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Editorial introduction

It is quite striking how many publications that seemed to make a contribution to the economics literature when printed become forgotten just a few years after that event. One may argue that this reflects the inability of economics to propose definite and precise laws governing people's economic behaviour. However, it can also be hypothesised that the lack of such laws is caused by the constant evolution of the subject being studied, i.e., people's economic activity. This is because that activity, in any given period, largely focuses on areas that a few decades or even a few years ago did not exist, or were of marginal importance. The current issue of Economics and Business Review supports this hypothesis, as it addresses the topics of ageing societies, the consequences of the COVID-19 pandemic, the export of services, Industry 4.0, and, predominantly, environmental responsibility. In other words, the set of nine articles that make up the current issue deals with topics that have only recently come to prominence in the economics literature. These nine articles, written by eighteen authors working in India, Indonesia, Japan, Morocco, Poland, and Tunisia, are briefly summarised below.

The opening article, titled **Unveiling financial well-being: Insights from retired people in Third Age group in Poland, Spain and Denmark**, by Alicja Jajko-Siwek contributes to the empirical literature on the silver economy. The study employs machine learning methods to explore predictors of older people's financial capability. It identifies both common determinants, such as household income, and country-specific determinants, such as food expenditure in Poland. The results may be of interest to policymakers responsible for developing old age public policies at the national and EU levels.

In their paper titled **Linder hypothesis and India's services trade**, Jadhav Chakradhar, Juhi Singh and Anusha Renukunta investigate the relationship between (dis)similarity in income levels and international trade intensity. Given its status as one of the top ten exporters of commercial services, India's case is unquestionably significant. The evidence for the years 2005–2021 suggests that the impact of income dissimilarity on the service sector exports is positive, rather than the expected negative. This underscores the necessity of constant development of the international trade theory.

The consequences of the extraordinary external shock triggered by the global spread of the SARS-CoV-2 virus continue to capture the attention of economists. The paper by Krzysztof Bartosik (**The effect of output on employment in Poland during the COVID-19 pandemic**) contributes to the existing

body of literature on this topic. Despite the relatively moderate impact of the pandemic on the Polish labour market, certain groups of workers are identified as bearing a disproportionate burden of the crisis, namely young people (especially women) and workers with temporary employment contracts. The study findings are of relevance for the formulation of labour market policies, underscoring the rationale for implementing targeted instruments and programmes.

The next paper, titled **CSR committees and their effect on green practices**, authored by Ngoc Bao Vuong, presents original findings based on a sample of non-financial Japanese firms. The empirical evidence for the period 2010–2021 provides support for the hypothesis that the existence of such committees is associated with a higher incidence of various green practices. The baseline result remains robust when alternative estimation approaches are employed. Furthermore, the article identifies variations in the relationship of interest, with the effect being stronger for firms that are more environmentally sensitive and for firms with CSR-linked compensation and a higher CSR strategy score. In general, the study indicates that the institutional framework is a non-negligible factor in the context of corporate sustainable behaviours.

The fifth article, entitled **The role of internationalisation in moderating the impact of ESG disclosure on financial performance**, is written by Yuli Soesetio, Ely Siswanto, Subagyo, Muhammad Fuad, Dyah Arini Rudiningtyas, and Siti Astutik. This study aims to determine the influence of environmental, social, and governance (ESG) disclosures on the financial performance of non-financial companies listed on the Indonesia Stock Exchange from 2012 to 2021. The results reveal the importance of analysing this relationship in emerging economies, as they indicate that indicators of environmental responsibility and governance practices are correlated with a decline in corporate financial performance. However, this decline is less pronounced among companies that internationalise their operations.

The next two papers in the current issue explore fluctuations on two selected emerging financial markets. In the first study within this strand, titled **Price limit bands, risk-return trade-off and asymmetric volatility: Evidence from Tunisian Stock Exchange sectors**, Othman Mnari and Bassma Faouel assess empirically the effects of the protective measure in the form of price limit. The Tunisian case allows the authors to consider two price limit regimes: the narrower price limit (NPL) and the wider price limit (WPL). Both crisis (COVID-19) and non-crisis times are analysed in order to gain insights into their performance during different economic conditions. The switch between the two regimes is identified as exerting a significant impact on risk-return relationship as well as volatility, with the effects varying between the large-cup and small-cup sectors.

The second study, by Ahmed El Oubani and titled **Quantile connectedness between social network sentiment and sustainability index volatility:**

Evidence from the Moroccan financial market, focuses on the volatility of the environmental, social, and governance (ESG) index and its relation to investor sentiment expressed on the X platform. The findings reveal a significant connectedness between sentiment and ESG index volatility, particularly during turbulent events. Most of the time, the sentiment index simply reflects the shocks that occur in the financial market; however, in some cases, it preceded changes in the sustainability index. The results also illustrate the impact of market conditions on the spillovers between the sentiment index and ESG volatility.

The paper **CEO pay ratio versus financial performance in Polish public companies**, written by Katarzyna Byrka-Kita and Karol Bulasiński, addresses the long-standing question of whether offering higher salaries to top management staff results in an observable improvement in financial performance. However, the results obtained for companies listed on the Warsaw Stock Exchange are ambiguous. On the one hand, the CEO pay ratio is found to be negatively correlated with return on sales. On the other hand, there is a positive impact on Tobin's *Q* and yearly stock return. These findings may be of interest for both short-term and long-term investors.

The issue closes with a contribution by Katarzyna Łukiewska (**Innovation and Industry 4.0 in building the international competitiveness of food industry enterprises: The perspective of food industry representatives in Poland**). A survey of representatives using the CATI method provides a unique dataset. The empirical evidence unequivocally demonstrates the significance of innovations for not only maintaining but also improving international competitiveness. This study offers some practical guidelines for the food industry sector by identifying the types of innovations with the highest potential to improve the competitive position on the international market.

Monika Banaszewska
Michał Pilc
Lead Editors

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Unveiling financial well-being: Insights from retired people in Third Age group in Poland, Spain and Denmark

Alicja Jajko-Siwek[1]

Abstract

The study investigates the financial well-being of older people in Poland, Spain and Denmark, with a particular focus on their ability to make ends meet. Using data from the SHARE survey to analyse retired individuals aged 65 to 79 years, it aims to identify the socio-economic factors that influence financial well-being among older people in these countries. In terms of methodology, it uses Light Gradient Boosting Machine algorithm and SHAP value calculations to predict the ability to make ends meet and determine the importance of 167 various features. The study concludes that household income and financial resources are the primary determinants of older people's ability to make ends meet. The findings underscore the need for policymakers and practitioners the fields of ageing and economics to address specific challenges, such as housing costs in Denmark and food expenditure in Poland and Spain, to improve the financial well-being of older individuals.

Keywords

- financial well-being
- LightGBM
- pensioner
- silver economy
- SHAP
- SHARE
- the ability to make ends meet

JEL codes: C38, G50, H55, I31.

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Introduction

The ageing population in the European Union has seen a notable speed from 2001 to 2023, with the percentage of people aged 65 and older rising from 15.8% to 21.3% (Eurostat, 2024). This demographic shift is expected to continue, with projections indicating that by 2050 nearly 29.5% of the EU population will be 65 years or older. This trend underlines the global phenomenon of ageing populations and presents both challenges and opportunities due to the potential of the older population on both the supply and demand sides (Barković Bojanić et al., 2024). Analysing countries like Poland, Spain, and Denmark, which exhibit distinct ageing patterns and socio-economic contexts, provides valuable insights into the dynamics of financial well-being among old people (Figure 1).

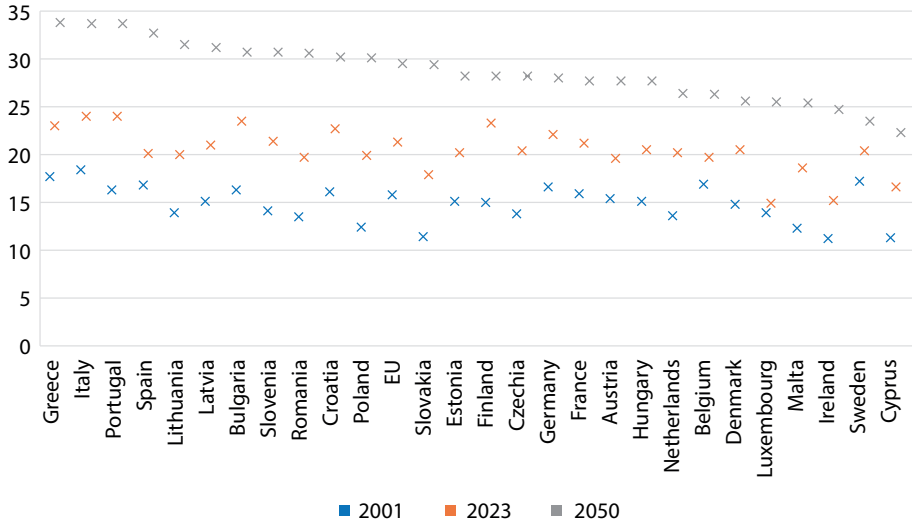

Figure 1. Population aged 65 and older (as % of the total population) in European Union countries in 2001, 2023 and 2050

Source: own calculations with data from Eurostat.

The growing proportion of older adults in the population drives the development of the silver economy, which is focused on meeting the needs of older individuals, especially retirees (Niemczyk et al., 2023). Financial well-being is a crucial aspect of this economy. The Consumer Finance Protection Bureau (CFPB), an agency of the United States government responsible for consumer protection in the financial sector, defines financial well-being as a state where individuals can meet current and ongoing financial obligations, feel secure in their financial future, and make choices that allow them to enjoy life

(CFPB, 2015, 2017). Financial well-being implies having financial security and financial freedom of choice, both in the present and in the future. Financial well-being includes four elements presented in Table 1. One of the proxies of financial well-being connected with security and the present situation is the ability to make ends meet.

Table 1. The four elements of financial well-being

	Present	**Future**
Security	Control over your day-to-day, month-to-month finances (ability to make ends meet)	Capacity to absorb a financial shock
Freedom of choice	Financial freedom to make choices to enjoy life	On track to meet your financial goals

Source: (CFPB, 2017, p. 7).

In recent statistical studies, significant variations have been observed across European countries regarding the populations' ability to make ends meet. The Eurostat Report highlighted that during the second quarter of 2022, the percentage of people who could easily make ends meet ranged widely, from as low as 3.6% in Bulgaria to 40.5% in Finland (Eurostat, 2022a). Eurostat data regarding the ability of individuals aged 65 and over to make ends meet in Spain, Poland, and Denmark indicated distinct differences across these countries. Denmark demonstrated a highly favourable scenario, with 43% of its older population finding it fairly or very easy to manage financially, reflecting a supportive environment for financial stability in old age. Conversely, in Poland, a significant portion (28.1%) faced greater difficulty in managing financially, indicating potential economic challenges for the senior population. Spain presented a more balanced situation; although a notable segment find it fairly easy, another group struggles to some extent. These findings underscore the diverse economic challenges for older individuals in different EU countries, emphasising the need for tailored financial support and policies to ensure older citizens can manage their finances adequately.

Despite extensive research on the relationship between financial well-being and various determinants, there remains a gap in understanding the comprehensive range of factors influencing retirees' ability to make ends meet. This study aims to address this gap by examining a broad spectrum of socio-economic determinants, social relations, health, household resources, and lifestyle which affect financial well-being among retirees aged 65 to 79 in Poland, Spain, and Denmark. The target group includes retirees aged 65–79 because this age range, known as the Third Age, is characterised by relatively better health, greater mobility, and social activity compared to older indivi-

duals, allowing for a more comprehensive analysis of their financial situation. Additionally, people with this market status typically have stabilised income sources from pensions, enabling a detailed examination of the determinants of their financial well-being.

By leveraging data from the SHARE (Survey of Health, Ageing and Retirement in Europe) survey and employing advanced statistical methods like Light Gradient Boosting Machine (LightGBM) and SHAP values (SHapley Additive exPlanations), this study seeks to provide a nuanced understanding of these relationships.

These insights could be valuable for policymakers, highlighting the need to consider a broad array of factors beyond the purely economic to fully understand the dynamics of making ends meet. Moreover, this study compares the financial capacity of individuals in Poland, Spain and Denmark—countries with different levels of ability to make ends meet and with varying ageing patterns. The results can contribute to a deeper understanding of the challenges faced by older individuals, which can also prove informative for entities in the silver economy.

Section 1 of this paper provides insight into ageing and retirement in Denmark, Poland, and Spain. The following part reviews the literature on financial security. Then, the paper discusses the dataset, research design, and methods. Section 4 is devoted to presenting the results. Finally, the study concludes with a critical discussion and conclusions.

1. Ageing population and retirement in Denmark, Poland, and Spain

Poland represents one of the fastest ageing populations in Europe, where the transition from a younger population to an older one is proceeding at a rapid pace. The change in the proportion of the population aged 65 and over from 12.4% in 2001 to 30.1% in 2050 gives a 17.7% change. Spain is also experiencing a significant increase in its proportion of the older population, from 16.8% in 2001 to 32.7% in 2050. In fact, this country has one of the highest projected percentages of older people by 2050. Denmark shows a moderate increase in the population aged 65 and over, from 14.8% in 2001 to 25.6% in 2050, with this 10.8 percentage point change reflecting a relatively balanced rate of population ageing. Trends in these three countries highlight the varying dynamics of population ageing across European countries, each with its own implications for silver economic planning and opportunities in the financial sphere, as well as in terms of financial well-being.

The employment rate for people aged 65 and over in Spain is currently 3.4%, in Poland 6.0%, and in Denmark 11.1% (European Commission, 2024). As a relatively small proportion of this age group remains economically active, the main source of income for people aged 65 and over in these countries is pensions. Therefore, people with this occupational status who are retired are analysed in this paper. Moreover, the pension systems in Poland, Denmark, and Spain differ significantly in their approaches and generate varying levels of pension adequacy. According to the Mercer report (Mercer, 2023), the Danish pension system, based on funded defined contribution schemes, is considered the best in the world and allows for the most adequate pensions (level A). The Polish system, based on notional defined contribution (NDC), is characterised by a low level of adequacy (C), while Spain's defined benefit system has an adequacy rated at an average level (B+). This has significant implications for the financial security of retirees in these countries.

Within the retired population aged 65 and over, it is crucial to distinguish between two subgroups: those aged 65–79, referred to as the Third Age, and those aged 80 and over, known as the "Fourth Age." This differentiation arises from significant disparities in health status, mobility, cognitive functions, and social and economic needs. Retirees aged 65–79 generally exhibit better health and greater mobility compared to those aged 80 and over, who are more likely to suffer from chronic illnesses and experience greater physical limitations (European Commission, 2024). Moreover, the social and economic aspects of life show marked differences between these groups. Retirees in the Third Age group often engage in social activities and maintain active social lives, whereas those in the Fourth Age group may face greater social isolation due to health problems and mobility restrictions. Financially, individuals in the Third Age group typically rely on pensions and savings for income, whereas those in the Fourth Age may incur higher expenses for healthcare and long-term care, impacting their financial stability (European Commission, 2024). Due to these significant differences, this article focuses on the 65–79 age group, treating it as a homogeneous cohort with similar needs.

2. Financial well-being among retired people: A literature review

The existing evidence from the international literature on financial well-being among retirees highlights the multifaceted nature of this issue, encompassing financial, health, and social dimensions. Income is a key factor in determining whether households can cover their present financial security (Badri et

al., 2022). As household income increases, the ease of covering expenses also grows (Hébert & Gyarmati, 2014). Individuals with lower incomes often find themselves more concerned with meeting their financial needs compared to those with higher incomes, both in general and in terms of personal finance (Johar et al., 2015; Kahneman & Deaton, 2010). The European Commission's report (European Commission, 2021) links the ease of meeting financial obligations to income, as well as factors like living conditions, including material deprivation, housing, living environment and access to services.

Working households, while generally having higher incomes and lower poverty levels, can still face material challenges impacting their financial stability (Danziger & Wang, 2005). The COVID-19 pandemic further strained the financial capabilities of lower-income households, making it harder for them to meet their needs (Albuquerque et al., 2022). The COVID-19 pandemic's impact on financial stability is also highlighted in surveys by Pew Research Centre (Horowitz et al., 2021; Parker et al., 2020) and reports by OECD (OECD, 2021).

Gumà-Lao (2022) and Nolen-Hoeksema et al. (2008) find a crucial link between the ability to make ends meet and the aggravation of mental health problems. Artazcoz et al. (2021) report a significant association between making ends meet and poor self-perceived health status and psychological well-being. Similarly, Marjanovic et al. (2015) and Netemeyer et al. (2018) provide evidence for the mediating role of financial capability in mental health and well-being. Social networks, as explored by Gray (2009) and Tilly (2012), are also a vital factor in the ability to make ends meet. The literature also examines variations in this ability across different household segments, with the Consumer Financial Protection Bureau (CFPB, 2020) and studies by Heflin (2016) and Tur-Sinai et al. (2022) focusing on demographic factors such as age and gender. The CFPB (2020) report highlights age as a critical factor in financial well-being. Older adults often face unique challenges, such as fixed incomes from pensions or social security, which may not keep pace with inflation or rising living costs. Additionally, unexpected health expenses can greatly affect older individuals, leading to increased financial strain. Heflin (2016) further explains that financial security can decline as people approach retirement age without sufficient savings. The gender dimension of financial well-being, as explored by Tur-Sinai et al. (2022), reveals that women often face greater financial challenges compared to men.

