 2006). Research results for companies listed on the Bombay Stock Exchange exhibit lower (higher) returns for the upward (downward) real earnings management. Additionally, these results show a premium for the stocks that experienced downward earnings management (Bansal et al., 2021).

The scale and form of earnings management are determined by a number of factors, among which the ownership structure plays an important role (Habib et al., 2022). Susanto et al. (2021) show that the effect of institutional ownership on earnings management is significant and negative. The effect of managerial ownership on earnings management is not significant. This shows that institutional shareholders want the management to report the state of financial performance, especially earnings, in accordance with the actual situation. Institutional investors are considered more experienced and can perform a better analysis so that the management finds it difficult to manipulate them. Therefore, managers tend to avoid earnings management practices and higher quality earnings (Susanto et al., 2021). According to Piosik and Genge (2020), the presence of institutional investors diminishes accrual-based upward earnings management prior to mergers and acquisitions. On the other hand, Kałdoński et al. (2020) find no linkage between real earnings management and institutional ownership in Poland. However, a weak negative association is reported between earnings management and long-term institutional ownership. Additionally, the relationship between institutional ownership and real earnings management is negative for single-class shares (firms under intense capital market pressure), but insignificant for dual-class shares. Similarly, research by Grabiński and Wójtowicz (2021) based on Polish companies listed on WSE in 2015–2018 does not support negative linkage between institutional ownership and real earnings management.

Liu and Lu (2007) find a positive and significant association between the level of ownership concentration and earnings management practices. Therefore, the concentrated ownership reduces the quality of financial reporting. Therefore, firms with concentrated ownership have a tendency to manipulate accounting data (Wang, 2006).

D'Onza and Lamboglia (2011) examine the relationship between corporate governance characteristics and financial statement frauds in Italy using logit regression analysis. The research covers a period of 11 years (2001–2011) and shows a significant positive relationship between concentrated ownership and financial reporting fraud in the Italian context.

The empirical results of research on China's capital market indicate that institutions with high shareholding concentration give managers incentives to manipulate discretionary accruals for short-term profitability (Hsu & Wen, 2015). Dong et al. (2020) find that Chinese firms with more influential largest shareholders are more prone to real earnings management. Accordingly, our second hypothesis is that there is an influence of ownership structure on the scale of earnings manipulation.

In the face of the complexity of the earnings management strategies used and the various channels of their impact on the market valuation of companies, methods that allow the identification of such practices play an important role. Among them, the best known are: the aggregated accruals Jones model (Jones, 1991), the modified Jones model (Dechow et al., 1995), the earnings distribution model (Burgstahler & Dichev, 1997), specific accrual models (McNichols & Wilson, 1988) or the M-score model (Beneish et al., 2013). The most popular of these is the M-score model, which uses eight financial indicators to create a synthetic measure used to identify companies manipulating financial statements.

There are many studies indicating the effectiveness of using the M-score model to detect earnings management. For example, a study conducted in Italy by Paolone and Magazzino (2014) on 1,809 industrial companies listed on the Italian stock exchange between 2005 and 2012 shows that half of them have a high probability of earnings manipulation. Maniatis (2022), based on a study of companies making up the main index on the Athens Stock Exchange, found that nearly one-fifth of them manipulated earnings in 2017–2018. Mahama (2015) indicated that users of Enron's financial statements, using the Beneish model, could have detected warning signs indicating manipulation of that company's results earlier (as early as in the beginning of 1997). Anh and Linh (2016) indicate, based on a 2013–2014 study of 229 non-financial companies listed on the HOSE in Vietnam, that 48.4% of them are involved in earnings management. Similarly, Hołda (2020) points out, using the example of more than 30 companies listed on the Warsaw Stock Exchange, that the Beneish model accurately identifies manipulators among them. Golec (2019) noted that the correctness of the classification of companies as manipulators by using the Beneish model in the Polish capital market is higher than in the case of research conducted for the UK market. These results justify the use of M-score in Polish conditions.

3. METHODS AND DATA

Two hypotheses are posed in the study. The first hypothesis assumes the existence of a negative relationship between manipulation of financial results and company value. To verify it, we used panel data models with two alternative measures quantifying enterprise value – i.e., the ratio of market value to book value of enterprise equity (P/BV) and Q-Tobin ratio, determined as the ratio of market capitalization to book value of enterprise assets – as explanatory variables. We used the M-score, a measure of financial performance manipulation, as the main explanatory variable of the model. The M-score was determined according to the following formula (Beneish 1999):

$$M = -4.84 + 0.920*DSRI + 0.528*GMI + 0.404*AQI + 0.892*SGI + \\ + 0.115*DEPI - 0.172*SGAI + 4.679*TATA - 0.327*LEVI$$

(Eq. 1)

where:
DSRI   – Days Sales in Receivables Index
GMI   – Gross Margin Index
AQI   – Asset Quality Index
SGI   – Sales Growth Index
DEPI   – Depreciation Index
SGAI   – Sales, General, and Administrative Expenses Index
LEVI   – Leverage Index
TATA   – Total Accruals to Total Assets

The method of determining the indicators included in the M-score is shown in Table 1.

Table 1
Ratios of M-score

Ratio	Formula
DSRI	Net receivables$_t$ / Sales$_t$) / (Net receivables$_{t-1}$ / Sales$_{t-1}$)
GMI	[(Sales$_{t-1}$ – Cost of goods sold$_{t-1}$) / Sales$_{t-1}$] / [(Sales$_t$ – Cost of goods sold$_t$) / Sales$_t$]
AQI	[1 - (Current Assets$_t$ + PP&E$_t$)/Total Assets$_t$] / [1 - (Current Assets$_{t-1}$ + PPE$_{t-1}$) / Total Assets$_{t-1}$]
SGI	Sales$_t$ / Sales$_{t-1}$
DEPI	[Depreciation$_{t-1}$ / (Depreciation$_{t-1}$ + PP&E$_{t-1}$)] / [Depreciation$_t$ / (Depreciation$_t$ + PP&E$_t$)]
SGAI	(SGA Cost$_t$ / Sales$_t$) / (SGA Cost$_{t-1}$ / Sales$_{t-1}$)
LEVI	[(Current Liabilities$_t$ + Total Long Term Debt$_t$) / Total Assets$_t$] / [(Current Liabilities$_{t-1}$ + Total Long Term Debt$_{t-1}$) / Total Assets$_{t-1}$]
TATA	[(Change in Current Assets – Change in Cash) – (Change in Current Liabilities – Change in Current maturities of Long Term Debt – Change in Income Tax payable) – Depreciation and Amortization$_t$] / Total Assets$_t$]

Source: Beneish (1999)

Additional control variables of the estimated models are measures that characterize the financial condition of companies from Altman's four-factor model. These measures are:

X_1-Working Capital/Total Assets;

X_2-Retained Earnings/Total Assets;

X_3-Earnings before Interest and Taxes/Total Assets;

X_4- Equity Book Value/Total Liabilities

The study was carried out taking into account the division of enterprises according to the criterion of ownership concentration. The division of enterprises was based on Moody's *Independence Indicator*, which distinguishes five categories of entities denoted by the letters A, B, C, D, U. Letter A is attached to any company with known recorded shareholders none of which

having more than 25% of direct or total ownership. Letter B stands for any companies with known recorded shareholders none of which with an ownership percentage (direct, total or calculated total) over 50%, but having one or more shareholders with an ownership percentage above 25%. Letter C is used to denote entities with a recorded shareholder with a <u>total</u> or a calculated total ownership over 50%. Letter D is allocated to any company with a recorded shareholder with a direct ownership of over 50%. Branches, foreign companies and marine vessels are also attributed indicator 'D'. Letter U is used to indicate entities whose status is unknown. All entities with such status were omitted from the study.