Silberman-Beltramella et al. (2022) look at the interplay between social relations, health, and socio-demographic factors among older people in Spain. Using data from the SHARE survey, this study emphasises the crucial role of social relations in the health and well-being of older people. It provides a comprehensive analysis of how these variables interact and impact the lives of older adults. Similarly, Serrano et al. (2014) explore demographic changes in Spain, highlighting the trend towards the ageing population. This research touches on economic aspects, living conditions, and poverty rates

among older individuals. It notes that most older adults live with others, typically a spouse or family members, although there is a growing trend of older adults, especially women, living alone. This situation presents unique challenges in terms of health, social relations, and economic well-being in Spain.

In exploring the factors affecting the ability to make ends meet in Poland, recent literature offers diverse perspectives. Dudek and Wojewódzka-Wiewiórska (2023) analyse the socioeconomic dynamics during the initial year of the COVID-19 pandemic, using data from the EU-SILC survey. Their findings indicate increased difficulty in making ends meet, results that are influenced particularly by factors such as household type, education level, urbanization, and the presence of disabled and unemployed household members. This study underlines the increased vulnerability of specific demographic groups, such as single-parent households and those with limited education or employment opportunities. The study conducted for the BIG InfoMonitor Debtors Register (BIG InfoMonitor, 2021) reveals a slight decrease in the percentage of Poles struggling to meet financial obligations in 2020 compared to 2019. However, a significant proportion of the population still expressed concerns about covering basic expenses. Complementing these insights, a report by Badowski (2022) analyses the changing consumer behaviour in Poland in response to the economic impacts of the COVID-19 pandemic and geopolitical factors like the Ukraine conflict. The report indicates a trend towards more modest lifestyles, with increased spending on necessities such as food and healthcare, and decreased expenditure on lifestyle-related categories. This shift reflects a broader trend of consumer adaptation in the face of economic uncertainties and shifting priorities. These studies highlight the importance of considering a range of factors, including demographic variables, socioeconomic status, and broader economic conditions, to understand the complexities of financial stability in Poland.

Brünner and Andersen (2018) provide valuable insights into the lives of older individuals (aged 69 to 85) in Denmark who face financial challenges, shedding light on their personal experiences, coping strategies, and the societal and historical factors that influence their current situations. They explored in particular the experiences of older people living in relative poverty and sought to understand how they manage their daily lives and financial challenges. A study by Meng et al. (2020) points out that the financial situation of older Danish people is interconnected with various factors like health, desire for leisure, and economic status. Poor health can lead to earlier retirement due to the inability to work, impacting financial stability. Similarly, a strong desire for leisure time influences the decision to retire, which can affect financial resources in later life. Economic considerations, including savings and pension plans, also play a crucial role in determining the financial well-being of retirees.

In terms of methodology, many empirical studies have investigated the determinants of the ability to make ends meet using various regression methods: logistic regression (Dudek & Wojewódzka-Wiewiórska, 2023), hierarchical multiple regression (Badri et al., 2022). Other popular methodologies include a series of fixed effects models (Wilkinson, 2016), and OECD methodology (Sconti, 2022). Some researchers also used life story interviews (Brünner & Andersen, 2018). This study employs the machine learning method Light Gradient Boosting Machine and SHAP values, which offers new possibilities in the area of statistical analysis.

Based on the literature review, this study aims to address the following research questions:

RQ1: What are the differences in the ability to make ends meet between retirees in the Third Age group in Poland, Spain, and Denmark?
RQ2: What are the main determinants of financial well-being for retirees in Poland, Spain, and Denmark?
RQ3: How do various socio-economic, health, and social network factors influence the ability to make ends meet among retirees?
RQ4: What new possibilities for statistical analysis in studies on the ability to make ends meet do machine learning methods like Light Gradient Boosting Machine and SHAP values offer?
RQ5: How can the findings of this study contribute to a better understanding of the challenges faced by older individuals, and what insights can be drawn for stakeholders in the silver economy?

These research questions guide the study's exploration of financial well-being among retirees, using advanced analytical methods to provide comprehensive insights into the factors influencing their financial stability and offer valuable recommendations for policy and practice.

3. Data and methodology

3.1. Data, variables and procedure

The data used for this study is from wave 8 of the SHARE panel survey carried out in 2019 and 2020 (Bergmann & Börsch-Supan, 2021; Börsch-Supan, 2022; SHARE ERIC, 2024) conducted in European countries by the European Research Infrastructure Consortium (ERIC) coordinated at the Munich Research Institute for the Economics of Ageing. The SHARE survey aims to understand individual health, social, economic, and family networks during the lives of

citizens aged 50 and over in Europe and beyond. In the study, retired Polish, Spanish, and Danish respondents aged 65–79 who participated in the interview were selected for the sample. These countries were selected because of their statistically different patterns of ageing and also for their financial conditions in aspects regarding the ability to make ends meet (Figure 2). Spain is just beneath the mean, suggesting that its citizens face a slightly greater difficulty in making ends meet compared to the average for EU countries. Denmark stands out with great ease in making ends meet, well above the average, whereas Poland is positioned towards the lower end, indicating that Polish pensioners find it more difficult to make ends meet compared to the majority of the countries in the chart, including Spain.

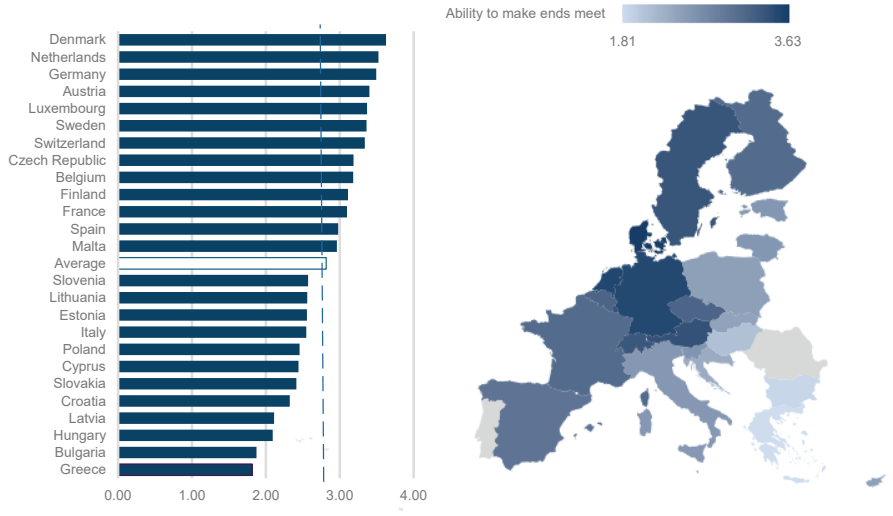

Figure 2. Ability to make ends meet of retired people in age 65–79 in European countries

Source: own calculations with data from SHARE Survey.

The total size of the sample is 2,681, with 938 pensioners from Poland, 954 from Denmark, and 789 from Spain. Approximately 55% of the sample in Poland identified as female, 42% in Spain, and 55% in Denmark (Table 2). Because, according to the *t*-test, there are no significant statistical differences in the ability to make ends meet between males and females across all three countries, the analysis is not done separately for the two sexes.

The dependent variable in the current analysis is the respondent's current ability to make ends meet, considered a subjective proxy of financial well-being. This variable is achieved as the result of the answer to the question: "Thinking of your household's total monthly income, would you say that your household is able to make ends meet with great difficulty (value 1), with

Table 2. Ability to make ends meet by gender

Country	Gender	N	M	SD
Denmark	male	432	3.63	0.633
	female	522	3.62	0.633
Poland	male	419	2.53	0.801
	female	519	2.40	0.792
Spain	male	455	2.97	0.894
	female	334	2.99	0.897

Source: own calculations with data from SHARE Survey.

some difficulty (2), fairly easily (3), with ease (4)". The study focused on the relationship with socio-demographics determinants. The explanatory variables characterised the situation of retirees in the following 19 modules: Demographics, Children, Social Networks, Social Support, Education, Physical Health, Behavioural Risks, Cognitive Function, Mental Health, Health Care, Consumption, Pensions, Housing, Household Income and Expenditure, Assets, Informal Technology, Financial Transfers, Activities, Time Expenditure. One of the explanatory variables is the CASP index (Control, Autonomy, Satisfaction, Pleasure), which holistically and integratively describes subjective and psychological well-being during early old age. This variable has been included as an explanatory factor for making ends meet because the relationship between financial security and overall well-being is complex and reciprocal. Better mental health can lead to higher levels of overall well-being, enhancing an individual's ability to work and earn money. Improved subjective well-being can also enhance the ability to cope with financial challenges. The complete list contains of 167 variables.

The first phase of this study presents descriptive statistics that analyse the ability to make ends meet in Poland, Spain and Denmark. Following this, the research details the accuracy of forecasts generated by a Light Gradient Boosting Machine model. This model uses financial capability as a dependent variable to predict overall financial well-being in each country. The final phase involves calculating SHAP values to assess the importance of various independent variables in these nations. The analysis employs statistical software packages SPSS and R throughout the study.

3.2. Method

Gradient Boosting Decision Trees (GBDT) (Friedman, 2001) have been highlighted by many researchers (Madakkatel et al., 2019; Sarker, 2021; Seto et al., 2022; Watanabe et al., 2023) as a highly effective method in various machine learning applications, particularly in scenarios involving large datasets and the need for high predictive accuracy (Olson et al., 2017). In the initial phase of the algorithm, a simple decision tree is constructed. Using information from the quality of this tree, subsequent trees are built iteratively to correct residual errors from previous models. Each new tree aims to remove the cumulative errors of its predecessors, thereby progressively improving the model. A gradient is used to systematically steer corrections in an optimal direction, increasing the efficiency of the learning process. Through this process, we ensure the development of a robust and accurate predictive model. This methodology is known as gradient boosting, in which each iteration gradually improves the accuracy of the model by focusing on correcting previous errors. The algorithm optimises the following objective function:

$$L^{(t)} = \sum_{i=1}^{n} l\left(y_i, \hat{y}_i^{(t-1)} + f_t(x_i)\right) + \Omega(f_t)$$

where l is a differentiable loss function that measures the difference between the actual and predicted values, Ω is a regularization term to avoid overfitting, y_i are the actual values, $\hat{y}_i^{(t)}$ are the predicted values, $f_t(x_i)$ represents the new function added in the t-th iteration to improve the prediction, x_i is the feature vector of the i-th observation in the training set, n is the number of observations, and t is the number of iteration (Chen & Guestrin, 2016). The first part measures the fit of the model to the training data. The second part is a regularisation term that penalises the complexity of the newly added tree.

The present study employs the Light Gradient Boosting Machine (LightGBM) algorithm (Ke et al., 2017), selected for its noted computational efficiency and accuracy preservation. This method was developed by Microsoft in 2016 as an efficient and scalable version of the Gradient Boosting algorithm (LightGBM Documentation, 2024). LightGBM grows trees leaf-wise (Best-first) rather than level-wise, leading to a more accurate model (Figure 3).

Figure 3. Decision tree learning algorithms—the tree growth process

Source: (LightGBM Documentation, 2024).

During each iteration, LightGBM minimises the following approximate objective:

$$\tilde{L}^{(t)} = \sum_{i=1}^{n} \left[g_i f_t(x_i) + \frac{1}{2} h_i f_t(x_i)^2 \right] + \Omega(f_t)$$

where g_i and h_i are the first and second order derivatives of the loss function with respect to the predictions. LightGBM enhances the efficiency of the model and reduces memory usage by incorporating two novel techniques: Gradient-based One-Side Sampling (GOSS) and Exclusive Feature Bundling (EFB), which address the limitations of the conventional GBDT techniques such as XGBoost or AdaBoost without sacrificing accuracy (Ke et al., 2017). More technical details about the GOSS and EFB techniques, which make the LightGBM the state-of-the-art for many applications, are explained by Ke et al. (2017).

Classification algorithms were used to determine the categorical dependent variable: ability to make ends meet. Model performance was quantified using the metrics of Area Under the Receiver Operating Characteristic Curve (AUC) and Accuracy. Furthermore, a 10-fold cross-validation method was implemented to establish confidence intervals for these performance indicators, thereby ensuring the robustness of the predictive model (Madakkatel et al.,

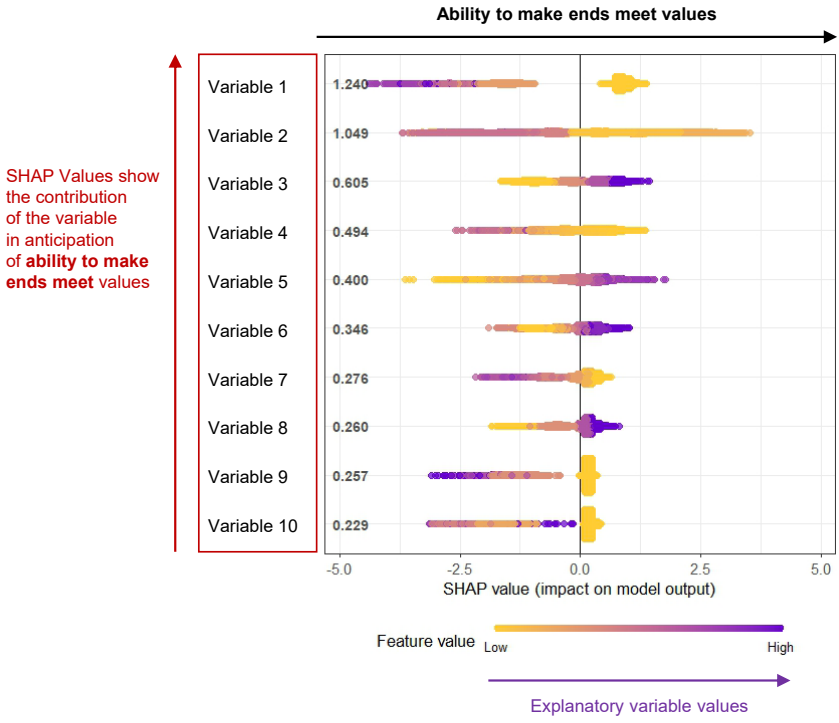

Figure 4. SHapley Additive exPlanations—sample chart

Source: own work.

2019). Important features in the LightGBM model were recognised using the SHAP values (SHapley Additive exPlanations) (Lundberg & Lee, 2017) calculated by a method derived from game theory (Figure 4).

The feature importance calculation for classification is based on how much the prediction value changes on average if the feature in question changes in its values. The bigger the changes in the prediction, the greater the feature importance. The SHAP summary plot illustrates the importance and impact of variables in the predictive model. The vertical position of a variable indicates its importance, with the most significant at the top. The horizontal spread shows the direction and extent of a variable's impact on the model's output, where rightward points suggest a positive influence on the dependent variable (the ability to make ends meet), and leftward points suggest a negative influence. The colour coding reflects the independent variable value, helping to visualise how low and high values of each variable affect the prediction.

4. Results

Figure 5 presents data highlighting disparities in financial conditions among the three countries selected. It reveals that individuals in Poland are more prone to facing difficulties in fulfilling basic financial needs, with 53% experiencing some or significant challenges in maintaining financial security. In contrast, Denmark shows the lowest percentage of individuals struggling financially: a mere 6% of the Danish population reports difficulties in meeting

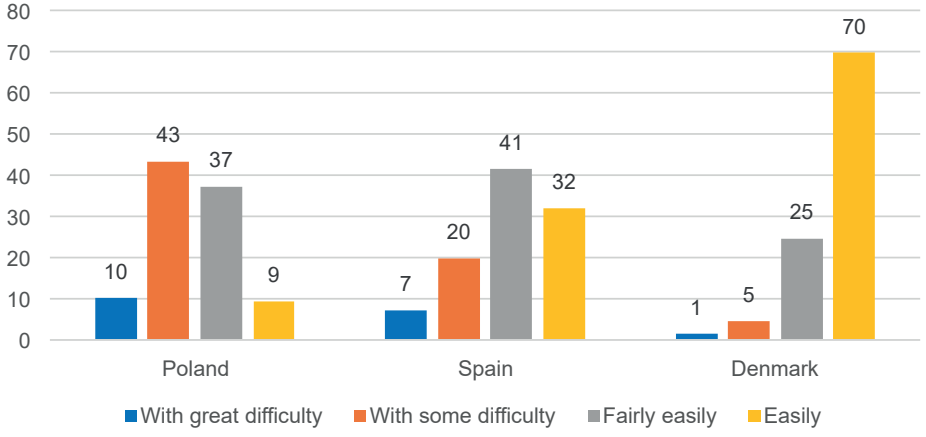

Figure 5. Ability of retired people aged 65–79 to make ends meet in Poland, Denmark, and Spain (in percentage of overall sample)

Source: own calculations with data from SHARE Survey.

basic financial needs. Spain displays moderate variation, with 27% of retirees in the Third Age group encountering challenges with their current finances. Therefore, the ability to make ends meet varies markedly among pensioners in Poland, Spain, and Denmark.

Figure 6 illustrates the importance and slope of the explanatory variables for LightGBM regressors. For the features across all three countries, approximately 30 of them begin to register a zero-importance score (Tables 3–5). This indicates a threshold in feature selection where the model's performance starts to stabilise. It is instrumental in the process of selecting the most important features, helping to determine the number of features that impart significant information to the model, and identifying the juncture at which additional features cease to substantially enhance the model's performance. Additionally, it serves as a visual tool to illustrate the variations in feature importance across different countries, highlighting how the most predictive features can differ depending on the particular country being analysed.