The positive verification of the hypothesis that there is a varying effect of earnings management on the value of companies gives grounds to expect that the propensity of managements to manipulate financial results will vary between companies depending on the extent of ownership control. This gives grounds for formulating the second hypothesis according to which there is an influence of ownership structure on the scale of earnings manipulation. To verify this hypothesis, as before, the collective of the surveyed enterprises was divided using the criterion of ownership concentration. For each of the four groups of enterprises, the median M-score was determined. Subsequently, using the Kruskal-Wallis test, we tested the hypothesis of equality of M-score distributions in each of the four groups. This allowed us to answer the question of whether the degree of ownership concentration determines earnings management. For the research described above, we used data from companies listed on the WSE between 2013 and 2020, excluding financial companies. We obtained the data from the BvD ORBIS database. The original collection included 632 companies. However, due to data shortages, the number of companies was reduced. Descriptive statistics for the variables used are presented in Table 2.

Table 2
Descriptive statistics of the studied variables

Variable	N	Mean	S.D.	Min	0.25	Mdn	0.75	Max
Pbv	3748	3.74	30.00	-284.09	0.57	1.13	2.50	967.74
Q	4036	4.54	139.64	0	0.29	0.57	1.31	8803.89
M	2041	-1.59	8.52	-16.11	-3.08	-2.64	-2.11	90.69
x1	4091	0.17	0.22	-0.16	0.01	0.14	0.33	0.57
x2	4088	-0.18	0.64	-2.38	-0.18	0.02	0.11	0.42
x3	4092	0.01	0.24	-1.43	-0.01	0.04	0.09	0.61
x4	3899	7.23	23.40	0.03	0.55	1.28	3.61	181.28

Source: Author's calculation

4. RESULTS

The first stage of the study served the purpose of answering the question of whether there is a relationship between the scale of earnings manipulation, as measured by the M-score, and the value of companies. In addition, we analyzed whether the strength of this relationship depends on the degree of ownership control. We conducted the study using two alternative variables describing enterprise value P/BV and Tobin's Q. In both cases, we used panel data models with random effects. Model selection was based on the use of the Hausman test. The estimation results for all the companies studied (ABCD) indicate that there is no statistically significant

relationship between earnings management and the value of companies (Table 3). Our results show that the scale of earnings manipulation can negatively affect the value of companies as measured by the P/BV ratio – but this applies to companies with weak ownership control. This effect is strongest among companies in which no shareholder owns more than 25% of the shares (subsample A). It is also noticeable among entities that do not have a direct majority shareholder (subsamples AB, ABC).

Table 3
Model estimation results – P/BV: dependent variable

Dep var.: P/BV	A	B	C	D	AB	ABC	ABCD
M	-0.3270** (0.1277)	-0.01179 (0.02958)	-0.0080 (0.0112)	-0.0400 (0.1135)	-0.0712* (0.0386)	-0.0710* (0.0377)	-0.0580 (0.0654)
x1	-28.6468*** (6.8443)	-3.3957 (2.1153)	-0.3732 (0.9342)	-29.1532*** (7.2914)	-14.1518*** (2.8777)	-13.9592*** (2.7925)	-6.5684 (4.1983)
x2	-0.3359 (2.7442)	-2.3497** (0.9417)	-0.062452 (0.5398)	-5.8825 (3.9167)	-1.3251 (1.2293)	-1.3372 (1.1947)	-0.1971 (1.9122)
x3	11.6941** (5.8390)	5.8127** (2.3888)	0.8504 (0.7720)	-15.4613 (9.5823)	7.2656*** (2.7323)	7.2557*** (2.6636)	-23.1206*** (4.6260)
x4	0.3541*** (0.03743)	0.1047*** (0.0318)	0.4547*** (0.0768)	4.0832*** (0.1222)	0.2924*** (0.0234)	0.2921*** (0.0223)	0.7088*** (0.0409)
Cons.	4.4951* (2.4800)	2.1329*** (0.5330)	1.2900 (1.0252)	-5.0495** (2.0817)	2.9037*** (0.9318)	2.8629*** (0.8954)	1.3365 (1.1668)
R2 within	0.2143	0.0297	0.6237	0.7235	0.1336	0.1333	0.1983
R2 between	0.1651	0.0391	0.0006	0.4694	0.1281	0.1286	0.1045
R2 overall	0.1757	0.0318	0.0319	0.5993	0.1286	0.1286	0.1391
N. obs	418	737	49	668	1155	1204	1872
N. companies	81	143	9	145	224	233	378

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, the deviations of the estimators (standard errors) are given in brackets

Source: Author's calculation

Analyses in which we used the Q-Tobin ratio as a quantifying variable for company value lead to similar conclusions (Table 4). In this case, too, there is a negative relationship between the scale of earnings manipulation and the value of the company for enterprises in which no shareholder owns more than 25% (subsample A). This relationship is even stronger than in the case of a study based on the P/BV variable. Similarly, the relationship between value and a measure measuring the scale of earnings manipulation is also noticeable in the group of entities with no direct owner with a controlling stake (subsamples AB, ABC).

Table 4
Model estimation results – Q-Tobin ratio: dependent variable

Dep. var.: Q-Tobin	A	B	C	D	AB	ABC	ABCD
M	-0.1147***	0.0006	-0.0027	-0.0070	-0.0205*	-0.0204*	-0.0163
	(0.0429)	(0.0026)	(0.0045)	(0.0272)	(0.0108)	(0.0105)	(0.0190)
x1	-8.3517***	0.1662	-0.3870	-7.5535***	-3.5278***	-3.4739***	-0.8699
	(2.2106)	(0.2378)	(0.2523)	(1.6787)	(0.8214)	(0.8003)	(1.1772)
x2	0.53174	-0.3194***	-0.0342	1.4243	0.2590	0.2523	0.8168
	(0.8461)	(0.1153)	(0.1105)	(0.9211)	(0.3598)	(0.3508)	(0.5423)
x3	2.1953	0.6218***	0.6415**	-24.5301***	0.77514	0.7775	-12.7684***
	(1.8978)	(0.2267)	(0.2843)	(2.2333)	(0.7682)	(0.7505)	(1.3330)
x4	0.1762***	0.0671***	0.2927***	1.3573***	0.1506***	0.1506***	0.2834***
	(0.0127)	(0.0036)	(0.0275)	(0.0290)	(0.0070)	(0.0068)	(0.0117)
Cons.	1.7824**	0.7161***	0.1459**	-0.7779	1.0839***	1.0607***	0.6659**
	(0.8463)	(0.1123)	(0.0587)	(0.4792)	(0.3141)	(0.3026)	(0.3253)
R2 within	0.3087	0.3174	0.8035	0.855	0.2704	0.2703	0.2908
R2 between	0.3318	0.4208	0.797	0.6686	0.2943	0.295	0.2609
R2 overall	0.3827	0.4306	0.8639	0.7738	0.365	0.3652	0.2722
N. obs	457	794	49	698	1251	1300	1998
N. companies	87	153	9	150	240	249	399

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$, the deviations of the estimators (standard errors) are given in brackets

Source: Author's calculation

The next step of our analysis was to answer the question of whether managers of companies with lower levels of shareholder control have a higher propensity for earnings management. To answer this question, we calculated the medians of the M-score for each of the groups of companies distinguished by Moody's *Independence Indicator*, and then used the Kruskal-Wallis test. Our results, presented in Table 5, show that the medians of the M-score for each group of companies differ slightly. The results of the Kruskal-Wallis test show that the degree of control over companies does not affect the magnitude of the earnings management phenomenon. Thus, there is no evidence of a relationship between the degree of ownership control and earnings management.

Table 5
M-score medians for ownership concentration subsamples

Value of M-score	
Subsample	**Median**
A	-2.62
B	-2.66
C	-2.55
D	-2.68
Kruskal-Wallis equality-of-populations rank test	$p = 0.4425$

Source: Author's calculation

5. CONCLUSIONS

According to previous literature, earnings management can result in suboptimal utilization of companies' resources, which leads to a reduction in their fundamental value (e.g. Badertscher, 2011; Cohen & Zarowin, 2010; Roychowdhury, 2006; Sakaki et al., 2017). The analyses we conducted partially support this view. We observed a strong negative relationship between P/BV and the Tobin's Q ratio and the value of the M-score in the group of companies with weak ownership control (that is, companies in which the leading shareholder does not own more than 25% of the shares – subsample A in our research). In contrast, in the group of companies with large shareholders (subsample B) or majority shareholders (subsamples C and D), the value of M-score does not have a significant impact on the market valuation of companies. In the case of companies with fragmented shareholding, financial statements are more significant for investors as they are the primary source of information about the condition of the company. In such a situation, earnings management undermines investor confidence in management. Therefore, higher M-score values lower the market valuation. On the other hand, if there are large investors in the company, as insiders they can use other internal sources of information besides financial statements. In such a situation, earnings manipulation will have little impact.

As the capital market reaction to financial performance manipulation is stronger for entities with weak ownership control, managers of such companies should manage earnings to a lesser extent. On the other hand, companies with strong control should be characterized by higher levels of manipulation. However, based on our analysis, we could not confirm the results obtained by Dong et al. (2020) according to which the presence of a large investor favors earnings management. Similarly to Kałdoński et al. (2020), we do not find a linkage between earnings management and ownership in Poland, although their study only looked at real earnings management and the ownership structure was reflected by the presence of institutional investors.

In our study, ownership structure is based on a breakdown that takes into account the extent of control over the company as measured by Moody's *Independence Indicator*. The lack of a clear link between the presence of strong investor and earnings management may be due to the balancing of two effects. The first is due to the pressure that large investors put on managers (Dechow & Skinner, 2000). The second is related to the professionalism of large investors, so the management finds it difficult to manipulate them. Therefore, managers tend to avoid earnings management practices (Susanto et al., 2021).

Our results suggest that managers of entities with weak ownership control should anticipate a negative capital market reaction to earnings management as – in their case – investors are more distrustful and react more strongly to manipulation.

Acknowledgments

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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

Paweł Witkowski[1]
University of Szczecin, Poland
Institute of Economics and Finance
pawel.witkowski@usz.edu.pl
ORCID: 0000-0003-0080-3893

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.

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 Lofgren 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, Calel and Dechezlepretre published a study that analyzed patents filed between 1979 and 2009 in the field of low-CO2 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[2], so-called carbon leakage[3] 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

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[2]　Increase in foreign investment in countries that have not introduced environmental regulations or have set environmental standards below their efficiency levels.

[3]　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[4]. 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

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[4] 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 tCO2e). 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:

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

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:

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

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:

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

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®), 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:

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

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)[5].

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

$$y_{it} = x'_{it\_} + u_i + e_{it}$$

$$i = 1, -, N; t = 1, -, T$$

(3.1)

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,
β – 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.

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[5]   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	*roe*	net profit$_{i,t}$ / equity$_{i,t}$	Ruggiero and Lehkonen (2017)
Excess rate of return	*err*	$ROE_{i,t} - r_{e\,i,t}$	
Independent variables			
Company size	*lna*	ln(total assets$_{i,t}$)	Hirsch (2014), Pattitoni (2014)
Enterprise growth rate	*gs*	sale$_{i,t}$ / sale$_{i,t-1}$ − 1	Yazdanfar (2013)
Financial leverage	*fin_lev*	total liabilities$_{i,t}$ / total assets$_{i,t}$	Nunes (2009)
Operational leverage	*op_lev*	fixed assets$_{i,t}$ / total assets$_{i,t}$	Nunes (2009)
Liquidity ratio	*liq_rat*	current liabilities$_{i,t}$ / current assets$_{i,t}$	Hirsch (2014)
Productivity	*prod*	value added$_{i,t}$ / (salary$_{i,t}$ amortization$_{i,t}$ + depreciation$_{i,t}$ + interest$_{i,t}$)	Yazdanfar (2013)
Economic growth	*ggdp*	GDP$_{i,t}$ / GDP$_{i,t-1}$ − 1	Pattitoni (2014)
Significance factor of cost of missing CO$_2$ emission allowances	*co2*	(total emission$_{i,t}$ − allocation$_{i,t}$) / total assets$_{i,t}$	
Year	*Year*	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/χ^2							0.92	
F/χ^2 statistic of the model	142.2***	54.14***	369.43***	28.81	31.91***	28.11***	20.1***	15.03**
R^2 within		0.6509	0.6498	0.5621	0.6645	0.6836	0.6711	0.0243
R^2 between		0.5988	0.6057	0.6289	0.5877	0.0708	0.5988	0.0579
R^2 overal		0.6239	0.6276	0.6029	0.6316	0.1404	0.6407	0.0423
Adj. R^2	0.6275	0.648		0.6071		0.6788	0.6622	
No. observation				607				
Fixed effect		6.73***			5.86***	6.48***	5.89***	
Θ			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/χ2	42.22**	32.46***	239.25***			33.68***
F/χ2 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 overal		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***
Ө			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.