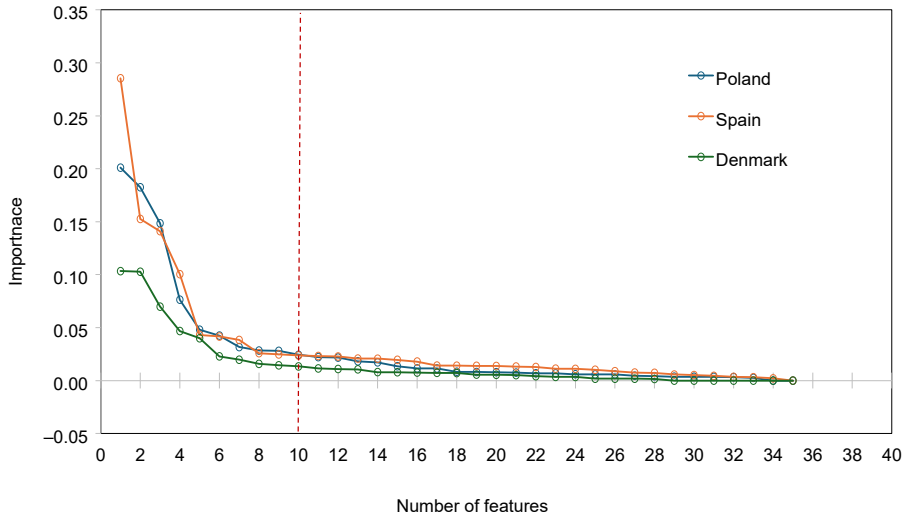

Figure 6. Importance of features affecting the ability to make ends meet

Source: own calculations with data from SHARE Survey.

As the number of features increases, the importance of the remaining features decreases. The importance scores for Poland and Spain are higher, separate from Denmark's curve at the beginning, and start to be similar as the number of features increases. Spain's importance scores decrease noticeably when the number of features increases to more than about five, indicating that the initial features are highly significant for the Spanish model. A very similar situation applies to Poland, but the first feature is less important than in the case of Spain. Denmark's curve remains relatively flat throughout the

six features. The point where the shape of the curves changes direction is referred to as the 'elbow' of the plot and is identified as the point of inflection, showing that the models rely on a few features. For all the countries studied, the curves begin to plateau after the inclusion of more than 10 characteristics, suggesting minimal additional importance beyond these features. Consequently, the first 10 significant features were selected for further analysis, as indicated by the vertical dashed line in the representation.

To demonstrate the precision of the learning models, Accuracy and AUC (Area Under the Curve) metrics for were calculated binary classification in the three countries. The accuracy metric for Poland reveals that the classifier accurately predicts outcomes 47.49% of the time. In Spain, the accuracy is lower at 43.98%, indicating that the model's predictions are less reliable. In contrast, Denmark shows a considerably higher accuracy rate of 62.32%, suggesting better model performance. According to the AUC (Area Under the Curve) results, the LightGBM binary classifier is most effective in Spain (0.6627). The model's performance is least effective in Poland (0.5077), while in Denmark (0.6536), it is moderate, with an AUC significantly better than Poland and closely following Spain.

4.1. Feature importance in Denmark

Table 3 shows all important variables for the ability to make ends meet in Denmark. The SHAP summary plot for Denmark (Figure 7) illustrates how different features influence the output of the LightGBM model. The most impactful features for financial present security are CASP, a measure of quality of life in older age, and household net worth, both of which positively impact the ability to make ends meet. Additionally, the third feature, total monthly household income, and the fifth feature, household size, have a positive impact. Mortgage on main residence, value of main residence, and value of old age pension have a lower impact on the model output and a negative influence on the ability to make ends meet. Among the top 10 features in the LightGBM model for Denmark, besides total household income, those related to finances include household gross financial assets, household net financial assets, and value of old age pension.

However, features such as household net worth, mortgage on main residence, value of main residence, and rent and home-related expenditures are related to the finances of the property owned. Only two features (CASP and household size) do not fall within this category. In Denmark, the most important factors for the ability of retired people to make ends meet, apart from quality of life and financial resources, are connected with housing-related financial resources.

Table 3. Performance of LightGBM binary classifiers. Variable importance in Denmark

Number	Feature	SHAP
1	CASP index for quality of life and well-being	0.1033
2	Household net worth	0.1028
3	Total household income—Version B	0.0698
4	Household gross financial assets	0.0468
5	Household size	0.0400
6	Household net financial assets	0.0229
7	Mortgage on main residence	0.0197
8	Value of main residence	0.0158
9	Rent and home-related expenditures	0.0144
10	Old age, early retirement, and survivor pensions	0.0134
11	Financial liabilities	0.0115
12	Age in 2020	0.0110
13	EURO depression scale	0.0106
14	Income from non-responding partner	0.0080
15	Children in the social network—count	0.0079
16	Total household expenditure	0.0076
17	Maximum of grip strength measures	0.0073
18	Amount spent on food at home	0.0071
19	Ever smoked daily	0.0057
20	Number of men in the social network	0.0055
21	Average contact with others in the social network	0.0052
22	Score of orientation in time test	0.0041
23	Time expenditure: paid work (mins)	0.0035
24	Health literacy: how often help needed	0.0034
25	Siblings in the social network—count	0.0018
26	The social network size in wave 8	0.0018
27	Gender	0.0018
28	Number of children	0.0016

Source: own calculations with data from SHARE Survey.

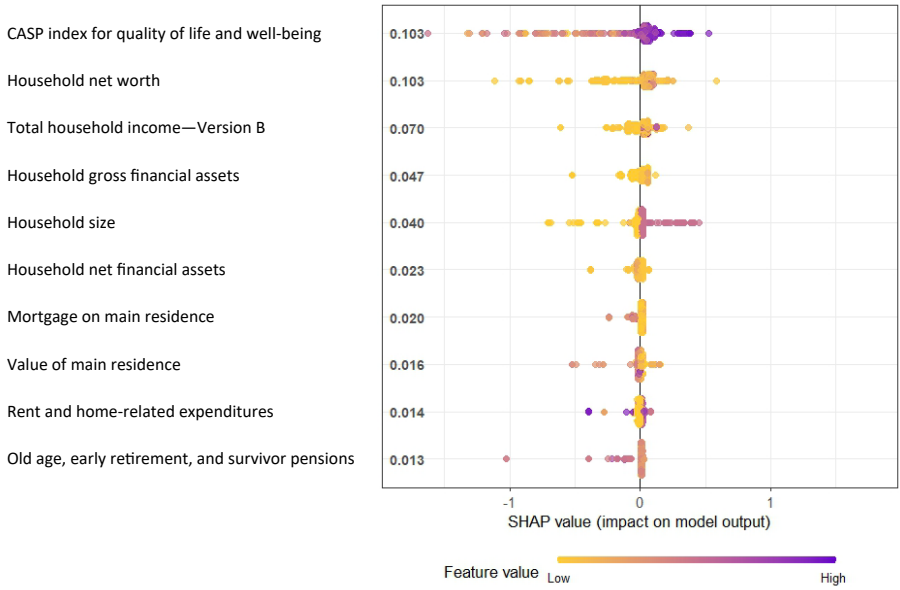

Figure 7. Importance of features influencing the ability to make ends meet in Denmark

Source: own calculations with data from SHARE Survey.

4.2. Feature importance in Poland

Table 4 presents all the important variables for ability to make ends meet in Poland. Figure 8 illustrates the direction and magnitude of the top 10 features in the classification of financial stability in Poland, as per the LightGBM model. The most influential features are the total household level of all individual income components, CASP, and total monthly household income. These three features, along with the number of financial gifts given worth 250 € or more, display a broad range of SHAP values, predominantly positive, suggesting that higher values correlate with an improved ability to make ends meet.

Notably, total household income demonstrates a significant spread in SHAP values, reflecting varied impacts based on the specific value of the feature. This spread indicates potential interactions with other features or a non-linear relationship with the dependent variable. Other features, such as the number of financial gifts given worth 250 € or more and household net financial assets, exhibit more vertical clustering around the zero line, denoting a more consistent but small impact on the LightGBM model's output.

In addition to two income-related variables, the model for Poland includes three other financial variables: number of financial gifts given worth 250 € or more, household net financial assets, and funds in bank accounts.

Table 4. Performance of LightGBM binary classifiers. Variable importance in Poland

Number	Feature	SHAP
1	Total household income—Version A*	0.2010
2	CASP index for quality of life and well-being	0.1825
3	Total household income—Version B*	0.1485
4	Number of given financial gifts 250 € or more	0.0764
5	Household net financial assets	0.0481
6	Area of building	0.0425
7	Number of children	0.0316
8	Funds in bank accounts	0.0284
9	Amount spent on food at home	0.0281
10	Frequency of dairy products consumption	0.0243
11	Social network members' year of birth—average	0.0222
12	Household gross financial assets	0.0217
13	Value of main residence	0.0182
14	Score of orientation in time test	0.0172
15	Seen/Talked to medical doctor in the last 12 months	0.0136
16	Network relationship to the closest person	0.0115
17	Weight	0.0115
18	Value of home-produced food	0.0084
19	Maximum of grip strength measures	0.0081
20	Appetite	0.0080
21	Average contact with siblings in the social network	0.0076
22	Health literacy: how often help needed	0.0069
23	Loneliness (short version of R-UCLA Loneliness Scale)	0.0069
24	Score on word list learning test—trial 2	0.0060
25	Number of the social network members with weekly contact or more frequently	0.0059
26	Activities requiring a moderate level of energy	0.0058
27	Total household expenditure	0.0047
28	Number of grandchildren	0.0042
29	Years of education	0.0037
30	Body mass index	0.0036
31	Age in 2020	0.0035
32	Age of partner in 2020	0.0033
33	Gender	0.0026

* The total household income is represented by two measures of this variable. The first measure (Total household income—Version A) is obtained by aggregating all individual income components at the household level, while the second measure (Total household income—Version B) is derived from a single question on monthly household income. There are no strong arguments for preferring one measure over the other. The availability of these two alternative measures provides complementary information on household income.

Source: own calculations with data from SHARE Survey.

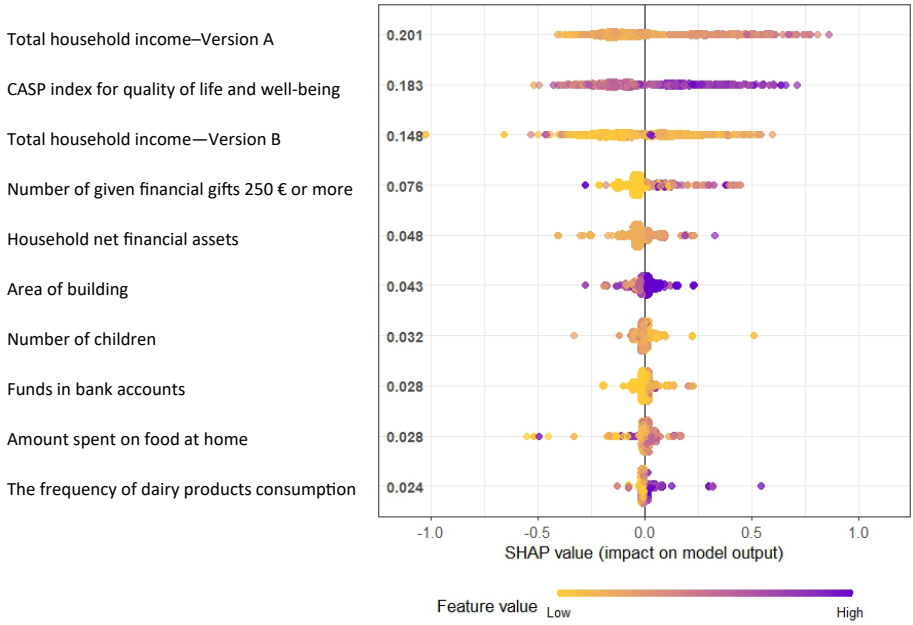

Figure 8. Importance of features influencing the ability to make ends meet in Poland

Source: own calculations with data from SHARE Survey.

Non-financial variables in the model encompass CASP, area of the building, number of children, annual food at home consumption, and the frequency of dairy product consumption. The area of the building and annual food at home consumption impacts the model's predictions rather positively, whereas the number of children tends to negatively affect the model's output. In Poland, distinctive features include the number of children and home lifestyle aspects, particularly in relation to food expenditure at home.

4.3. Feature importance in Spain

Table 5 shows all important variables for ability to make ends meet in Spain. Figure 9 presents the SHAP values derived from the LightGBM model for Spain. As with the findings for Poland, the total household level of all individual income components and total monthly household income, both income-related features, emerge as the most important. The graph, marked by purple dots, indicates that higher income levels correlate with an enhanced capacity to make ends meet. This visualisation reveals that for most features higher values generally contribute positively to present financial security.

Table 5. Performance of LightGBM binary classifiers. Variable importance in Spain

Number	Feature	SHAP
1	Total household income—Version A	0.2854
2	Total household income—Version B	0.1526
3	Amount spent on food outside home	0.1411
4	Funds in bank accounts	0.1005
5	Household gross financial assets	0.0432
6	Number of chronic deseases	0.0416
7	Time expenditure: leisure (mins)	0.0384
8	Feels left out	0.0259
9	Interest/dividend from bank account, bond, stock and mutual funds	0.0247
10	Funds in bond, stock and mutual funds	0.0237
11	Value of main residence	0.0233
12	Percentage of house owned	0.0227
13	The frequency of legumes, beans or eggs consumption	0.0208
14	Household real assets	0.0207
15	Old age, early retirement, and survivor pensions	0.0196
16	Number of given financial gifts 250 € or more	0.0180
17	The social network members proximity—average	0.0142
18	Value of cars	0.0141
19	Height	0.0140
20	Amount spent on food at home	0.0138
21	Body mass index	0.0133
22	Maximum of grip strength measures	0.0128
23	Years of education	0.0113
24	Male or female	0.0111
25	Total household expenditure	0.0103
26	The social network members year of birth—average	0.0089
27	Network relationship to the closes person	0.0076
28	At least taking 5 different drugs a typical day	0.0074
29	Number of children	0.0057
30	Age in 2020	0.0052
31	Area of building	0.0045
32	Number of grandchildren	0.0035
33	Number of women in the social network	0.0032
34	Household size	0.0021

Source: own calculations with data from SHARE Survey.

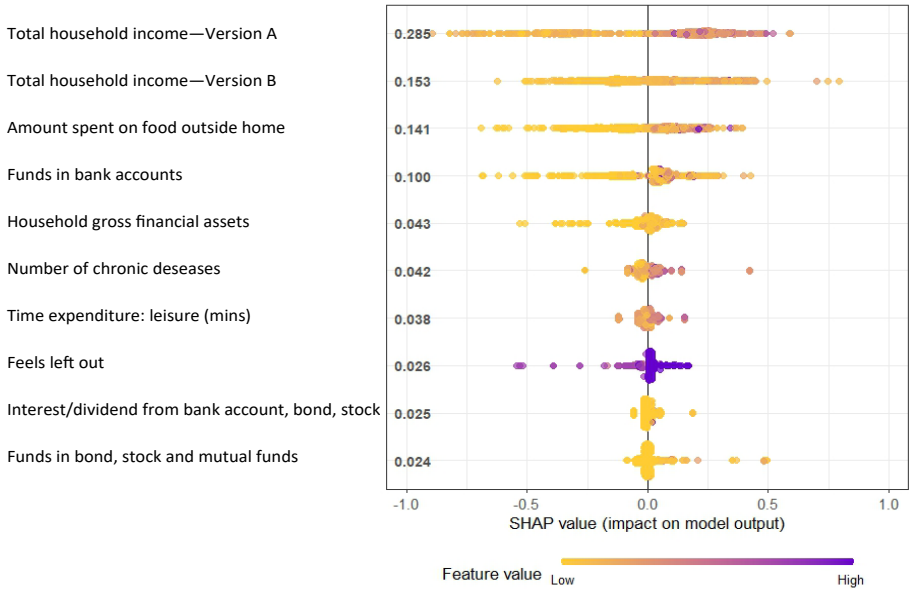

Figure 9. Importance of features influencing the ability to make ends meet in Spain

Source: own calculations with data from SHARE Survey.

A notable observation is the strong positive correlation between annual food outside home consumption and the dependent variable, suggesting that increased expenditure on eating out is linked to better finance present security. Feeling left out shows a limited range of SHAP values, signifying a consistent impact on financial stability. Among the most influential variables are two related to household income and four other financial aspects: funds in bank accounts, household gross financial assets, interest from bank accounts, and government/corporate bonds. Non-financial features, apart from the amount spent on food outside home and feeling left out, include the number of chronic diseases and time spent on leisure activities, measured in minutes. The distinctive factors for Spain, as highlighted by this model, are connected to health and lifestyle aspects, particularly in relation to spending on dining out and leisure time allocation.

Conclusions

This paper provides comprehensive insights into the financial well-being of retirees aged 65–79 in Poland, Spain, and Denmark, and answers several

critical research questions. In responding to the first research question regarding the differences in the ability to make ends meet among retirees in Poland, Spain, and Denmark, it is apparent that the financial well-being of retirees varies significantly between these countries, which is consistent with the Eurostat report (Eurostat, 2021). In Denmark, retirees generally find it easier to manage their finances, primarily due to higher household incomes and substantial social welfare systems. In contrast, a larger percentage of retirees in Poland face difficulties making ends meet, with financial challenges being more widespread. Spain falls between these two extremes, with moderate challenges influenced by cultural and economic factors.