Acknowledgments

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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
err	0.0764	0.0857	0.1998
roe	0.09	0.0936	0.1002
prod	1.3218	1.2891	0.3106
op_lev	0.619	0.6284	0.1344
lna	15.33	15.4	2.035
co2	0.0009	−0.00008	0.0792
gs	0.0739	0.0408	0.2139
liq_rat	0.762	0.7294	0.2369
fin_lev	0.5928	0.5905	0.1456
ggdp	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.

Dividend Versus Investment – Cash Flow Allocation

Elżbieta Bukalska

Faculty of Economics, Maria Curie-Skłodowska University in Lublin,
Plac Marii Curie-Skłodowskiej 5, 20-031 Lublin, Poland
elzbieta.bukalska@mail.umcs.pl
https://orcid.org/0000-0001-8097-5964

Anna Maziarczyk[1]

Faculty of Economics, Maria Curie-Skłodowska University in Lublin,
Plac Marii Curie-Skłodowskiej 5, 20-031 Lublin, Poland
anna.maziarczyk2@mail.umcs.pl
https://orcid.org/0000-0001-8485-0915

Kinga Ociesa

Faculty of Management, Department of Finance and Accounting,
Lublin University of Technology, Nadbystrzycka 38, 20-618 Lublin, Poland
k.ociesa@pollub.pl
https://orcid.org/0000-0003-4973-1990

ABSTRACT

The aim of the article is to find out about the pattern in which operating cash flows are allocated between dividends and investment. We analyzed 419 companies from the Warsaw Stock Exchange and covered the period of 2007–2020 with 4,760 firm-year observations. We prepared regression models for the dividend and investment ratio depending on the company specificity. We found a positive relation between dividends and investment. Additionally, we found that with the increase of operating cash flow, both dividends and investment increase. We think that the best explanation of our findings lies in the free cash flow hypothesis and signaling theory of dividends. Dividends and investment might be a tool to mitigate managerial decisions and at the same time a tool to send a positive signal to the investor about the present and future good financial situation. The results contribute to the literature on firms' investment- and dividend-cash flow sensitivity and the order of decisions: in a residual dividend policy, investment decisions are made first and the remaining profit is paid out as dividends while another theoretical approach implies that firms decide first on their dividend level, and then make investment decisions as they are reluctant to cut dividends.

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[1] Corresponding author.

1. INTRODUCTION

Dividend and investment decisions are the most important issues in corporate finance. Dividends especially draw the attention of many researchers. Up till now, dividend decisions are well reflected in many theories, some dividend policies have been identified and many factors affecting dividend payment have been noted. There are two approaches to dividend payment: the first assumes that companies try to adjust their investment decisions in order to maintain a stable value of dividends (especially not to decrease the dividends, the dividend decisions are the priority) and the second assumes that companies try to adjust dividend decisions in order to maintain sufficient investment funding (residual dividend policy; the investment decisions are the priority). Both of the approaches assume a negative relation between dividends and investment. The theory indicates that there is substitution between dividend payment and investment expenses. However, recently, a decreasing trend and propensity to pay dividends (DeAngelo & DeAngelo, 2006), but also a reduction in the investment rate (Döttling et al., 2017) have been identified. Still, some research finds positive relations between investment and cash flow (e.g. Fazzari et al., 1988) and some see positive relations between dividend and cash flow (e.g. Franc-Dąbrowska et al., 2019). Thus, our analysis is further motivated by inconclusive research on the relation between cash flow, dividend payouts and investment expenditure.

The aim of the article is to find out about the pattern in which operating cash flows are allocated between dividends and investment. We hypothesized a negative relation between dividends and investment. We also hypothesized that with an increase of the operating cash flow, the dividend ratio decreases and the investment ratio increases.

We collected the data of companies listed on the Warsaw Stock Exchange (WSE). The target sample, excluding banks and other financial institutions, included 419 companies in the period 2007–2020 (14 years) with 4,760 firm-year observations. We prepared several regression models for the dividend ratio and investment ratio depending on the company specificity (investing companies, dividend paying companies, companies having positive operating cash flow). We found a positive relation between dividends and investment. Additionally, we find that with the increase of operating cash flow, both dividends and investment increase. We believe we uncovered support for the signaling hypothesis, free cash flow hypothesis and life cycle theory of dividends. However, our findings contradicted our hypotheses and some of the previous research.

In our study, we seek to contribute to the literature on dividends by adding investment decision and cash flow allocation between dividends and investment. Since the existing research on dividend payment and investment expenditure refers mostly to the U.S. and developed markets, researchers have recently started looking at the corporate dividend policy of firms in emerging markets and increasingly recognize that the dividend policy may be affected by the international context in which it occurs (see, e.g., Aivazian et al., 2003; La Porta et al., 2000; Naceuret al., 2006). This paper adds to these studies by examining the dividend-investment relation of Polish listed companies over the period 2007–2020 in an attempt to provide additional insight into dividend payouts and capital expenditures in the emerging Polish market. In particular, this paper tests how cash flows are distributed between dividends and corporate investment by Polish firms.

The remainder of the article consists of several parts. Initially, a detailed review of the available literature and research was performed. Based on the review, the necessary research hypotheses were formulated. The sample and research methods were then defined. The variables used in the study were also described in detail. Subsequently, the most important findings and conclusions of the study are described and compared with previous research.

2. LITERATURE REVIEW

2.1. Theory and practice of dividend payouts

Making a decision to pay a dividend is one of the most important decisions in the course of a company's operation. There is much research on dividend payments, and a thorough review of the existing research is provided by Bhattacharyya (2007). On the basis of the findings about dividend payouts, some theories were developed. One is the theory of dividends irrelevance developed by Miller and Modigliani (1961). Another theory – the 'bird in the hand' theory developed by Gordon (1956) and Litner (1962) – assumes that investors prefer to receive short-term income rather than wait long for uncertain future returns.

In turn, the signaling theory developed by Bhattacharya (1979) and John and Williams (1985) supports the significance of the dividend. According to this theory, people from inside the company have more information about the company's situation than outside investors. Hence, there is information asymmetry between managers and potential investors. Therefore, the announcement of dividend payment is treated as a signal and reduces the level of information asymmetry. According to the theory, the announcement of an increase in dividend payouts sends a positive signal to the investor about future profits, and a reduction in dividend payouts signals the worsening of the company's situation.

Signaling is connected with agency problems. According to the agency theory and free cash flow hypothesis, the payment of dividends might serve to align the interests and mitigate the agency problems between managers and shareholders by reducing the discretionary funds available to managers for their own self-interest (Easterbrook, 1984; Jensen, 1986). Another theory, the firm life cycle theory of dividends, is based on the notion that as a firm becomes mature, its ability to generate cash overtakes its ability to find profitable investment opportunities. Eventually, it becomes optimal for the firm to distribute its free cash flow to shareholders in the form of dividends (Grullon et al., 2002; DeAngelo et al., 2006).