With regard to the second research question, the study identifies several key determinants of financial well-being for retirees. Household income is a primary factor across all three countries. Higher incomes correlate strongly with better financial stability. Additionally, the research findings align with literature expectations, indicating that past financial resources, such as savings and household assets, are essential in determining the capacity to meet present financial security across various countries (Badri et al., 2022; Hébert & Gyarmati, 2014). In Denmark, housing costs are a major concern, with housing expenses consuming a substantial portion of retirees' budgets. According to the Eurostat data (Eurostat, 2022b), all housing expenses account for as much as 29% of retired Danes' household budgets. In Spain and Poland, food-related expenses play a more significant role. Polish retirees spend more on in-home food, while Spaniards allocate a larger share to dining out.

Taking into account the third research question, which aims to determine how various socio-economic, health and social network factors influence retirees' ability to make ends meet, the study confirms the results of other studies, namely that the critical factors influencing financial security are the mental and physical health features (Artazcoz et al., 2021; Marjanovic et al., 2015; Netemeyer et al., 2018). However, the impact of these variables varies across different countries. In Poland and Denmark, overall quality of life, encompassing both mental and physical health, is closely linked to financial security. However, in Spain, individual health aspects, such as chronic diseases, have a more pronounced impact. Social network factors, like support from family and friends, also play a critical role in financial well-being, although their influence varies across the countries.

Considering the fourth research question, which explores what new possibilities for statistical analysis in studies on the ability to make ends meet are offered by machine learning methods like Light Gradient Boosting Machine and SHAP values, the study demonstrates that these techniques enable a more nuanced understanding of the factors influencing financial well-being. For instance, SHAP values help in identifying the most critical features and their respective impacts, offering a clearer picture of the determinants of financial security. This approach highlights the fact that while many features can

influence financial well-being, only about 30 show significant importance, streamlining the focus for policymakers.

The fifth research question concerns the contributions of this analysis to understanding the challenges faced by older individuals in maintaining financial security. The study indicates that for Poland targeted policies should focus on enhancing household income and providing financial planning services to maximise returns from savings and assets. Support for households with dependents is also crucial, as the number of children negatively affects financial stability. In Spain, strategies should prioritise income enhancement and financial asset stability, with a balanced approach to spending on lifestyle and leisure activities. Financial institutions could offer tailored products for retirees to maximise returns from bank accounts and bonds. In Denmark, retirement planning and financial literacy should be emphasised, with a particular focus on managing household net worth and property-related finances. Given the high value placed on well-being, healthcare and long-term care planning are essential for addressing the needs of the ageing population.

The analysis has limitations, primarily due to the reliance on pre-crisis SHARE data. The current polycrisis, including the COVID-19 pandemic, the war in Ukraine, and the economic crisis, likely affects retirees' financial well-being. Future research should examine these impacts and explore the financial security of retirees in other European countries. Additionally, examining the specific conditions of individuals over 80 years of age, who have distinct health needs, would provide further valuable insights.

The study provides comprehensive insights into the financial well-being of retirees in Poland, Spain, and Denmark. This paper underlines the associations between financial well-being and various socio-economic variables, offering distinct recommendations for stakeholders in the silver economy. By understanding how retirees manage their resources, policymakers can better address the financial challenges faced by the ageing population. The insights gained from this research highlight the importance of comprehensive financial planning, targeted support, and balanced lifestyle considerations in enhancing the financial well-being of older individuals.

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Linder hypothesis and India's services trade

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Abstract

This study examines the empirical validity of the Linder hypothesis for India's service sector exports from 2005 to 2021, focusing on 35 major importing countries. We use a gravity model trade, applying Feasible Generalised Least Squares (FGLS) and two-step system generalised method of moments (GMM), incorporating country- and time-fixed effects. Our results confirm that the Linder hypothesis does not hold for Indian service exports, revealing an increase in trade intensity between countries with dissimilar income levels. The study finds that distance has a positive and significant impact on Indian service exports. Exchange rates have a negative and significant impact on India's service exports, while the results for the RTA dummy variable are inconclusive. Sharing a common border, a common colony, and a language has a positive and significant effect on Indian service exports.

Keywords

- Linder hypothesis
- service export
- gravity model
- India

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Introduction

The proportionate contributions of the industry, agricultural and service sectors to the global economy have undergone significant changes over the past two decades. Nayyar et al. (2021) assert that in 2019, the service sector accounted for 55% of total output in developing economies and provided employment opportunities for 45% of the workforce. The contemporary evolution of global trade dynamics is characterised by a confluence of factors, including the reduction of trade barriers, increased fluidity in the movement of production factors, and a surge in investments in digital technologies. These combined forces are reshaping the traditional contours of trade, particularly in services. Recent estimates indicate a discernible trend wherein the growth rate of trade in services surpasses that of trade in goods, signalling a profound transformation in the structure and emphasis of international trade patterns (Loungani et al., 2017). Between 2006 and 2022, global service exports increased from USD 3.03 trillion to USD 6.95 trillion. Developing and emerging economies are major exporters and consumers of services, with India being the largest exporter (UNCTAD, 2022). Since 1991, the percentage share of service exports in India's Gross Domestic Product (GDP) has increased from 4.0% to 12.0% in 2020 (World Bank, 2022). Between 2008 and 2018, service exports in India increased by 94%, from USD 139 billion to USD 205 billion, while merchandise exports increased by only 66%, from USD 200 billion to USD 332 billion (World Bank, 2022).

India is the eighth largest exporter of commercial services and continues to register robust growth compared to other major service exporters globally (World Trade Organisation, 2018). Banga (2005) observes that India's significant increase in service sector growth has immense potential for employment generation and for promoting economic growth. The proliferation of modern service sectors, encompassing IT solutions, engineering, communication, and business services, has been noted to stimulate economic output, generate employment opportunities, and drive the expansion of service exports (Eichengreen & Gupta, 2013). India's service exports have grown significantly compared to other sectors of the economy, driven primarily by a combination of factors, including the deregulation of financial markets, tax concessions, and the creation of special economic zones (SEZs) (Sahoo & Dash, 2014, 2017).

The theoretical discourse on trade, such as Absolute Advantage theory (1776), Comparative Advantage theory (1817), and Factor Endowment theory (1919), underscores the significance of supply-side determinants in shaping trade patterns. These theories posit that relative disparities in labour and capital proportions utilised in production processes dictate trade dynamics.

In 1961, Linder posited that a similar demand structure between trading partners leads to more intensive trade in manufactured goods. Furthermore, nations with higher per capita incomes tend to prioritise high-quality prod-

ucts, thereby developing a comparative advantage in goods with strong domestic demand (home market effect) (Krugman, 1979, 1981). Building on this concept, Fajgelbaum et al. (2011) theoretically argue that, driven by the home market effect, countries specialise in specific commodities and engage in intensive trade with each other. Previous research has focused on evaluating the relevance of the Linder hypothesis within the manufacturing sector, particularly for developed nations', thus corroborating Linder's postulation. For instance, Chow et al. (1999) examined the trade patterns between New Industrial Countries (NICs) and OECD countries; Fajgelbaum et al. (2011) analysed trade between Germany and Korea; Francois and Kaplan (1996) investigated trade between the USA and major OECD countries; Rauh (2010) studied German trade with Europe; Thursby and Thursby (1987) explored trade in 17 countries; Jošić and Metelko (2018) investigated 184 Croatia's import partner countries, and Bo (2013) examined trade patterns in China.

Recently, a few studies have examined the applicability of the Linder hypothesis to the service sector. In this context, Wernerheim and Waples (2013) employed quarterly time-series data from 1961 to 2006 for Canada's three principal trade partners—the United States, the United Kingdom, and Japan. Their findings align with the Linder hypothesis, revealing that 83% of Canadian service trade is intra-industry. They also identify a significant causal relationship between per capita GDP and trade in commercial services. Similarly, Fu et al. (2020) explored the interplay among income similarity, bilateral trade in services, and income inequality across 173 countries and 11 service sectors from 1995 to 2012. Their study demonstrates that income similarity and levels of inequality positively influence bilateral trade in services at the aggregate level. However, they observe considerable heterogeneity across the 11 service sectors. In contrast, using the Tobit model, Braymen and Briggs (2015) examined the relationship between service trade and income similarity from 2000 to 2010 across 2,683 country pairs. Their results diverge from the Linder hypothesis, indicating that countries with dissimilar per capita income levels tend to engage more in bilateral trade in services. This suggests that empirical investigations into the impact of similar per capita GDP on service trade have produced mixed and inconclusive results.

Despite notable research on the application of the Linder hypothesis to the manufacturing sector in developed countries, there remains a significant gap in the literature regarding its application to the service sector in developing nations. Given the scarcity of empirical research in this critical and under-explored domain, this paper aims to address this gap by providing empirical evidence on the Linder hypothesis's applicability from a developing country perspective. Specifically, it evaluates the empirical validity of the Linder hypothesis for India, focusing on the period from 2005 to 2021 with its 35 major export partners. This research advances the trade literature and offers essential policy recommendations.

There are several compelling reasons for focusing on the application of the Linder hypothesis to service sector trade and specifically to India. Firstly, unlike goods, services are often intangible. These characteristic highlights the need to understand how countries specialise in certain services based on their comparative advantage, which drives inter-industry trade. Furthermore, the Global Value Chain (GVC) is particularly relevant in the service sector, where various stages of a service may be specialised across different countries. This specialisation significantly contributes to inter-industry trade in services, suggesting that similar demand patterns between countries do not necessarily lead to increased bilateral trade intensity in services. Secondly, the service sector plays a pivotal role in India's economy. Service sector accounted for 54% of India's Gross Value Added (GVA) and recorded a notable growth rate of 8.1% during the same fiscal year. Additionally, the sector contributed 34% of total employment during the 2017–2018. India also holds a prominent position in global service trade; in 2017, India was ranked eighth in exports and tenth in imports. Over the past decade, India's share of global commercial services exports has consistently increased, reaching 3.5% in 2017 (Ministry of Finance, Government of India, 2018).

The literature reveals that a few studies have explored the application of the Linder Hypothesis to the service sector using the gravity model (Braymen & Briggs, 2015; Fu et al., 2020). However, these studies exhibit several limitations. Firstly, their estimations have not addressed issues related to cross-sectional dependence, serial correlation, and panel group-wise heteroscedasticity. The estimated results produce bias in the presence of cross-sectional dependency, serial correlation, and heteroscedasticity (Marques & Fuinhas, 2012). Therefore, this study employed FGLS as the primary estimation method for its appropriateness in handling panel data with cross-sectional dependence, serial correlation, and heteroscedasticity (Nguyen et al., 2020). Secondly, their models have failed to account for potential endogeneity issues. Unlike prior research, the study employs a two-step system GMM to control unobserved heterogeneity, autocorrelation, dynamic endogeneity, and simultaneity (Blundell & Bond, 2000; Roodman, 2009). Thirdly, in contrast to previous research, we include a dummy variable for RTAs to evaluate their impact on India's service sector exports. RTAs often facilitate trade by reducing regulatory barriers and providing preferential access to member markets. They also encourage deeper economic integration, which can enhance trade flows. In this context, this study aims to answer the following questions: How does income similarity impact service trade? In other words, does Linder's hypothesis hold for the Indian service trade? Moreover, what impact do RTAs have on India's service exports?

The subsequent sections of the paper are structured as follows: Section 1 offers a literature review focusing on the applicability of the Linder hypothesis. Section 2 outlines the data sources, and Section 3 provides the analytical

framework employed in the study. Section 4 presents the results and discussions. The final section contains the study's conclusions, policy implications, and limitations.

1. Literature review

The factor-proportions model, proposed by Heckscher (1919) and refined by Bertil Ohlin (1933), Stolper, and Samuelson (1941), links trade patterns to relative factor endowments. Despite its influence, the model faces challenges, such as the "Leontief Paradox" (Leontief, 1953). In contrast, Linder's theory (Linder, 1961) emphasises demand-driven trade, suggesting that countries with similar factor endowments engage in trade due to overlapping demand.

Linder's (1961) demand-side proposition and the theoretical framework developed by Fajgelbaum et al. (2011) are prominent in trade literature. Linder's hypothesis suggests that countries with similar per capita incomes tend to have similar preferences and produce differentiated goods, leading to overlapping demand in trade, especially in manufacturing. However, the empirical validity of the Linder hypothesis remains ambiguous and contentious. The degree of empirical support for Linder's theory is debated within academic circles, leading to the emergence of two distinct strands of literature: one that supports Linder's hypothesis and another that challenges it.

Early examinations of the Linder hypothesis, notably by Sailors et al. (1973) and Greytak & McHugh (1977), yielded favourable results through rank correlation analysis. Their failure to incorporate regression analysis into their methodology has been scrutinised, as this analytical approach helps mitigate the confounding influence of distance on trade intensities. Although later studies have employed regression analysis to address the influence of geographic distance, the findings failed to conclusively validate the Linder model (Hoftyzer, 1984; Kennedy & McHugh, 1980, 1983; Qureshi et al., 1980). Nevertheless, a subset of studies, including those by Fortune (1971), Hirsch and Lev (1973), Kohlhagen (1977), Thursby and Thursby (1987), and Bergstrand (1990), support the Linder hypothesis.

Many studies have investigated the influence of income similarity on manufacturing trade. McPherson et al. (2000) found empirical support for Linder's hypothesis on demand similarity in 18 of the 19 OECD countries studied. Hallak (2006) developed a framework to investigate the influence of cross-country disparities in product quality on bilateral trade flows. Through empirical analysis, Hallak's studies confirmed that affluent nations tend to import proportionally more from exporting countries that offer high-quality products. Moreover, these studies highlighted how variations in product quality between countries

exert a substantial impact on the dynamics and direction of international trade flows. Dalgin et al. (2008), in their study focusing on the United States, Germany and Japan, employed cross-country panel regression analysis covering the years 2000 to 2006. Their results revealed that if income distribution in the United States resembled that of Canada, the United States would experience an increase of approximately 13–19% in essential goods imports and a decrease of 9–13% in luxury product imports. Rauh (2010) validated Linder's hypothesis by analysing German manufacturing trade flows with European countries using a gravity model with fixed effects from 2003 to 2008.

Few studies have investigated the applicability of the Linder hypothesis to developing economies, and those have yielded mixed results. In this context, Chow et al. (1999) and Hanink (1988) revealed support for the Linder hypothesis in their research on trade between four East Asian nations and OECD countries. The Hanink hypothesis, which posits that the Linder hypothesis provides a reasonable explanation for nations with incomes above a specific per-capita threshold, was corroborated by manufacturing exports from Singapore and Hong Kong between 1965 and 1990. Given the comparable per capita income levels in Singapore and Hong Kong to OECD nations, trade intensity between these regions and OECD countries exceeded that between Taiwan, Korea, and OECD nations (Chow et al., 1999). A study conducted in six East African countries—Ethiopia, Kenya, Tanzania, Rwanda, Sudan, and Uganda—from 1984 to 1992, using the Tobit model, supports the Linder hypothesis, except for the Tanzanian economy (McPherson et al., 2001). An empirical study by Atabay (2016), covering the period from 1996 to 2010 in BRICS nations, supports the Linder hypothesis. The application of Linder's argument to trade between China and ASEAN-5 countries presents mixed results (Siah et al., 2007). Conversely, empirical analysis of trade between China and its 14 trading partners aligns with this hypothesis (Bo, 2013).

Choi (2002) argues that globalisation significantly strengthens the Linder hypothesis. However, a study by Kitenge (2021) found that the Linder hypothesis has gradually lost relevance during the globalisation process. Hallak (2010) noted that the degree of income similarity positively influences trade contingent upon product quality. Bo (2013) and Viciu et al. (2016) suggest that trade patterns in the emerging Romanian economy are primarily influenced by the country's political and economic conditions, contradicting Linder's assertion. Haq and Meilke (2011) analysed the hypothesis in the agricultural food and beverage products trade across 52 developed and developing economies from 1990 to 2000. Their findings do not support the traditional Linder hypothesis.

Nevertheless, a few studies have documented the nexus between per capita income levels and service trade (Braymen & Briggs, 2015; Fu et al., 2020; Wernerheim & Waples, 2013), mainly from a developed country perspective, yielding mixed and inconsistent results. Overall, the literature survey suggests that most previous studies have focused on similar demand patterns and their

impact on manufacturing sector trade. However, due to the unique nature of services, it is assumed that similar per capita income levels are unlikely to generate more demand for trade in services. To our knowledge, no studies have examined the impact of an overlapping demand structure using various specifications of Linder terms on Indian service exports within the gravity model framework.

2. Data sources and measurement

The selection of countries was based on two criteria: the proportion of India's trade with its import countries and the availability of consistent annual data for service exports. Bilateral trade in services (million US dollars) data were collected from the OECD-WTO Balanced Trade in Services Statistics (BaTIS). Our variable of interest, GDP per capita (current US dollars), was sourced from the World Development Indicators (WDI) database. Data on common borders, common languages, colonial ties, and distance (kilometres) were obtained from the Centre d'Études Prospectives et d'Informations Internationales (CEPII) developed by (Mayer, & Zignago, 2011). The common border variable assumes a value of 1 if the reporter and partner country share a common border and 0 otherwise. Similarly, the common language variable is binary, taking a value of 1 if countries i and j have a common official language and 0 otherwise. Colonial ties are also reported as a binary variable, assuming a value of 1 when countries i and j share a common coloniser and 0 otherwise. The exchange rate is measured as the real exchange rate. The RTA dummy variable assumes a value of 1 if the trade partners are members of one of India's RTAs; otherwise, it takes a value of 0. Before estimation, all variables were converted into natural logarithms to mitigate data measurement errors, multicollinearity, and heteroscedasticity (Chakradhar & Gupta, 2024). The dataset used in this study consists of a balanced panel comprising 595 observations encompassing 35 export countries over 17 years ($T = 17$, $N = 35$; $T \times N = 17 \times 35 = 595$). A detailed description of the variables, data sources, and sample countries is reported in Appendix (Tables A and B).

3. Empirical framework

The panel data gravity model has been extensively employed to evaluate the empirical validity of the Linder hypothesis (Braymen & Briggs, 2015; Choi, 2002; Fu et al., 2020; Wernerheim & Waples, 2013). Tinbergen (1962)

and Pöyhönen (1963) introduced the gravity model. The model posits that the trade volume between two nations is directly proportional to their GDPs and inversely proportional to the physical distance that separates them. The gravity equation for trade can be written as:

$$\ln Trade_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \, dist_{ij} + \mu_{ijt} \tag{1}$$

where $\ln Trade_{ijt}$ represents the log of trade flow between countries i and j at t time, and GDP_i and GDP_j, denote the *GDPs* of countries i and j, respectively. The $dist_{ij}$ variable indicates the geographical distan*i*e between countries i and j. Here, β_0 is a constant and μ_{ijt} denotes the idiosyncratic error term. Panel data methodology offers several advantages compared to time series and cross-section models (Baltagi, 2005). It captures individual heterogeneity, reduces collinearity, as well as capturing more information and variability, which increases degrees of freedom (Wooldridge, 2002). It makes econometric estimations more efficient and reliable. The log-log augmented gravity model can be expressed as follows:

$$\begin{aligned} \ln Trade_{ijt} = \beta_0 + \beta_1 \, Linder_{ijt} + \beta_2 \ln dist_{ij} + \beta_3 \, Border_{ij} + \beta_4 \, Commonlag_{ij} + \\ + \beta_5 \, Col_{ij} + \beta_6 \ln RE_{ijt} + \beta_7 \, RTA_{ijt} + \delta_i + \gamma_t + \mu_{ijt} \end{aligned} \tag{2}$$

where $\ln Trade_{ijt}$ is the logarithm of service export from India i and partner country j at time t. Following the previous works of Braymen and Briggs (2015) and Hallak (2010), differences in per capita GDP between trade partners are measured using one of the four accepted Linder terms. Each term quantifies the difference in per capita GDP between India and its trading partners as follows: $(\ln y_0 - \ln y_d)^2$, $|y_0 - y_d|$, $\ln|y_0 - y_d|$ and $|\ln y_0 - \ln y_d|$, where y_0 and y_d takes the per capita GDP of India and its trading partners, respectively.

The negative sign of β_1 supports the Linder hypothesis, while a positive sign rejects it. Distance represents the physical distance between export and import countries. Greater distances between trading partners typically correlate with lower levels of service trade due to logistical challenges and higher transportation costs. However, in the modern era, advanced communication technologies and improved transportation infrastructure may reduce the significance of distance as a barrier to service trade. Factors such as digital connectivity and efficient transportation networks can mitigate the impact of distance on service trade (Luong & Nguyen, 2021; Nath & Liu, 2017; Tay, 2018).

This study also incorporates social and cultural proximity indicators, including common borders, language, and colonial history (De, 2013; Rahman et al., 2019; Truong et al., 2019). The influence of (RTAs on service trade is assessed based on whether the RTA explicitly includes provisions addressing the trade of services. The RTA variable is binary, assuming a value of one if India is a member of any of the following RTAs: Asia-Pacific Trade Area (APTA), India—MERCOSUR Preferential Trade Agreement (PTA), ASEAN-India Free Trade Area

(AIFTA), or South Asia Free Trade Area (SAFTA). Building on previous studies which suggest that exchange rates negatively affect trade flows (Kaushal, 2022; Thuy & Thuy, 2019), we have included the real exchange rate as one of the independent variables in the estimation process. δ_i is the country-fixed effect that controls for the impact of infrastructure, Multilateral Trade Resistance (MRT), and other country-specific effects (Jagdambe & Kannan, 2020; Mawusi, 2020). γ_t is the time-fixed effect that captures the volatility in trade due to fluctuations in business cycles and natural shocks in global trade (Jagdambe & Kannan, 2020; Mawusi, 2020). μ_{ijt} is the idiosyncratic error term that varies across cross-sectional units and over time. Model (2) can be estimated using the fixed effects and random effects models. However, traditional panel data estimates produce biased results in the presence of cross-sectional dependency, serial correlation, and heteroscedasticity (Marques & Fuinhas, 2012). Therefore, this study employed FGLS as the primary estimation method, which is suitable for managing panel data that exhibit cross-sectional dependence, serial correlation, and heteroscedasticity (Nguyen et al., 2020). The equation for the FGLS corresponds to Equation (2).

Endogeneity in gravity models, notably with RTAs, arises from reverse causality and omitted variable bias (Baldwin & Taglioni, 2006; Yotov et al., 2016). According to the "natural trading partners" hypothesis, countries often form RTAs with significant trading partners, causing the RTA variable to correlate with the error term. Instrumental variable (IV) estimation like two stage least square (2SLS) can address this, but finding valid instruments is challenging (Greene, 2003), as they must correlate with RTAs without directly affecting trade volumes.

Ideally, the explanatory variables on the right-hand side of the equation should not correlate with the error term, otherwise causes endogeneity. The Durbin-Wu-Hausman test examines the correlation between the residuals (error term) and the explanatory variables (Ullah et al., 2018). To address these endogeneity concerns, we utilise GMM estimation technique. This method offers consistent and efficient estimates, especially in situations where endogeneity may arise from factors like reverse causality or omitted variables (Ullah et al., 2018). GMM has several advantages over other estimators. Firstly, it can account for certain unobservable effects. Secondly, using appropriately lagged values of variables as instruments can control for the potential endogeneity of all explanatory variables, including the lagged dependent variable. Thirdly, GMM produces unbiased and robust results for panel data with short time periods (T) relative to the number of cross-sectional units (N), which fits the nature of our dataset. These benefits of the GMM estimator are particularly useful when N is larger than T (Roodman, 2006). Fourthly, it enhances efficiency by complementing the initial difference equations with equations in levels. By combining regression in differences with regression in levels, it can better address issues related to omitted variables, measurement errors, and potential endogeneity (Arellano & Bover, 1995; Blundell & Bond, 1998).

Therefore, for robustness purposes and to correct the endogeneity issue, our study employs the two-step system GMM estimation method.

$$\ln Trade_{ijt} = \beta_0 + \beta_1 \ln Trade_{ijt-1} + \beta_2 Linder_{ijt} + \beta_3 \ln dist_{ij} + \\ + \beta_4 Border_{ij} + \beta_5 Commonlag_{ij} + \beta_6 Col_{ij} + \beta_7 \ln RE_{ijt} + \\ + \beta_8 RTA_{ijt} + \delta_i + \gamma_t + \mu_{ijt} \quad (3)$$

In the equation provided, $\ln Trade_{ijt-1}$ represents the one-year lag of the dependent variable, while the descriptions of the other variables remain consistent with those in Equation (2). The reliability of the estimators depends on the assumptions that the errors are not serially correlated and that the instruments are genuinely exogenous. To verify these assumptions, we used the Arellano-Bond AR (2) test for autocorrelation to ensure that the errors in the first-difference regression do not show second-order serial correlation (Veeramani & Dhir, 2022). We also used the Hansen (1982) J test for over-identifying restrictions to confirm the exogenous of the instruments. Due to concerns that having too many instruments could reduce efficiency, we decided to keep the number of instruments below the number of groups. This was done by either limiting the number of lags used as instruments or by collapsing the instrument matrix, following Roodman (2009).

4. Results and discussion

Table 1 provides the descriptive statistics for the variables used in the panel data regression analysis. The mean value of service exports is 7.57, with

Table 1. Summary of descriptive statistics

Variable	N	Mean	Std. Dev.	Minimum	Maximum
Service exports	595	7.57	0.96	5.24	10.60
$(\ln y_0 - \ln y_d)^2$	595	28.07	3.05	21.98	32.46
$\lvert y_0 - y_d \rvert$	595	31003.03	24235.04	12.10	101463.31
$\ln\lvert y_0 - y_d \rvert$	595	9.64	1.63	2.49	11.52
$\lvert \ln y_0 - \ln y_d \rvert$	595	5.29	0.29	4.68	5.69
Distance	595	8.62	0.53	7.01	9.61
Common border	595	0.05	0.23	0	1
Common language	595	0.25	0.43	0	1
Colony	595	0.02	0.16	0	1
Exchange rate	595	4.59	0.15	3.81	5.37
RTA	595	0.34	0.47	0	1

Note: The summary of descriptive statistics is calculated using log conversion data.

Source: own elaboration.

a standard deviation of 0.96, while the mean squared log difference in per capita income is 28.07. The absolute difference in per capita income stands at 31,003.03. Additional statistics include a mean distance of 8.62, and binary indicators for common border (0.05), common language (0.25), and colonial history (0.02). The mean exchange rate is 4.59.

Prior to estimating the panel models, three preliminary tests were conducted: the Wooldridge test for autocorrelation (Wooldridge, 2003), the modified Wald statistic/Breusch-Pagan test for heteroscedasticity (Greene, 2003), and the cross-sectional dependence test proposed by Pesaran (2015). The results indicate the presence of serial autocorrelation and heteroscedasticity under fixed-effect specifications (Table 2). Consequently, following the methodology of previous studies (Nguyen et al., 2020), the proposed models are estimated using the FGLS methodology.

Table 2. Diagnostic test results for heteroscedasticity and serial correlation

Test	Endogeneity concern	Test statistic	*p*-value
Modified Wald ($\chi 2$)	Heteroscedasticity	134.85***	0.000
Wooldridge test (F-test)	Serial correlation	69.14***	0.000

Note: *** $p < 0.01$. Modified Wald test for groupwise heteroskedasticity in fixed effect regression model; H_0: sigma(i)^2 = sigma^2 for all i: No heteroscedasticity. Serial correlation: Wooldridge test for autocorrelation in panel data; H_0: No first-order autocorrelation.

Source: own elaboration.

In accordance with the methodology outlined by Rasoulinezhad (2017), we specifically conducted the cross-sectional dependence (CD) test for the time-variant variables within our gravity equation. It is important to note that the CD test is not applicable to time-invariant variables. The results of Pesaran's (2015) cross-sectional dependency test are reported in Table 3. At the 1% significance level, the Pesaran test rejected the null hypothesis of cross-sectional

Table 3. Pesaran (2015) CD test for cross-section independence

Variable	CD-test	*p*-value
Service exports	93.13***	0.000
$(\ln y_0 - \ln y_d)^2$	102.51***	0.000
$\lvert y_0 - y_d \rvert$	29.24***	0.000
$\ln\lvert y_0 - y_d \rvert$	31.26***	0.000
$\lvert \ln y_0 - \ln y_d \rvert$	98.71***	0.000
Exchange rate	–0.016***	0.000

Notes: Under the null hypothesis of cross-section independence, $\mathrm{CD} \sim N(0,1)$; *** $p < 0.01$.

Source: own elaboration.

independence, indicating the presence of cross-sectional dependency within the panel. To address this issue, we incorporated both country- and time-fixed effects into the estimated model, as recommended by Irshad et al. (2018).

4.1. Service sector exports: FGLS model

Table 4 presents the results of the augmented gravity model using the FGLS method, incorporating time and country fixed effects. Across all specifications of the Linder term, the empirical findings consistently show that India's service sector exports increase notably when trading with partners that have substantial disparities in per capita GDP. This finding suggests that India's services exports thrive most in relationships with trade partners characterised by significant income differences. The relationship is consistently positive and statistically significant at the 1% level across all model specifications of the Linder

Table 4. Exports of service sector: GLS method

Variables	$(\ln y_0 - \ln y_d)^2$	$\lvert y_0 - y_d \rvert$	$\ln \lvert y_0 - y_d \rvert$	$\lvert \ln y_0 - \ln y_d \rvert$
With time effect and country effect				
Linder term	0.14***	0.15***	0.33***	1.41***
	(0.36)	(0.01)	(0.02)	(0.04)
Distance	0.39***	0.36***	0.22***	0.38***
	(0.03)	(0.06)	(0.06)	(0.03)
Common border	0.54***	0.76***	0.96***	0.54***
	(0.18)	(0.19)	(0.13)	(0.18)
Common language	0.22***	0.13**	0.11*	0.22***
	(0.04)	(0.06)	(0.07)	(0.04)
Colony	1.72***	1.91***	1.62***	1.72***
	(0.03)	(0.11)	(0.12)	(0.03)
Exchange rate	–0.73***	–0.21*	–0.49**	–0.70***
	(0.11)	(0.18)	(0.19)	(0.11)
RTA	–0.01**	0.61***	0.46***	–0.81**
	(0.03)	(0.06)	(0.06)	(0.03)
Constant	–3.13***	2.41**	–0.02	–6.65***
	(0.73)	(1.15)	(1.18)	(0.77)
Observations	595	595	595	595

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: own elaboration.

term. Based on their analysis of a larger sample of cross-country datasets encompassing 2,683 country pairs, Braymen and Briggs (2015) found that dissimilar per capita income levels across trade partners positively and significantly influence services trade. Our results align with their conclusions. Moreover, the estimated outcomes provide compelling evidence countering the conventional Linder hypothesis concerning India's service exports. This explains why differing demand patterns in countries with varying factor endowments are likely to create a pattern of inter-industry trade in Indian service exports. It is worth noting that there appears to be an absence of any association between nations demonstrating higher domestic sales of services and those exhibiting greater international sales of the same service products. We assert that India's services exports are propelled by comparative advantages rooted in factors such as resource endowments, technological capabilities, and skill levels.

The coefficient of the distance between India and partner countries is positive, with a 1% significance level across all the Linder term specifications. In all the columns in Table 4, the coefficient of service export with respect to distance is positive. The likely reason for this outcome is that advancements in ICT have enabled trade in services globally. An optimal large distance also reflects time-zone differences, allowing for the synchronisation of work, which should positively impact service exports and provide both the exporting and importing countries with high-quality electronic infrastructure. However, the ultimate effect of distance will depend on the composition of aggregate services (Goswami et al., 2012). Moreover, unlike physical goods, service products do not necessarily need physical transportation from one location to another. The nature of services varies; some may require the movement of individuals, while others can be transmitted electronically. Consequently, the importance of distance in services trade may be reduced or even negligible, reflecting the varied modes of delivery inherent in the service sector. This finding is in line with Kimura and Lee (2006), Demirkan et al. (2009), Tay (2018), Tharakan et al. (2005) and Walsh (2006).

Furthermore, Table 4 affirms that control variables such as sharing a common border, common colony and language are found to have a positive and statistically significant effect on Indian service exports at 1% significance levels. The previous literature found that countries sharing a common border tend to increase trade flows due to shorter transportation distances, lower costs, cultural ties, and easier market access (Batra, 2007; Kim et al., 2022). The language variable is statistically significant in all four specifications of Linder term. This demonstrates that the two nations' shared language increased bilateral trade. Our findings supported previous research: language fostered trade as a network and communication instrument (Egger & Lassmann, 2012; Melitz, 2008; Rauch & Trindade, 2002).

Furthermore, the bilateral exchange rate consistently has a significant negative impact on service exports at conventional levels across all four specifica-

tions, respectively. This suggests that as the exchange rate of the host economy rises, the import price of services for partner countries also increases. Consequently, this price escalation diminishes the demand for service imports from the partner country, highlighting the sensitivity of service trade to fluctuations in exchange rates. The findings are consistent with those reported by Sahoo (2018) and are also corroborated by the studies conducted by Sahoo et al. (2019). Finally, the coefficients for the RTA dummy are found to have a negative effect on the export of Indian services, significant at both the 1% and 5% levels across two specifications of the Linder term. Our analysis concludes that the results for the RTA dummy variable are mixed. Prior research by Singh (2015) suggests that in RTAs, India has prioritised swift tariff liberalisation in goods, with less focus on the service sector. Moreover, these agreements largely focus on trade in goods and offer only limited engagement in trade in services. This suggests that India's trade agreements do not align with modern Regional Trade Agreements (RTAs), which typically include provisions beyond the WTO framework and emphasise deeper regulatory standards. As a result, the service sector's exports have not significantly benefited from these agreements.

4.2. Two-step system GMM approach

For robustness purposes, we have used the two-step system GMM approach. The results presented in Table 5 indicate that the impact of all independent variables on service exports remains consistent with the Generalised Least Squares (GLS) estimator.

Table 5. Exports of sector: Two-step system GMM approach

Variables	$(\ln y_0 - \ln y_d)^2$	$\lvert y_0 - y_d \rvert$	$\ln\lvert y_0 - y_d \rvert$	$\lvert \ln y_0 - \ln y_d \rvert$
With time effect and country effect				
Linder term	0.024***	0.030***	0.044***	0.243***
	(0.001)	(0.052)	(0.007)	(0.013)
One lag of SE	0.718***	0.806***	0.831***	0.722***
	(0.008)	(0.005)	(0.003)	(0.008)
Distance	0.090*	0.025**	0.026**	0.088*
	(0.048)	(0.038)	(0.023)	(0.045)
Common border	0.247*	0.217**	0.224***	0.237*
	(0.141)	(0.156)	(0.179)	(0.140)
Common language	0.156***	0.203***	0.185***	0.157***
	(0.036)	(0.045)	(0.023)	(0.036)

cont. Table 5

Variables	$(\ln y_0 - \ln y_d)^2$	$\lvert y_0 - y_d \rvert$	$\ln\lvert y_0 - y_d \rvert$	$\lvert \ln y_0 - \ln y_d \rvert$
Colony	0.797***	0.897***	0.664***	0.789***
	(0.112)	(0.314)	(0.166)	(0.112)
Exchange rate	–0.225***	–0.006*	–0.089***	–0.220***
	(0.019)	(0.030)	(0.023)	(0.019)
RTA	–0.068**	–0.184***	–0.101***	–0.064*
	(0.033)	(0.044)	(0.025)	(0.033)
Constant	–0.229	1.053***	0.294	–0.842*
	(0.493)	(0.404)	(0.248)	(0.453)
Observations	595	595	595	595
Number of countries	35	35	35	35
Number of instruments	24	24	24	24
AR (1) test	–4.42	–4.40	–4.44	–4.43
p-value	0.000	0.000	0.000	0.000
AR (2) test	1.29	0.25	–0.81	1.33
p-value	0.198	0.806	0.417	0.183
Hansen J statistics (p-value)	0.638	0.629	0.623	0.636

Notes: Standard errors are in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Hansen J statistics test used to check over-identified restrictions in the estimated models. The AR(1) (AR(2)) test is the Arellano-Bond test for the existence of the first-order (second-order) autocorrelation in residuals.