There are also other dividend theories: clientele theory (Pettit, 1977) and catering theory (Baker & Wurgler, 2004). The considerations about the dividend policy do not end with the theories and policies discussed above. There are dividend theories stemming from corporate behavioral finance (Hirshleifer, 2015). After numerous studies over many years, it can be said that there are no clear results why companies decide to pay dividends. As a result, the subject of dividends requires further research (Lotto, 2020).

Apart from dividend theories, there are some dividend policies identified: residual dividend policy (assuming that a dividend is paid after all investment financing needs are met), regular dividend policy (assuming that a dividend is paid annually in the same value per share), increasing dividend policy, extra dividend or constant ratio dividend policy (assuming that a constant part of net profit is paid out as a dividend) (Profilet, 2013).

All these theories provide explanations that contradict each other but this results from a different approach and different factors included. Beyond the factors included in dividend theories (such as, e.g., tax, asymmetry of information, agency problems), existing research reveals several other factors that affect dividend payout. Among others, these are profitability, liquidity, leverage, company size and investment opportunities. It is worth mentioning that some researchers also document the influence of factors such as the independence of the board, the size of the board, the quality of the audit or the shareholding structure (e.g., Ye et al., 2019).

One important factor affecting dividend payment is corporate investment opportunities and capital expenses. A reference to the relation between investment and dividend is included in the free cash flow hypothesis, life cycle theory of dividend, pecking order theory of capital structure and residual dividend policy. All of the aforementioned assume that a relation between dividends and corporate investment exists. However, there is little research on the relation between dividends and investment.

2.2. The relations between dividends and corporate investment

Modigliani and Miller (1961) show that in a perfect capital market, period-by-period investment decisions by a firm are separable from its dividend decisions. In contrast, Dhrymes and Kurz (1967) provide early evidence that dividends and investment are interdependent. Accordingly, firms with a residual dividend policy make investment decisions first and the remaining profit is paid out as dividends (Dhrymes & Kurz, 1967). Dhrymes and Kurz state that internal funds are a cheaper source of financing for the firm than new security issues, and dividends and investment are competing uses for limited internal funds.

The residual dividend policy stems from the pecking order theory (Myers & Majluf, 1984). According to this theory, profitable firms prefer to use their own funds first, then debt, and finally seek and raise equity capital. Companies that finance their investment from profit are not willing to pay dividends. The free cash flow hypothesis assumes that owners use different tools to mitigate managerial practices. Here, generous dividend payouts are used to discourage managers from over-investment. The firm life cycle theory of dividends assumes that as a firm becomes mature, its ability to generate cash overtakes its ability to find profitable investment opportunities. Eventually, it becomes optimal for the firm to distribute its free cash flow to shareholders in the form of dividends (Grullon et al., 2002; DeAngelo et al., 2006).

On the other hand, there is some research on dividend policy showing that companies are reluctant to cut dividend payments, which leads to giving up much profitable investment (Brav et al., 2005). Lintner's (1956) survey evidence implies that firms decide first on their dividend level, and then make investment decisions. He finds that firms are willing to cut their capital budget to maintain (or even increase) their current dividend levels. Similarly, in a more recent survey of CFOs, Brav et al. (2005) report that dividend choices are made simultaneously with (or perhaps a bit sooner than) investment decisions. What is more, maintaining the level of dividends per share is the most important element of the dividend policy, but increases in dividends are considered only after investment and liquidity needs are met. Indeed, the surveyed managers state that they are willing to pass up on some positive-NPV projects before cutting dividends.

Grullon et al.'s (2002) findings on declining return on assets, cash levels, and capital expenditures in the years after large dividend increases suggest that firms that anticipate a declining investment opportunity set are the ones that are likely to increase dividends. Moreover, Grullon et al. (2002) saw that dividend-increasing firms do not increase their capital expenditures in the years after dividend increases. However, Auerbach and Hassett (2003) suggest that many firms in the U.S. nonfinancial corporate sector do vary their dividends in response to cash flow, investment and debt, and the relation between dividend and investment is negative with statistical significance in all their models. Bulan and Hull (2013) also recognized that managers remain reluctant to cut dividends, as Lintner originally described. Mathur et al. (2016), following Auerbach and Hassett (2003), replicated the statistically significant negative relationship.

All that research provides findings that contradict each other: some show that companies prioritize investment and dividends are adjusted accordingly (residual dividend policy) and some show that companies are reluctant to cut dividends and investment is adjusted accordingly. On the basis of the available literature, we formulate hypothesis 1:

> H1: There is a negative relation between dividend payouts and corporate investment expenditure.

2.3. Cash flow allocation between dividends and investment

Dividends, investment expenditure and cash flow altogether were initially taken into account when the investment-cash flow sensitivity was investigated. According to Fazzari et al. (1988), all manufacturing firms can be divided into three classes based on the dividend payout policy. Their class 1 firms have a dividend payout ratio of less than 10 percent in at least ten of fifteen years, class 2 firms have a dividend payout ratio between 10 percent and 20 percent, and class 3 firms have a dividend payout ratio higher than 20 percent. The average investment-capital ratio is, respectively, in class 1: 0.26, class 2: 0.18, and class 3: 0.12. Moreover, the average cash flow-capital ratio is, respectively, 0.30, 0.26 and 0.21, and average correlations of cash flow with investment is, respectively, 0.92, 0.82 and 0.20. Their data prove a negative relation between dividends and investment, a negative relation between cash flow and dividends and a positive relation between cash flow and investment. After 1988, there were more studies on the relation between investment and cash flow, and all researchers agree that for a typical firm, the investment-cash flow sensitivity is statistically positive (e.g. Bond et al., 2003; Mizen & Vermeulen, 2005). However, there are some differences in the level of the investment-cash flow sensitivity identified. In addition, some studies link the differences in the investment-cash flow sensitivity with the degree of financial constraints (e.g. Kaplan & Zingales, 1997). In the KZ formula of financial constraints, the dividend payment is included with a negative sign. This means that the lower the dividend payment, the higher the KZ index and the tighter financial constraints. As with Fazzariet al.'s work (1988), Kaplan and Zingales find that investment is positively related to cash flow.

Apart from some investment-cash flow sensitivity and financial constraints research, including altogether cash flow, investment and dividends, there are few studies that bring together all the variables. Daniel et al. (2007) find that when companies are faced with cash flows that fall short of the sum of expected dividend and investment levels, firms must do one of the following: cut dividends, cut investment or raise funds through security sales, asset sales or reductions in cash reserves. Our analysis indicates that while very few firms (6%) cut dividends, the majority (68%) make significant cuts in investment relative to expected levels. Investment cuts make up for approximately half of the shortfall, with the other half being covered primarily by debt financing, while net equity issues, reductions in cash balances and asset sales account for a trivial percentage of the shortfall. However, the work by DeFusco et al. (2007) shows that shocks to dividends do have long-run consequences for investment and vice versa, implying a bi-directional interdependence. Hence, they provide evidence against the separation principle. They find, rather, that companies increase their dividends in response to an increase in earnings, while as for investment, the reaction to an increase in earnings might be both positive and negative; dividends increase with an increase in investment, and investment increases with an increase in dividends. Yeo (2018) researched the effect of cash flow on investment levels and dividend payment in the shipping industry. The study confirms a significant positive impact of free cash flow on investment and a negative impact on the payment of dividends.