Source: own elaboration.

The coefficient magnitudes differ when compared with GLS estimators. However, the overall conclusions of the two-step system GMM model align with the GLS model. Furthermore, the lagged dependent variables are found to be significant across all specifications.

Conclusions

The main objective of this study is to examine the impact of income similarity on India's service sector exports from 2005 to 2021 for 35 major import countries. To achieve this, we employ the gravity model of trade using FGLS and two-step system GMM econometric techniques incorporating country and time-fixed effects. The results of the FGLS and GMM estimations show that across all four specifications of the Linder term, there is a positive and significant effect of income dissimilarity on India's service exports, revealing a higher

trade intensity between countries with dissimilar income levels. Our findings indicate that the Linder hypothesis does not hold for Indian service exports at aggregate levels. Countries specialise in producing specific services driven by their comparative advantage, a phenomenon that fosters inter-industry trade. This comparative advantage is influenced by factors such as resource endowments, technological capabilities, and skill levels. The distance's positive and statistically significant coefficient across the Linder term specifications underscores the impact of geographical separation, suggesting that distance plays a positive role in influencing Indian service exports. Additionally, the exchange rate has a negative and significant impact on India's service exports. Furthermore, the positive and statistically significant effects of control variables, such as sharing a common border, a common colony, and a common language, highlight their role in driving Indian service exports. However, our results regarding the RTA dummy variable are inconclusive.

This study contributes to the theoretical discourse by challenging the Linder hypothesis within the context of India's service exports. These findings reveal specific outcomes that confirm expectations based on the traditional Heckscher-Ohlin (H-O) theory, which posits that trade patterns are primarily driven by differences in factor endowments with different supply capabilities. Our findings suggest that income dissimilarity, rather than similarity, drives trade intensity in the service sector, aligning with the recent study by Braymen & Briggs (2015). The present study shows that income disparities can enhance bilateral trade by creating diverse demand patterns and market opportunities, particularly in services. As such, this research adds to the growing body of literature that re-evaluates the applicability of the Linder hypothesis in modern and developing economies, providing new insights into the dynamics of international trade.

In light of our findings, we recommend that policymakers and practitioners in India's service trade sector focus on fostering trade relationships with nations possessing dissimilar per capita income levels. This strategy is likely to enhance trade intensity and provide substantial economic benefits. By targeting countries with diverse income levels, India can exploit potential markets for its service exports, which is crucial for expanding its network of trading partners. Additionally, efforts should be made to reduce trade barriers and improve trade facilitation measures, ensuring smoother and more efficient service trade flows. Finally, in future trade negotiations, India must include provisions for services to enhance trade with RTA member countries.

This empirical study presents evidence refuting the applicability of the Linder hypothesis to Indian service sector exports at aggregate levels. It should be noted that our analysis does not research the influence of a similar demand structure on the disaggregated service sector exports of India. Consequently, a substantive gap exists in our understanding of this specific aspect, warranting further and more detailed investigation to illuminate the nuanced dynamics at play in India's disaggregated service sector exports.

Appendix

Table A. Description of variables and sources

Variable	Description	Sources
Service exports	natural log of export services between India (*i*) and partner Country (*j*)	OECD-WTO Balanced Trade in Service Statistics
Linder term	$(\ln y_0 - \ln y_d)^2$, $\lvert y_0 - y_d \rvert$, $\ln\lvert y_0 - y_d \rvert$ and $\lvert \ln y_0 - \ln y_d \rvert$	Calculated and data is obtained from World Bank Development Indicators (WDI). https://databank.worldbank.org/source/world-development-indicators
Common border	the dummy variable takes the value 1 if country *i* and *j* share a common border or contiguous; 0 otherwise	The Centre d'Études Prospectives et d'Informations Internationales (CEPII) database. http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp
Common language	the dummy variable takes the value 1 if country *i* and *j* share a common official language; 0 otherwise	The Centre d'Études Prospectives et d'Informations Internationales (CEPII) database. http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp
Colony	colonial history/ties variables are dummy variables that take value one if the country *i* and *j* share a common coloniser; otherwise, 0	The Centre d'Études Prospectives et d'Informations Internationales (CEPII) database. http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp
Distance	log of geographical distance between country *i* and *j*, measured in kilometres and as the distance between two capital cities of trading countries	The Centre d'Études Prospectives et d'Informations Internationales (CEPII) database. http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp
Exchange rate	bilateral exchange rate between *i* and *j* in natural logarithm	World Development Indicators. https://databank.worldbank.org/source/world- development-indicators
RTA	dummy equal to 1 if *i* and *j* country are engaged in a regional trade agreement; 0 otherwise	World Trade Agreement (WTO)-Regional Trade Agreements Database. http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

Source: own elaboration.

Table B. List of countries in the sample

Country	Region	Income level
Angola	Sub Saharan Africa	Lower Middle Income
Australia	East Asia and Pacific	High Income
Bangladesh	South Asia	Lower Middle Income
Belgium	Europe and Central Asia	High Income
Brazil	Latin America and the Caribbean	Upper Middle Income
Canada	North America	High Income
China	East Asia and Pacific	Upper Middle Income
Denmark	Europe and Central Asia	High Income
France	Europe and Central Asia	High Income
Germany	Europe and Central Asia	High Income
Ireland	Europe and Central Asia	High Income
Indonesia	East Asia and Pacific	Lower Middle Income
Israel	Middle East and North Africa	High Income
Italy	Europe and Central Asia	High Income
Japan	East Asia and Pacific	High Income
Korea, Rep.	East Asia and Pacific	High Income
Malaysia	East Asia and Pacific	Upper Middle Income
Mexico	Latin America and the Caribbean	Upper Middle Income
Netherlands	Europe and Central Asia	High Income
Nigeria	Sub Saharan Africa	Lower Middle Income
Norway	Europe and Central Asia	High Income
Qatar	Middle East and North Africa	High Income
Russia	Europe and Central Asia	Upper Middle Income
Saudi Arabia	Middle East and North Africa	High Income
Singapore	East Asia and Pacific	High Income
South Africa	Sub Saharan Africa	Upper Middle Income
Spain	Europe and Central Asia	High Income
Sweden	Europe and Central Asia	High Income
Switzerland	Europe and Central Asia	High Income
Thailand	East Asia and Pacific	Upper Middle Income
Turkey	Europe and Central Asia	Upper Middle Income
United Arab Emirates	Middle East and North Africa	High Income
United Kingdom	Europe and Central Asia	High Income
United States	North America	High Income
Vietnam	East Asia and Pacific	Lower Middle Income

Source: own compilations based on data from OECD and New World Bank country classifications by income level: 2020–2021.

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The effect of output on employment in Poland during the COVID-19 pandemic

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Abstract

The COVID-19 pandemic caused a significant decline in output, as well as economic policies aimed at mitigating the negative effects of the pandemic. Both of these factors had an impact on the labour market. This paper investigates changes in employment across groups of workers during the coronavirus pandemic in Poland and the effect of output on these changes. Firstly, it examines changes in employment growth rates across different groups of workers in 2020. Secondly, the paper analyses the impact of the coronavirus crisis on employment by comparing actual and predicted employment growth during the pandemic period (2020). Using Okun's law, Ordinary Least Squares, and quarterly data, the elasticities of employment growth with respect to GDP growth in the pre-pandemic period (2003–2019) are calculated. These elasticities are then used to estimate projected employment growth during the pandemic. The results suggest that the total employment response to output change was relatively small, compared to the historical pattern. However, the response was unequal across groups of workers. The youngest workers, particularly women, and those with temporary employment contracts were most affected by the pandemic.

Keywords

- COVID-19
- employment
- employment elasticity
- Okun's law

JEL codes: E24, E32, J21, J23.

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Introduction

The pandemic caused a sharp fall in Poland's GDP. In response, policies known as "anti-crisis shields" were introduced to mitigate the negative effects. These included wage subsidies, exemptions from social security contributions, and other forms of social security support to maintain economic activity and protect jobs (Ambroziak, 2022; Dębkowska et al., 2021). These instruments may have encouraged labour hoarding among employers and reduced the responsiveness of employment to output. This effect may have been reinforced by the institutional reforms that started in 2016, which increased employment protection for temporary workers (Dral, 2016; Paluszkiewicz, 2017) and reduced their share in total employment (see Figure A1 in the Appendix). This may have affected the responsiveness of employment to output, as temporary workers are less protected and more likely to be laid off in a downturn than permanent workers. This raises the question of whether these changes have affected the cyclical sensitivity of different groups of workers, in particular, those who tend to be laid off in recessions, such as young workers and those on temporary contracts.

This paper investigates changes in employment across groups of workers during the coronavirus pandemic in Poland and the effect of output on these changes. The study identifies which groups of workers were most affected by layoffs and if the relationship between output and employment changed after the introduction of structural reforms and anti-crisis policies. This can contribute to a better understanding of inequalities in job security in the Polish labour market.

Firstly, the paper examines employment growth rates across different groups of workers in 2020. The analysis considers breakdowns by age, gender, education, working hours, employment status, and type of contract. Secondly, the paper analyses the impact of the coronavirus crisis on employment by comparing actual and predicted employment growth during the pandemic (2020). Using an employment version of Okun's law and Ordinary Least Squares (OLS), the study estimates the elasticities of employment growth to GDP growth (Okun's coefficient) for the pre-pandemic period (2003–2019). These elasticities are then used to estimate projected employment growth during the pandemic. The difference between the predicted and actual changes highlights the distinct employment response to output during the coronavirus crisis compared to the previous years.

The study uses quarterly data from Statistics Poland and the Eurostat database. The analysis focuses on the changes in employment in 2020. This is due to the availability of comparable data. The methodology of the Polish Labour Force Survey (LFS) changed in 2021, which means that data from 2021 onwards may not be entirely comparable to previous years.

This article extends the existing literature on the impact of the pandemic on the Polish labour market by analysing the employment response to output for different groups of workers using Okun's law. Previous studies have focused on different issues and used different methodologies. Kukołowicz (2021) found that actual unemployment was lower than the unemployment predicted by international and national institutions. This was due to some workers who had been dismissed becoming economically inactive. Kwiatkowski and Szymańska (2022) argue that the coronavirus crisis caused a reallocation shock, resulting in reduced employment in some sectors and increased employment in others. Maj and Kubiciel-Lodzińska (2022) examined the impact of the pandemic on immigrant employment in the Opolskie Voivodeship and found that immigrants were often the first to be laid off, especially in the early stages of the pandemic, but often on their own initiative. According to Strzelecki (2020, pp. 16–17), the reduction in Ukrainian employment was relatively small, due to the low share of their wages in wage funds and the flexible forms of employment. Other studies have examined changes in employment structure. Muster (2022) and Radziukiewicz (2021) found a significant increase in the number of people working from home during the pandemic.

The remaining sections of the paper are structured as follows. Section 1 presents the literature review. Section 2 describes the research method and used data. Section 3 presents the results of the analysis. Section 4 presents a discussion and conclusions.

1. Literature review

This paper refers to research trends that use Okun's law to analyse the impact of macroeconomic shocks on the labour market, and to analyse cyclical sensitivity across age and gender. For example, Cazes et al. (2013) and IMF (2010) use Okun's law to examine the impact of the global financial crisis on unemployment in a sample of OECD countries. They found that the responsiveness of unemployment to output changed over time. Additionally, the responsiveness was higher in countries with low employment protection and a high proportion of temporary workers. The IMF (2010) also showed that other factors such as financial stress, house price collapse and sectoral shocks increased this responsiveness during the recession. In a more recent study, the IMF (2022) showed that during the coronavirus pandemic in OECD countries, the response of unemployment to output contraction was muted compared to the past and varied across countries, mainly due to anti-crisis policies, in particular, the implementation of job retention schemes (JRS). In turn, Hutengs and Stadtmann (2014), and Dunsch (2016) examined the re-

sponse of unemployment to output by age in Poland, among other countries. They found that economic fluctuations affect younger workers more than older ones. Zanin (2014) also found that younger workers are more sensitive to changes in output than older workers, but also that young men are more sensitive than women.

This paper also relates to studies analysing the impact of the pandemic on labour markets. Cross-country studies, such as those conducted by the OECD (2020) and Eurofound (2021, 2022), also show that the impact of the pandemic on employment and unemployment varied across countries, due to different policy responses. For example, EU countries that implemented different JRSs experienced lower job losses than the US. Country case studies confirm that JRS programmes reduced the impact on the labour market. For example, Aiyar and Dao (2021) suggest that Germany's job protection programme (*Kurzarbeit*) reduced the rise in unemployment by about 3 percentage points in the second quarter of 2020. Similarly, Meriküll and Paulus (2023) indicate that the job retention scheme in Estonia prevented the unemployment rate from being 2–4 percentage points higher in 2020. Osuna and Perez (2021) find that the unemployment rate in Spain would have reached 42% without short-time work (STW).

The research demonstrates also that the pandemic had varying effects on employment across different groups of workers. According to García-Pérez and Villar (2020), in Spain, mainly young and less-educated workers were laid off. Gaudecker et al. (2021) indicate that in the Netherlands, the self-employed and less educated workers experienced the largest reductions in working hours, while workers with higher education began working from home more frequently. Beland et al. (2020) found that self-employed Canadians experienced the largest reductions in working hours. This was particularly true for women, immigrants, and those with lower levels of education. The sectors most affected were arts, culture, and recreation, social, community, and government services, as well as sales and services. Lemieux et al. (2020) demonstrated that in Canada the pandemic had a more significant impact on low-wage workers, as well as sectors that were most affected by lockdown measures, such as accommodation and food services, and younger and non-unionized workers. Lee et al. (2021) found that in the US the pandemic disproportionately affected women, young people, those with lower levels of education, and ethnic minorities. Auer (2022) shows that in Germany immigrants were more strongly affected than natives. Nunes et al. (2023) found that in Portugal municipalities with a higher proportion of temporary workers had a higher increase in unemployment.

Other studies indicate that the prevalent use of working from home helped to protect jobs during the pandemic. Gallacher and Hossain (2020) indicated a negative correlation between the ability to work remotely and employment losses in Canada. Alipour et al. (2020) showed that working from

home in Germany reduced the risk of short-term work and coronavirus infection. However, studies indicate that the ability to work remotely varies across different groups of workers, sectors, regions, and countries. Dingel and Neiman (2020) fund that in the US, individuals who are better-paid and educated, employed in the financial sector, or provided professional services are more likely to work from home. They also suggest that the ability to work from home is generally higher in developed countries.

2. Research method and data

2.1. Method

This paper analyses the impact of the coronavirus crisis on employment by comparing actual and predicted employment growth during the pandemic period (2020). A two-step method is used. In the first step, Okun's law (Okun, 1962) is used to calculate the elasticity of employment growth to economic growth, known as Okun's coefficient, during the pre-pandemic period (2003–2019). In a second step, this elasticity is used to estimate the forecast for 2020. The actual and the forecast changes are then compared. The difference highlights the different response of employment to output during the coronavirus crisis compared to the past. This approach is similar to that used by the IMF (2010, 2022) to identify the drivers of cross-country variation in unemployment dynamics during recessions. Unlike the IMF (2010, 2022), this study uses a different specification of Okun's law, focuses on employment and differences between groups of workers in the single country.

The study uses the employment version of Okun's law, which relates the employment growth rate (Δn) to the GDP growth rate (Δy):

$$\Delta n_t = \beta_0 + \beta_1 \Delta y_t + \varepsilon_t \tag{1}$$

The basic specification is modified, as proposed by Sögner & Stiassny (2002, p. 1776), by including the current and lagged changes in GDP. The use of this specification allows taking into consideration delayed adjustment of employment to output (e.g., due to the notice period):

$$\begin{aligned} \Delta n_t &= \beta_0 + \beta_1 \Delta y_t + \beta_2 \Delta y_{t-1} + \varepsilon_t = \\ &= \beta_0 + \beta_1 \Delta^2 y_t + (\beta_1 + \beta_2)\Delta y_{t-1} + \varepsilon_t \end{aligned} \tag{2}$$

where Δ represents the percentage change from the same quarter in the previous year, Δ^2 represents the change in the GDP growth rate from the

previous quarter, the β_0 is an intercept, and the β_1 coefficient captures the short-term effect while ($\beta_1 + \beta_2$) captures the total effect of GDP changes on employment changes. Employment and GDP growth rates are measured as the change compared with the same quarter of the previous year. Model (2) is estimated using OLS.

A large number of studies have confirmed the existence of Okun's law, the relationship between output and (un)employment. It is a useful tool for studying the impact of output on (un)employment socio-economic groups and how this impact changes over time because the value of Okun's coefficient depends on the cost of adjusting employment to output, which can be vary, due to economic policy and institutional factors. This study focuses on the output-employment relationship, because during the pandemic the relationship between output and unemployment was affected by changes in the labour force participation rate (see next section).[2] This paper employs a basic specification of Okun's law to analyse the differences in employment sensitivity across groups of workers.[3] The use of this specification allows us to overcome the limited data availability and to analyse the effects of the pandemic in more detail, as some data are not available at the level of employee groups and on a quarterly basis.

2.2. Data

The study uses quarterly data from Statistics Poland and the Eurostat database. Data on the real GDP growth rate (at constant prices) is sourced from the *Macroeconomic Data Bank* and *Quarterly Macroeconomic Indicators* of Statistics Poland. Data on the labour market is obtained from the Polish LFS, which is published by Statistics Poland and the Eurostat database. The analysis focuses on the changes in employment in 2020, because the methodology of the LFS changed in 2021, and data from 2021 onwards may not be fully comparable to previous years (see Statistics Poland, 2020, 2022). To ensure data comparability over time, the study primarily used data based on the methodology before 2021 for most calculations. As a result, in most cases, the analysis only goes up to the fourth quarter of 2020. Table 2A in the Annex presents descriptive statistics for the variables used to estimate Okun's coefficient.

[2] Examples of studies using the employment version of Okun's law include Döpke (2001), Basu and Foley (2013) and Chinn et al. (2014).

[3] Many studies use the basic versions of Okun's law. For example, Sögner & Stiassny (2002), Cazes et al. (2013), d'Apice (2014), Zanin (2014), Ball et al. (2017), Russnak et al. (2023).

3. Empirical analysis

3.1. Changes in GDP and employment

The analysis starts by presenting the main developments on the Polish labour market. Figure 1 shows the long-term changes in employment and GDP growth rates from the first quarter of 2001 to the fourth quarter of 2021. It shows that during the pandemic, the sharpest decline in economic growth coincided with a moderate decline in employment. In the second quarter of 2020, GDP fell by 7.8% compared to the same quarter of 2019. In the following quarters, it fell by 1.0% and 1.8%, respectively. However, the changes in employment are much smaller. Only in the second and third quarters of 2020 did employment fall by 1.3% and 0.6%, respectively (or by 1.7% and 0.8% according to the data defined for 2021). This contrasts with previous economic slowdowns at the turn of the century or during the global financial crisis, when employment fell more than GDP. A larger fall in output than in employment implies a fall in labour productivity, which in turn suggests that labour hoarding was an important mechanism of labour market adjustment to the shock.

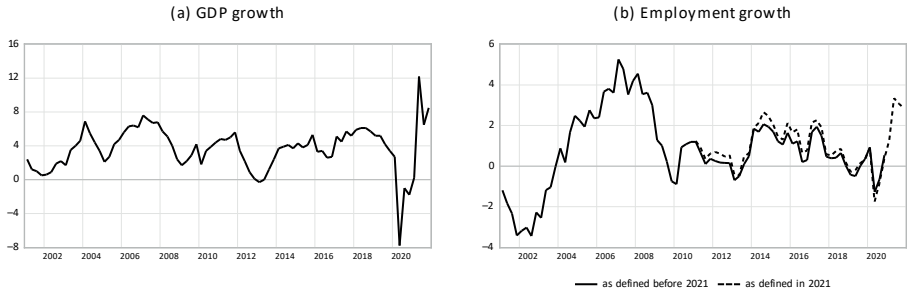

Figure 1. GDP and employment growth rates (in %, 2001q1–2021q4)

Note: Change is compared to the quarter of the previous year.

Source: Statistics Poland and own calculations.

Figure 2 shows in more detail the changes between the first quarter of 2020 and the fourth quarter of 2021.[4] It shows that the adjustment took place main-

[4] Figure 2 consists of two panels because, as mentioned above, the LFS methodology changed in 2021. Panel I shows 2020 data as defined before 2021 and 2021 data as defined in 2021, while panel II shows unified data as defined in 2021.

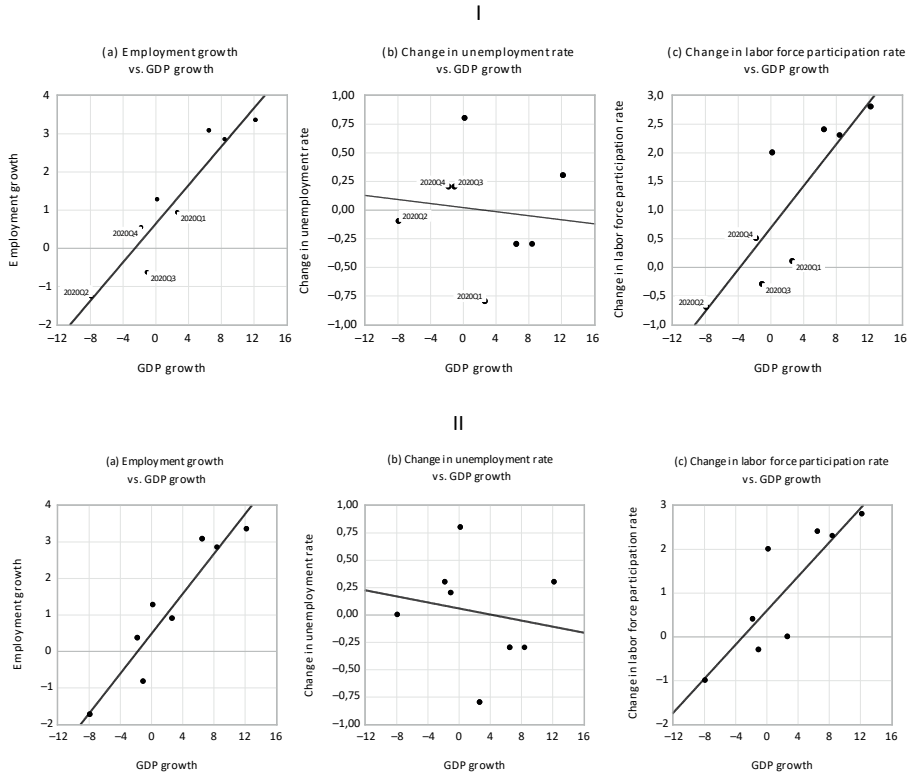

Figure 2. GDP growth rate and changes in selected labour market indicators (in 2020–2021)

Note: Panel I in 2020 data as defined before 2021 and in 2021 data as defined in 2021; Panel II in 2020–2021 data as defined in 2021; change compared to the same quarter of the previous year; GDP and employment growth rates in per cent; change in unemployment rate and labour force participation rate in percentage points.

Source: Statistics Poland and own calculations.

ly through changes in employment and labour force participation rate, and to a lesser extent through changes in unemployment. Figure 2 suggests a positive relationship between changes in GDP and employment in 2020–2021, as predicted by Okun's law, and changes in the labour force participation rate. However, the relationship between GDP and unemployment appears to be weaker. The procyclical behaviour of the participation rate suggests a larger transition from employment to inactivity than to unemployment, and a stronger impact of output on employment than on unemployment (see also Table A1 in the Appendix). This also means that the unemployment rate only partially reflects the impact of the pandemic on the labour market.

3.2. Changes in employment across groups of workers

To examine the impact of the pandemic on different groups of workers, the average employment growth rates are calculated for the period between the second and fourth quarters of 2020, when economic growth slowed down. They are calculated for different age groups, genders, levels of education, working hours, employment status and types of employment contracts. Tables 1–3 present the results, which suggest that the changes in employment were significantly different across groups of workers.

Young workers, especially those aged 15–24, experienced the largest falls in employment. While the total number of employees fell by 1.2%, the number of those aged 15–24 and 25–34 fell by 17.2% and 4.9%, respectively. Employees on temporary contracts were also hard hit by redundancies. The number of employees on permanent contracts rose by 2.8%, while the number on temporary contracts fell by 16%. Declines were common to all working age groups, but the largest falls were in the 15–24 and 24–25 age groups, at 22.5% and 17.9%, respectively. Note also that these groups were the only ones to experience a fall in permanent employment, by 9.6% and 0.2%, respectively. Larger falls in employment were recorded for those working part-time than full-time, by 3.5% and 0.2%, respectively. Again, the largest falls were in the 15–24 and 25–34 age groups, by 28.9% and 7.6%, respectively.

Table 1. The growth rate of employees by age, gender, and employment contract (in %, 2020q2–q4)

	Total			Males			Females		
	Employment contract								
	total	permanent	temporary	total	permanent	temporary	total	permanent	temporary
Total	–1.2	2.8	–16.0	–1.6	2.1	–15.9	–0.9	3.6	–16.0
15–24	–17.2	–9.6	–22.5	–13.5	–5.0	–20.2	–21.8	–16.3	–25.4
25–34	–4.9	–0.2	–17.9	–5.6	–2.4	–15.5	–4.1	2.7	–20.2
35–44	1.7	4.4	–12.3	1.6	4.0	–12.1	1.8	4.9	–12.4
45–54	2.4	5.2	–14.6	1.8	5.1	–19.0	3.1	5.3	–10.3
55–59	–1.8	0.0	–15.6	–3.1	0.1	–25.7	–0.5	–0.3	–2.8
60–64	7.1	9.1	–2.9	3.6	5.4	–7.5	14.5	17.3	2.4
65+	11.1	13.1	6.5	14.3	17.7	6.2	6.8	7.4	5.7

Note: Date as defined before 2021; compared to the similar period of the previous year.

Source: Statistics Poland and own calculations.

More men than women were laid off. However, women experienced greater job losses than men in the 'at-risk' groups. In the youngest age group, 21.8% of women and 13.5% of men were dismissed, including 25.4% and 20.2%, respectively, on temporary contracts. The employment of women on part-time contracts was reduced by 4.3%, while the employment of men on part-time contracts dropped by 1.8%.

Table 2. The growth rate of employed persons by age and education level (in %, 2020q2–q4)

	Total			Males			Females		
	Level of education								
	primary	secondary	tertiary	primary	secondary	tertiary	primary	secondary	tertiary
Total	–2.4	–0.6	1.2	–2.0	0.8	0.0	–3.5	–2.3	2.0
15–24	–21.6	–11.1	–27.2	–24.4	–2.7	–26.0	–13.1	–21.0	–27.8
25–34	–1.5	–1.7	–6.2	1.2	–3.1	–7.7	–12.9	0.9	–5.1
35–44	–6.9	1.1	5.5	–6.0	2.8	5.8	–9.1	–1.3	5.2
45–54	–0.2	3.4	7.8	0.7	6.0	4.9	–1.7	0.9	9.8
55–64	2.7	0.1	4.9	1.7	0.5	2.3	5.2	–0.4	7.2
65+	19.7	5.7	0.2	24.9	–	–6.2	–	4.5	11.6

Note: date as defined before 2021; compared to the similar period of the previous year.

Source: Statistics Poland and own calculations.

The relationship between education and changes in employment appears to be ambiguous. On the one hand, those with primary and secondary education experienced the largest falls in total employment, 2.4% and 0.6%, respectively. The number of those with tertiary education increased by 1.2%. On the other hand, in the 15–24 and 25–34 age groups, the largest decline was among those with tertiary education, 27.2% and 6.2%, respectively.

Interestingly, the number of self-employed increased by 2.7%, with a particularly high increase of 21.6% among women aged 15–24, who experienced sharp declines in other categories. This may indicate that the pandemic has forced self-employment.

The negative impact of the pandemic on the labour market was mitigated by government support (see Ambroziak, 2022; Dębkowska et al., 2021) and the widespread use of working from home (see Muster, 2022; Radziukiewicz, 2021). This reflects two pandemic-specific changes in the structure of employment. Firstly, Figure 3 shows an unprecedented increase in the share of employees temporarily released from work. Before the pandemic, the proportion

Table 3. The growth rate of employed persons by working time and by status in employment (in %, 2020q2–q4)

	Total		Males		Females		Total	Males	Females
	Working time						Status in employment		
	full--time	part--time	full--time	part--time	full--time	part--time	self-employed		
Total	–0.2	–3.5	–0.3	–1.8	–0.1	–4.3	2.7	3.5	1.0
15–24	–14.9	–28.9	–12.0	–28.9	–20.2	–36.4	8.2	3.7	21.6
25–34	–3.6	–7.6	–3.9	4.9	–3.0	–12.1	1.9	2.0	1.6
35–44	0.9	7.9	0.8	26.2	1.0	2.7	–0.6	1.4	–4.4
45–54	3.3	2.8	3.4	–0.6	3.2	3.3	5.7	7.5	2.5
55–64	3.2	–6.7	2.3	–12.8	4.4	–3.0	4.1	4.5	2.8
65+	8.5	5.7	9.3	2.9	6.2	8.8	4.0	–0.7	16.4

Note: date as defined before 2021; compared to the similar period of the previous year.

Source: Statistics Poland and own calculations.

of these workers increased gradually but never exceeded 8%. In 2020, however, it reached almost 15%. Secondly, the share of people working from home increased significantly to almost 9% in 2020, compared with around 4.5% in the pre-pandemic years. These pandemic-specific changes in the structure of employment may help to understand why a relatively small number of workers were laid off. The limited availability of detailed data for 2020 makes it difficult to analyse these phenomena in depth in Poland. However, the greater impact of the pandemic on the young, those with temporary contracts,

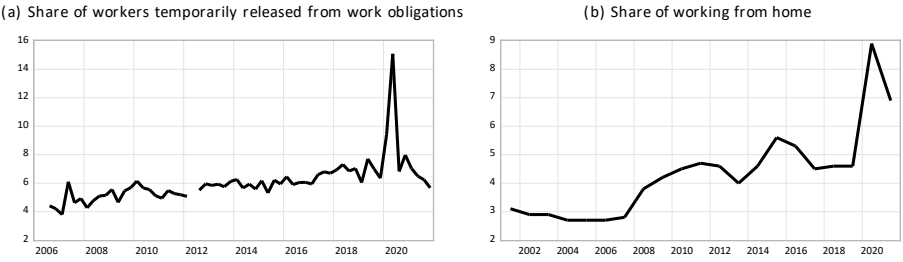

Figure 3. Share of workers temporarily released from work obligations and working from home (in %)

Note: share of workers temporarily released from work obligations—quarterly data seasonally adjusted, after 2020 as defined in 2021; share of working from home yearly data.

Source: Eurostat, Statistics Poland, and own calculations.

less educated and women suggests that these groups were less likely to benefit from these forms of support.

3.3. Employment response to the output

This section estimates Okun's coefficients for the pre-pandemic period (2003–2019) and compares actual and predicted employment growth during the pandemic period (2020). The pre-pandemic sample starts in 2003q1 because some of the changes in employment at the turn of the century, such as the sharp rise in the number of workers with temporary contracts and the fall in the number of workers with permanent contracts, were unlikely to be related to economic growth.[5] The analysis is carried out separately for total employment (aged 15–64) and for young people (aged 15–24), who were most affected by the coronavirus crisis. Both groups are disaggregated by sex, education, working hours, type of contract, and employment status.

3.3.1. Pre-pandemic employment elasticity

Tables 4 and 5 show the elasticities calculated for the pre-pandemic period. Some interesting findings emerged from these results. They confirm that economic growth determines changes in total employment in the Polish economy, but its impact varies for different groups of workers. Between the first quarter of 2003 and the fourth quarter of 2019, the coefficient ($\beta_1 + \beta_2$) for total employment is 0.48. This means that a 1% change in GDP growth was associated with a 0.48% change in total employment growth.

However, the elasticity of employment to business fluctuations varies between groups of employees. For total employment, the elasticities for men and women are similar at 0.49 and 0.48, respectively. Full-time employment, permanent employment, and self-employment are sensitive to output with elasticities of 0.55, 0.63, and 0.53, respectively. The Okun's coefficient for young employees is 1.23. This is almost twice as high as for total employment. However, among young people, female employment is more elastic than male employment, with elasticities of 1.39 and 1.10, respectively. Part-time and permanent employment are sensitive to output, with elasticities of 1.67 and 3.38, respectively. In both age groups, employees with primary education are

[5] It seems that shortening the time series should result in a smaller discrepancy between actual and forecast employment. On the one hand, e.g., the analysis for the years 2003–2019 gives more accurate forecasts than for the period 2001–2019. On the other hand, starting the analysis in 2014, e.g., after the global financial crisis and the debt crisis in Europe, leads to inconclusive results.

Table 4. Okun's coefficients for employed persons and employees aged 15–64 (2003q1–2019q4)

Employed persons growth rates	Δ^2GDP	ΔGDP$_{t-1}$	Constants	N	R^2	Prob (F-stat)
Total	0.28	0.48***	–0.73	68	0.27	0.000
	(0.18)	(0.15)	(0.55)			
Males	0.25	0.49***	–0.73	68	0.25	0.000
	(0.21)	(0.15)	(0.61)			
Females	0.32*	0.48***	–0.73	68	0.23	0.000
	(0.18)	(0.17)	(0.59)			
Primary education	0.43	1.35***	–10.17***	68	0.28	0.000
	(0.47)	(0.35)	(1.51)			
Secondary education	0.28	0.67***	–2.74***	68	0.27	0.000
	(0.28)	(0.19)	(0.76)			
Tertiary education	0.43	–0.10	6.43***	68	0.03	0.380
	(0.42)	(0.27)	(1.25)			
Full-time	0.29	0.55***	–0.76	68	0.28	0.000
	(0.22)	(0.18)	(0.61)			
Part-time	0.41	–0.08	–1.00	68	0.02	0.597
	(0.46)	(0.30)	(1.16)			
Self-employed	0.12	0.53***	–2.49***	68	0.19	0.001
	(0.23)	(0.15)	(0.70)			
Employees growth rates	**Δ^2GDP**	**ΔGDP$_{t-1}$**	**Constants**	N	R^2	**Prob (F-stat)**
Total	0.36	0.58**	–0.74	68	0.20	0.001
	(0.26)	(0.23)	(0.87)			
Permanent contract	–0.00	0.63**	–1.38	68	0.15	0.005
	(0.42)	(0.25)	(1.16)			
Temporary contract	1.63	0.26	3.09	68	0.03	0.422
	(1.34)	(0.89)	(3.89)			

Note: Newey-West standard errors in parentheses, statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Eurostat, Statistics Poland, and own calculations.