There are also some studies on the relation between cash flow and dividend payments that show a positive relation between cash flow and dividends. Bar-Yosef and Venezia (1991), for example, set up a rational equilibrium expectation model. Accordingly, Bayesian investors expect that dividends will be proportional to cash flows. What is more, Mirza and Azfa's (2010) study on the dividend policy of 100 companies listed on the Pakistani stock exchange on the basis of data for the years 2005–2007 found a positive relationship between operating cash flow, profitability and cash dividends. Here, high cash flow from operating activities has a positive impact on the potential of enterprises to pay out high dividends. The positive impact of cash flows on dividend payments is also confirmed by Pappadopoulos and Dimitrios (2007). The sample analyzed included 72 companies listed on the Athens Stock Exchange in 1995–2002. Beyond the aforementioned, Franc-Dąbrowska et al. (2019) estimated a random probit panel model

confirming a statistically significant impact of free cash flow, profitability, liquidity, company growth and size on dividend payment decisions. In this model, an increase in the values of the indicated variables is associated with a greater probability of dividend payment. The results indicate that highly profitable companies with more stable incomes have greater free cash flow, which has a positive effect on dividend payments. The pecking order theory (Myers & Majluf, 1984) explains the influence of the profitability on dividend payments. According to this theory, the relationship between profitability and dividend payment should remain negative (Rohov et al., 2020). On the other hand, in a survey undertaken by Lintner (1956), the key factor affecting the dividend decision of a firm was seen to be the net earnings. In yet one more study, Fama and French (2001) found that the larger and more profitable firms pay more dividends as compared to smaller and less profitable firms. However, the aforementioned research on the relation between cash flow and dividend left out the investment opportunities factor.

The existing research presented above refers indirectly to the relation between investment and dividend when taking decisions on cash flow allocation. Additionally, it only partially tackles the problem included in our research with different variables and their definition. This makes our approach unique and distinct from the existing ones.

Although there is research done on the Polish market (Franc-Dąbrowska et al., 2019), it tries to find the determinants of dividend payout decisions (with free cash flow, profitability, liquidity, company growth and size taken into account). Our approach focuses directly on cash flow allocation between dividends and investment and in this way it differs quite significantly. Again, this makes our approach unique and distinct from the existing ones.

Due to inconclusive research on cash flow, investment and dividends, following Fazzari et al.'s (1988) and Yeo's (2018) research and assuming a negative relation between dividends and investment, we formulate hypothesis 2:

H2a: There is a negative relation between dividend payouts and cash flow;
H2b: There is a positive relation between investment expenditure and cash flow.

3. METHODOLOGY

3.1. Cash flow allocation between dividends and investment

To conduct our analysis, we collected data of companies listed on Poland's Warsaw Stock Exchange (WSE). As of July 2021, there were 435 companies listed, but after excluding banks and other financial institutions, we were left with 419 companies. The financial data covers the period of 2007–2020 (14 years). The sample constitutes an unbalanced panel, with some companies entering and leaving the WSE. Ultimately, we obtained 4,760 firm-year observations. All data were 'winsorized' at 98% upper and 2% lower percentile.

Firstly, we prepared descriptive statistics describing the sample (4,760 firm-year observations), but also subsamples. We grouped our sample companies into several subsamples depending on different criteria:
1) companies with zero-dividend (DIVno = 2,709 firm-year observations, 57% of the sample) and companies paying out dividends (DIVyes = 2,051 firm-year observations, 43% of the sample);
2) companies with zero-investment (CAPno = 235 firm-year observations, 5% of the sample) and companies with investment expenditure (CAPyes = 4,525 firm-year observations, 95% of the sample);
3) companies with positive operating cash flow (OCFposit = 3,621 firm-year observations, 76% of the sample) and negative operating cash flow (OCFnegat = 1,139 firm-year observations, 24% of the sample).

3.2. Models

In our research, we constructed several hypotheses, and, thus, we adopted different statistical methods to verify each of them.

Firstly, we presented descriptive statistics results just to depict the sample. Secondly, we applied the Mann-Whitney U test to evaluate the differences in the variables. We compared the subsamples of the companies: paying and non-paying dividends, with zero and positive CAPEX, having negative and positive operating cash flow. The Mann-Whitney U test does not require that the distribution of the sample need be assumed to be normally distributed. By comparing the level of variables during normal times and crisis times and testing this level via the Mann-Whitney U test, we were able to ascertain whether these variables differ significantly.

To show the relation between variables, we also prepared a correlation matrix. Additionally, we used the pooled OLS analysis as we have unbalanced panel data. We then prepared several regression models separately for the subsamples. The general formula of the regression model is the following:

$$DV = \beta_0 + \beta_1 IV + \beta_2 CV + \varepsilon_i \tag{1}$$

where:

DV – dependent variables vector, reflecting proxies for dividend payment and investment expenditure;
IV – independent variables vector, reflecting proxies for operating cash flow;
CV – control variables vector, reflecting proxies for cash holdings, leverage and size;
β – coefficient estimate for the independent and control variables;
ε_i – random error term/residual variable.

3.3. Variables

To find out how operating cash flow is allocated, we included several variables. The dependent variables reflect dividend payment and investment expenditure. To describe investment expenditure, we calculated the I-CFRatio – the relation between CAPEX and operating cash flow. This ratio reveals what part of operating cash flow is spent on investment (CAPEX). To describe investment expenditure, we also used CapRatio. This is calculated as the relation between investment expenditure (CAPEX) and total assets. To describe dividend payment, we calculated the D-CFRatio – the relationship between dividends and operating cash flow. This ratio shows what part of operating cash flow is spent on dividends. To describe dividend payment, we also used DivRatio. It is calculated as the relation between dividends and total assets.

The independent variable is linked to operating cash flow. We calculated OCFRatio as the relation between operating cash flow and total assets. OCFRatio is a substitute for profitability. In our research, we found a strong and positive correlation between profit and operating cash flow.

We included in our research some control variables: cash holdings, leverage and size of the companies.

Cash holdings are calculated as the relation between cash (and its equivalents) and total assets. Previous research noted that there is negative relation between cash holdings and investment, as companies that invest more save less cash (Riddick & Whited, 2009; Bates et al., 2009). Former research also indicated that there are no conclusive results on the relation between cash holdings and dividends. For example, a negative association between dividend payment and cash holdings was discerned by, e.g., Opler et al. (1999). Accordingly, the payment of dividends will reduce the level of kept funds. On the other hand, a positive association is also expected between dividend payment and cash holdings, as documented by, e.g., Ozkanand Ozkan (2004). The company

will also be able to pay dividends depending on its financial liquidity (amount of cash holdings and cash-flow position). Therefore, companies with more liquidity should pay more dividends (Cristea & Cristea, 2017; Kumar & Sujit, 2018).

Leverage is calculated as the relation between total liabilities and total assets. Previous research discovered that leverage is negatively related to investment (Aivazian et al., 2005) and negatively related to dividends (Lang & Young, 2001). Moreover, Rozeff (1982) argues that firms with a high leverage ratio have high fixed payments for using external financing; therefore, the higher the leverage ratio, the lower the chance for a dividend.

Size is calculated as the natural logarithm of total assets. Research holds that size is negatively related to investment (Borensztein & Ye, 2018) and positively to dividends (Aivazian et al., 2003). Indeed, some studies, based on the signaling theory, state that large companies no longer need to signal their position by paying dividends. Thus, the relationship between the size measured by the size of assets or revenues and dividends is negative (Lestari, 2018). On the other hand, based on the agency theory, it was noticed that larger companies should pay more dividends to attract more investors in order to monitor the company's activities, as the bigger the company is, the more difficult it is to monitor its activity (Jaara et al., 2018).

All financial data are calculated for the year the dividend decision and payout is made. Dividend decisions are taken in a current year but are related to net profit from the previous year. But dividend decisions are related to financial categories (total assets, operating cash flow) from the current year. We believe that our attitude reflects real business decisions: dividend decisions and dividend payouts.

4. FINDINGS

Table 1 presents descriptive statistics of the total sample (N = 4,760 firm-year observations).

Table 1
Descriptive statistics of the total sample

		mean	median	min	max	SD
OCFRatio	Operating cash flow to total assets	5.9	6.1	-28.0	36.1	11.6
I-CFRatio	CAPEX to operating cash flow	42.0	23.3	-335.9	499.8	122.5
CapRatio	CAPEX to total assets	4.6	2.7	0.0	23.1	5.2
D-CFRatio	Dividends to operating cash flow	12.4	0.0	-41.2	124.4	28.7
DivRatio	Dividends to total assets	1.6	0,0	0.0	16.4	3.3
CashRatio	Cash holdings to total assets	9.3	5.7	0.0	47.3	10.5
DebtRatio	Total liabilities to total assets	50.5	49.2	0.0	133.7	24.8

Source: Authors' own calculations.

The average level of operating cash flow is positive and stands for app. 6% of total assets. On average, 40% of operating cash flow is spent on CAPEX and 12% on dividends. It is worth noting that more than half of the companies do not pay dividends (D-CFRatio and DivRatio medians are zero). On average, cash amounts to 9% and total liabilities to 50% of total assets.

Table 2 presents the results of comparing the subsamples with the Mann-Whitney U test.

Table 2
Mann-Whitney U test results

	DIVyes (N = 2,051)	DIVno (N = 2,709)	Mann-Whitney U test	CAPyes (N = 4,525)	CAPno (N = 235)	Mann-Whitney U test	OCFposit (N = 3,621)	OCFnegat (N = 1,139)	Mann-Whitney U test
OCFRatio	9.3	3.3	-19.423**	6.3	-1.2	-10.390**	10.5	-8.6	-50.979**
	8.9	3.8		6.5	-0.2		8.7	-5.4	
I-CFRatio	48.7	37.0	-11.264**	44.2	0.0	-14.274**	76.6	-68.4	-50.812**
	33.7	11.6		26.2	0.0		41.3	-16.0	
CapRatio	4.9	4.3	-11.536**	4.8	0.0	-25.887	5.1	3.0	-17.403**
	3.6	2.1		3.0	0.0	0.000	3.3	1.0	
D-CFRatio	28.8	0.0	-48.714**	13.0	1.3	-8.425**	18.0	-5.3	-34.470**
	21.3	0.0		0.0	0.0		0.0	0.0	
DivRatio	3.7	0.0	-65.516**	1.6	0.2	-10.785**	1.9	0.5	-16.564**
	2.1	0.0		0.0	0.0		0.0	0.0	
CashRatio	10.1	8.7	-9.275**	9.5	6.8	-7.887**	9.4	9.1	-3.428**
	6.6	4.9		5.8	2.6		5.6	5.0	
DebtRatio	48.7	51.9	-2.125*	50.1	58.9	-1.859*	49.9	52.5	-0.783
	48.4	50.1		49.0	54.5		49.0	49.8	

Statistical significance: (*) for results that are significant on a 5% basis and (**) for results that are significant on a 1% basis

Source: Authors' own calculations.

We found that companies paying dividend (when comparing to non-payers) have higher operating cash flow, invest more, have higher cash holdings and lower leverage. Similarly, we saw that investing companies (when comparing to non-investing) have higher operating cash flow, pay higher dividends, have higher cash holdings and lower leverage. We also discovered that companies with positive operating cash flow (when comparing to the companies with negative operating cash flow) invest more, pay higher dividends, have higher cash holdings and lower leverage (but this last variable has no statistical significance).

We were thus able to uncover a specific co-relative profile of the surveyed companies paying out dividends: investing, having higher operating cash flow, higher cash holdings and lower leverage.

For the sake of further investigation, we developed a correlation matrix – Table 3.

Table 3
Correlation matrix

	DivRatio	CapRatio	OCFRatio	CashRatio	DebtRatio	size
DivRatio	1					
CapRatio	0.085**	1				
OCFRatio	0.374**	0.229**	1			
CashRatio	0.196**	-0.006	0.168**	1		
DebtRatio	-0.151**	-0.098**	-0.131**	-0.229**	1	
size	-0.019	0.018	0.116**	-0.183**	0.117**	1

Statistical significance: (*) for results that are significant on a 5% basis and (**) for results that are significant on a 1% basis

Source: Authors' own calculations.

We noted a positive relation between dividend payment and investment expenditure, on the one hand, and operating cash flow, on the other hand. This means that companies with higher operating cash flow decide both on higher investment expenditure and higher dividend payment. This implies that companies do not treat investment and dividends as alternative ways of distributing cash flows; rather, they try to sustain a balance between the interests of the company (investment) and owners (dividends). But this evidence allows for stating that we cannot find support for our H1 hypothesis assuming to find a negative relation between dividends and investment and H2a hypothesis assuming to find a negative relation between dividend payouts and cash flow. However, we find evidence to confirm our H2b hypothesis assuming to find a positive relation between investment expenditure and cash flow.

Additionally, we observed a positive relation between cash holdings and dividend payment and between cash holdings and leverage. We also saw a negative relation between leverage and dividend payment and between leverage and investment expenditure. Apart from that, we discerned a negative relation between the leverage and operating cash flow ratio and between leverage and cash holdings.

Due to the perceived relation between independent and control variables, we included a VIF factor to check the multicollinearity. The results of regression analysis are listed in Table 4 for the total sample and for subsamples with positive and negative operating cash flows and in Table 5 for the subsample of dividend payers and non-payers and the subsample of investing and zero-investing companies.

Table 4
OLS regression analysis results for the total sample and for subsamples with positive and negative operating cash flows (with VIF in parenthesis)

Sample	total	total	OCFposit	OCFposit	OCFnegat	OCFnegat
Observations	N = 4,760	N = 4,760	N = 3,621	N = 3,621	N = 1,139	N = 1,139
Dependent variable	DivRatio	CapRatio	DivRatio	CapRatio	DivRatio	CapRatio
OCFRatio	0.099** (1.066)	0.104** (1.066)	0.172** (1.193)	0.181** (1.193)	-0.003 (1.178)	-0.009 (1.178)
DebtRatio	-0.010** (1.075)	-0.017** (1.075)	-0.017** (1.072)	-0.026** (1.072)	-0.002 (1.102)	-0.001 (1.102)
CashRatio	0.036** (1.115)	-0.032** (1.115)	0.021** (1.054)	-0.090** (1.228)	0.007 (1.144)	0.051** (1.144)
Size	-0.001* (1.069)	0.000 (1.069)	0.000 (1.054)	0.001 (1.054)	0.001** (1.160)	-0.002* (1.160)
R-squared	0.165	0.061	0.199	0.085	0.011	0.023
F statistics	234.840**	77.328**	224.251**	83.871**	3.082*	6.597**

Statistical significance: (*) for results that are significant on a 5% basis and (**) for results that are significant on a 1% basis

Source: Authors' own calculations.

Table 5

OLS regression analysis results for the subsample of dividend payers and non-payers and the subsample of investing and zero-investing companies (with VIF in parenthesis)

Sample	DIVyes	DIVyes	DIVno	CAPyes	CAPyes	CAPno
Observations	N = 2,051	N = 2,051	N = 2,709	N = 4,525	N = 4,525	N = 235
Dependent variable	DivRatio	CapRatio	CapRatio	DivRatio	CapRatio	DivRatio
OCF Ratio	0.168** (1.106)	0.134** (1.106)	0.097** (1.043)	0.104** (1.055)	0.102** (1.055)	0.005 (1.088)
DebtRatio	-0.026** (1.106)	-0.031** (1.106)	-0.010** (1.066)	-0.012** (1.086)	-0.017** (1.086)	-0.001 (1.026)
CashRatio	0.043** (1.162)	-0.098** (1.162)	0.009 (1.098)	0.037** (1.123)	-0.040** (1.075)	0.001 (1.033)
Size	-0.005** (1.080)	0.002** (1.080)	-0.002** (1.080)	-0.001* (1.075)	-0.001* (1.075)	0.000 (1.088)
R-squared	0.332	0.120	0.051	0.168	0.056	0.015
F statistics	254.385**	69.546**	36.023**	229.856**	67.484**	0.871

Statistical significance: (*) for results that are significant on a 5% basis and (**) for results that are significant on a 1% basis

Source: Authors' own calculations.

In general, we observed that there is a positive impact of operating cash flow on investment expenditure and dividend payment. This positive impact is present in all subsamples, and in almost all subsamples, this relation is statistically significant.

Regression analysis results confirmed our previous findings on a positive impact of operating cash flow both on investment expenditure and dividend payment: the higher the operating cash flow, the higher both the investment expenditure and dividend payment. Thus, we cannot find support for our H2a hypothesis assuming to find a negative relation between dividend payouts and cash flow. But, we find evidence to confirm our H2b hypothesis assuming to find a positive relation between investment expenditure and cash flow.

Additionally, in all models, we saw a negative impact of leverage on investment expenditure and dividend payment. However, cash holdings are perceived to be positively related to dividends, but negatively to investment. In addition, size showed both negative and positive impacts depending on the subsample.

5. CONCLUSIONS AND DISCUSSION

The aim of the paper was to find out about the pattern in which operating cash flows are allocated between dividends and investment. We found a positive relation between dividends and investment. We also saw that companies having better financial standing (higher operating cash flow) are more prone both to invest in fixed assets and to pay out dividends. This is against the mainstream of research showing that dividends and investment are competing uses of cash flows (e.g., Dhrymes & Kurz, 1967; Auerbach & Hassett, 2003). Our results support the findings on a positive relation between investment and dividends (e.g., Defusco et al., 2007).

We think that the best explanation of the positive relation between cash flow, dividend payment and investment expenditure lies in the free cash flow hypothesis, signaling theory of dividends and life cycle theory of dividends. The free cash flow hypothesis assumes that owners use different tools to mitigate managerial decisions. Accordingly, generous dividend payments

are used to discourage managers from over-investment when internal funds (operating cash flow) increase (Grullon et al., 2002; DeAngelo et al., 2006).

The signaling theory assumes that dividend payment sends a positive signal to the investor about the present and future good financial situation (when internal funds increase) (Bhattacharya, 1979; John & Williams, 1985). The firm life cycle theory of dividends assumes that younger companies have more investment opportunities and pay less frequent and lower dividends (DeAngelo et al., 2006). The last theory might be in line with the specificity of the companies in the sample. The sample comes from Poland – a country with an emerging economy with a relatively young stock market and relatively young and growing companies. The distribution of the sample supports this notion, as there are more companies investing than paying out dividends. This also supports a residual dividend policy that sets the priority on investment – and if internal funds are higher, a dividend is paid out. This is done to mitigate over-investment and to send positive signals to owners.

Additionally, we find a negative impact of leverage on investment expenditure and dividend payment. This is in line with previous research both regarding investment (Aivazian et al., 2005) and dividends (Lang & Young, 2001). This might be explained with Rozeff's (1982) argumentation that firms with a high leverage ratio have high fixed payments for using external financing; therefore, the higher the leverage ratio, the lower the chance for dividends and investment.

However, cash holdings are perceived to be positively related to dividends, but negatively to investment. A positive association is also expected between dividend payment and cash holdings, as documented by, e.g., Ozkan and Ozkan (2004). The company is able to pay dividends depending on its financial liquidity (amount of cash holdings and cash-flow position). Therefore, companies with more liquidity pay more dividends (Cristea & Cristea, 2017; Kumar & Sujit, 2018). Some previous research noted that there is a negative relation between cash holdings and investment, as companies that invest more save less cash (Riddick & Whited, 2009; Bates et al., 2009).

In this study, we encountered some limitations. Our analysis takes into account an unbalanced panel of data for a specific country. We also used a specific set of companies in our sample – companies listed on the Warsaw Stock Exchange (WSE). Such companies are subjected to specific corporate governance regulations that private (unlisted) companies are not compelled to follow. The limitations show the direction for future research. This might include companies from other (mature) stock markets as well as other company life cycle variables.

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