Table 5. Okun's coefficients for employed persons and employees aged 15–24 (2003q1–2019q4)

Employed persons growth rates	Δ^2**GDP**	Δ**GDP**$_{t-1}$	**Constants**	N	R^2	**Prob (*F*-stat)**
Total	0.68	1.23***	–5.83***	68	0.21	0.001
	(0.49)	(0.29)	(1.23)			
Males	0.71	1.10***	–5.16***	68	0.18	0.001
	(0.54)	(0.35)	(1.27)			
Females	0.69	1.39***	–6.65***	68	0.15	0.006
	(0.68)	(0.35)	(1.80)			
Primary education	1.18	1.58**	–8.85***	68	0.06	0.134
	(1.50)	(0.59)	(2.28)			
Secondary education	0.40	1.17***	–5.75***	68	0.14	0.007
	(0.60)	(0.37)	(1.62)			
Tertiary education	3.23*	1.28	–0.98	68	0.06	0.136
	(1.89)	(1.15)	(4.75)			
Full-time	0.32	–0.56	–0.71	68	0.01	0.654
	(1.34)	(0.78)	(3.28)			
Part-time	0.89	1.67***	–7.07***	68	0.26	0.000
	(0.59)	(0.42)	(1.56)			
Self-employed	–2.32*	0.39	–5.01*	68	0.06	0.155
	(1.34)	(0.60)	(2.98)			
Employees growth rates	Δ^2**GDP**	Δ**GDP**$_{t-1}$	**Constants**	N	R^2	**Prob (*F*-stat)**
Total	1.21**	1.63***	–6.47***	68	0.25	0.000
	(0.55)	(0.42)	(1.53)			
Permanent contract	0.50	3.38***	–14.84***	68	0.25	0.000
	(1.40)	(0.89)	(3.60)			
Temporary contract	1.83	0.61	–0.40	68	0.04	0.230
	(1.20)	(0.76)	(3.19)			

Note: Newey-West standard errors in parentheses, statistical significance: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Eurostat, Statistics Poland, and own calculations.

more sensitive to business fluctuations than those with secondary education (1.35 vs. 0.67 and 1.58 vs. 1.17).

Economic fluctuations impacted the employment of most groups before the pandemic. However, some groups remained unaffected by changes in output. For the 15–64 age group, GDP fluctuations were statistically significant for 9 out of 12 subgroups. For the 15–24 age group, GDP fluctuations were statistically significant for 8 out of 12 subgroups. Among those aged 15–64, output effect was statistically insignificant for individuals with part-time and temporary contracts. In the 15–24 age group, output effect was statistically insignificant for the self-employed, full-time employees, and temporary employees. In both age groups, output had no statistically significant effect on employment for those with tertiary education. This suggests that factors other than changes in output also influence employment dynamics and are of different importance across groups of workers.

These finding are interesting for two reasons. Firstly, some groups of employees with atypical contracts are insensitive to economic fluctuations. However, some previous research (e.g., Cazes et al., 2013; IMF, 2010, 2022) suggests that employees with temporary contracts are more sensitive to economic fluctuations than workers with permanent contracts. Secondly, some of the groups insensitive to changes in output were strongly affected by the pandemic. Striking examples are employees with temporary contracts, young people with tertiary education, and all with part-time contracts. It is likely that the sensitivity of these groups to economic fluctuations depends on the phase of the business cycle or has increased recently. On the other hand, also groups of workers with high elasticities, such as workers with primary education, experienced relatively large declines in employment (see Tables 1–3).

3.3.2. Actual and predicted changes in employment

Using the estimated elasticities for the 2003–2019 samples, forecasts were generated to predict employment growth rates in the subsequent quarters of 2020. Figures 4 and 5 compare the actual and predicted changes in employment, Table A3 in the Appendix presents forecast errors. The findings show that in 2020, the total employment response to the changes in GDP growth was smaller than suggested by the historical relationship. However, this response varied across different groups of workers.

Figures 4 and 5 confirm that the response of total and youth employment to changes in output follows different patterns. Total employed persons and total employees are less responsive and more smoothed than the forecast values. For example, in the second quarter of the 2020, when economic activity contracted most, they fell less than forecasts. In contrast, youth employment fell more than predicted. These trends were similar for the most sub-groups

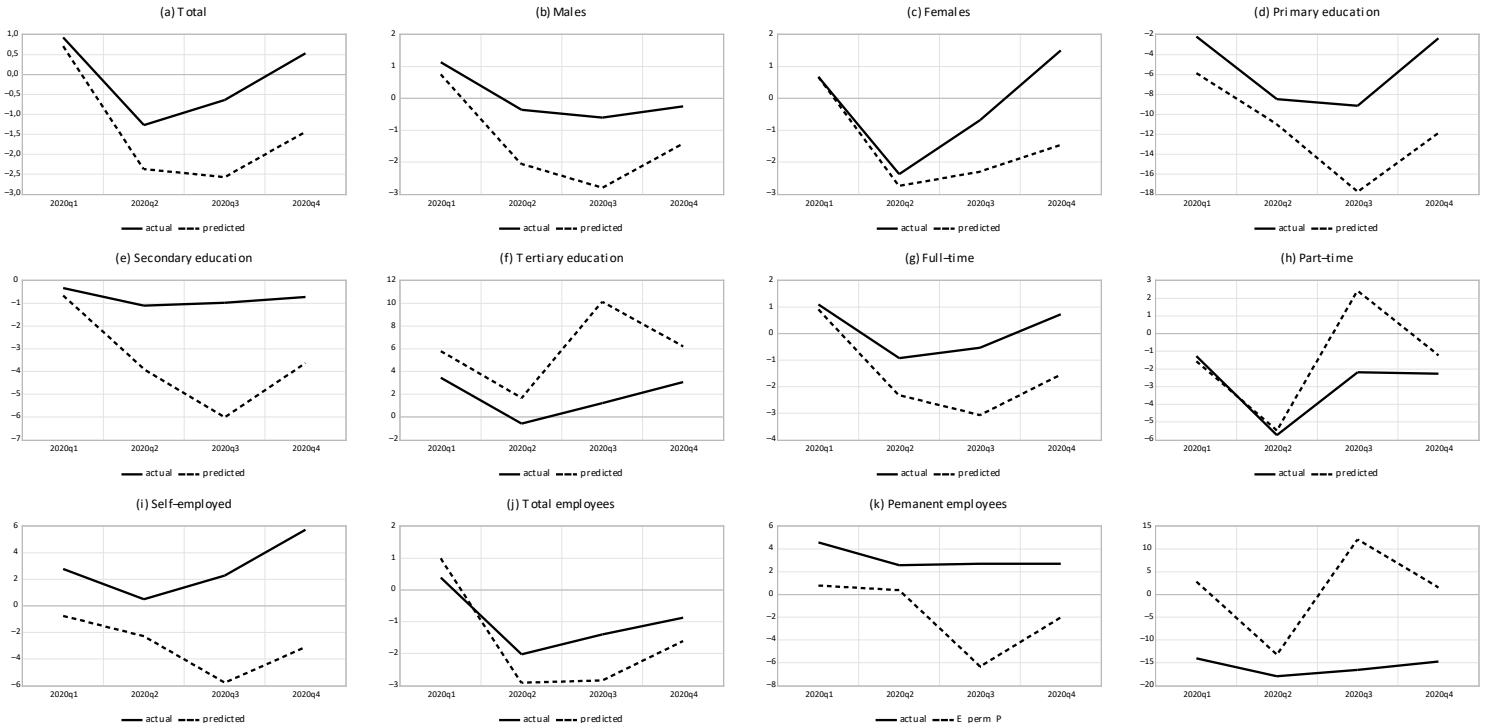

Figure 4. Actual and predicted changes in employment by gender, education, working time, employment contract, and employment status for aged 15–64 (in %, 2020)

Note: Changes compared to the same period in the previous year.

Source: Eurostat, Statistics Poland, and own calculations.

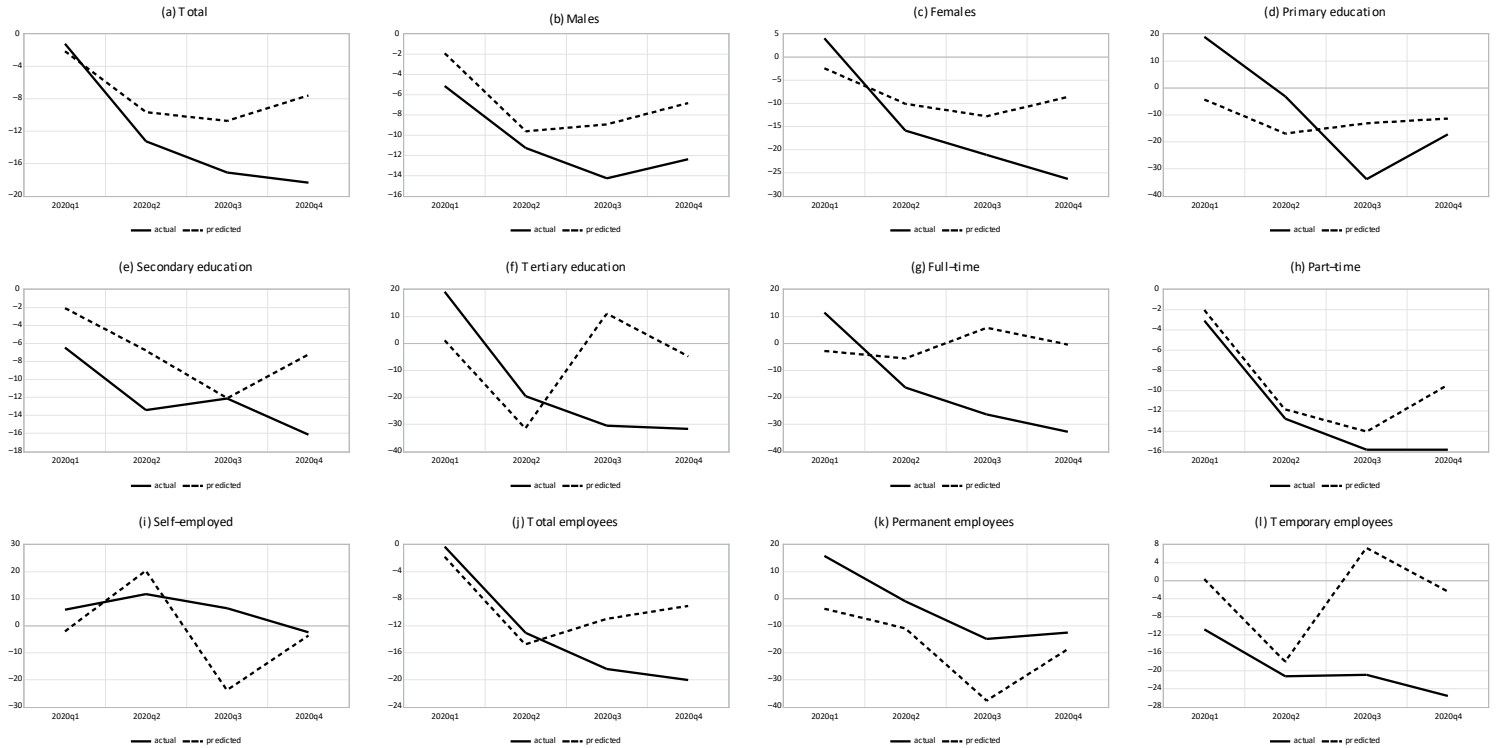

Figure 5. Actual and predicted changes in employment by gender, education, working time, employment contract, and employment status for aged 15–24 (in %, 2020)

Note: Changes compared to the same period in the previous year.

Source: Eurostat, Statistics Poland, and own calculations.

of workers. The graphical presentation of the data makes it possible to follow the dynamics of changes throughout the year. For total employed persons and employees, the actual changes are in many cases in line with the forecasts. However, youth employment continues to decline in several cases in the second half of the year, although the forecasts suggest a reversal of the negative trends. This suggests that young workers were hit harder and for longer.

Table A3 in the Appendix shows the forecast errors (Mean Error – ME and Root Mean Square Error – RMSE). For the 15–64 age group, most of the MEs are positive. For the 15–25 age group, however, most of the MEs are negative. For example, the ME is 1.31 for total employment and –4.95 for youth employment. A positive ME value can be interpreted as the forecast underestimating the result, and a negative sign as an overestimation. A positive ME value suggests that the actual changes in employment are higher than the predicted changes. On the other hand, a negative ME value suggests that the actual changes in employment are below the predicted changes. These differences may indicate that some factors changed a long-term relationship between output and employment during the pandemic. In the case of the 15–64 age group, they weakened it, while in the case of the 15–24 age group, they strengthened it.

It is beyond the scope of this paper to assess the forecasting ability of models based on Okun's law. However, the analysis of the data suggests that forecasts for total employment are more accurate than those for youth employment. In all cases, the forecast error is smaller for total employment. For example, the RMSE is 1.49 for total employment and 6.53 for youth employment. Moreover, for some groups of workers, changes in output have a limited ability to predict changes in employment. This is particularly the case for groups of workers for which the estimated Okun's coefficients are statistically insignificant, suggesting that employment was not sensitive to GDP fluctuations. Among those aged 15–64, those with tertiary education, part-time and temporary contracts were characterised by high forecasting errors. For the group aged 15–24, the self-employed, full-time and temporary employees and those with a tertiary education were also characterised by high forecasting errors.

Conclusions and discussion

The paper analyses the impact of output changes on employment for different groups of workers during the coronavirus pandemic in order to understand how employment adjusted to the changes in GDP and which groups were most affected by the pandemic. The study shows that economic

growth impacted on employment in the Polish economy in the pre-pandemic and pandemic periods. The change in employment during the pandemic was smaller than suggested by Okun's law, but probably relatively larger than the change in unemployment, as some of those laid off became economically inactive. However, the impact of output on employment was varied across groups of workers.

The results are in line with previous research that found a positive relationship between output and employment in Poland (e.g., Ciżkowicz & Rzońca, 2003; Czyżewski, 2002; Jadamus-Hacura & Melich-Iwanek, 2014) and different sensitivity across age and gender to business cycle fluctuations (Dunsch, 2016; Hutengs & Stadtmann, 2014; Zanin 2014). While some of these studies suggest that the sensitivity of unemployment is higher for young men than for young women, this paper finds that in the case of employment sensitivity, the opposite is true. It is likely that women are less attached to the labour market and that more women than men become economically inactive after being dismissed, hence the differences in the elasticity of unemployment and employment.

Much of the relatively weak impact of output changes on employment can be explained by the anti-crisis policies aimed at protecting jobs. As mentioned above, Poland, like other countries, introduced such a policy including typical JRS instruments, such as wage subsidies, exemptions from social security contributions and other forms of social security support to maintain economic activity and protect jobs. Cross-country and country case studies (e.g. Eurofund, 2021; IMF, 2022) have shown that these instruments weakened the impact of output on employment. During the pandemic, Polish employers used labour hoarding to adjust the labour demand to the fall in output. This is evidenced by the significant decline in labour productivity (output fell much more than employment) and changes in employment structure. On the one hand, there was an unprecedented increase in the number of workers temporarily exempted from work obligations. On the other hand, there was the significant reduction in the employment of low-skilled workers, those with primary education and the youngest workers, for whom re-employment costs are relatively low in economic recovery. However, other factors such as the widespread use of working from home may also have changed the relationship between the economic growth and employment.

The impact of the pandemic on employment varied between groups of workers, while the composition of employment changes was similar to those in other countries. The employment levels of the youngest workers, especially women, and those on part-time and temporary contracts was severely affected by the pandemic. Part of this heterogeneity can be explained by differences in the responsiveness of employment to output. For example, younger workers are more responsive to output than older workers, and changes in their employment were also higher. This seems to reflect differences in the

share of temporary workers. Typically, a relatively high proportion of young workers have temporary employment contracts, are less protected and are more likely to be laid off in a downturn than permanent workers. However, the results suggest that temporary employment behaves asymmetrically over the business cycle. It is only responsive to output during recessions, as it was insensitive to output in the pre-pandemic period and suffered from large cuts during the pandemic. Some previous studies, Cazes et al. (2013) found that Polish unemployment is more responsive during recessions than during recoveries. Nevertheless, the coronavirus crisis showed that temporary workers are still easily dismissed, despite the structural reforms that started in 2016, which strengthened their employment protection.

This indicates that policies should concentrate on groups at higher risk of redundancy. Specifically, efforts should aim to protect the jobs of young, low-paid workers and women. Additionally, these policies should offer social protection for these groups to reduce the risk of material deprivation during periods of unemployment or economic inactivity.

Further research could examine how the structural reforms have affected the responsiveness of employment to output. Admittedly, they did not prevent the decline in temporary employment during the pandemic, but the question is how they affected employment growth during the recovery. Further research could also more closely examine the impact of 'anti-crisis shields', labour hoarding and working from home on employment during the pandemic.

Appendix

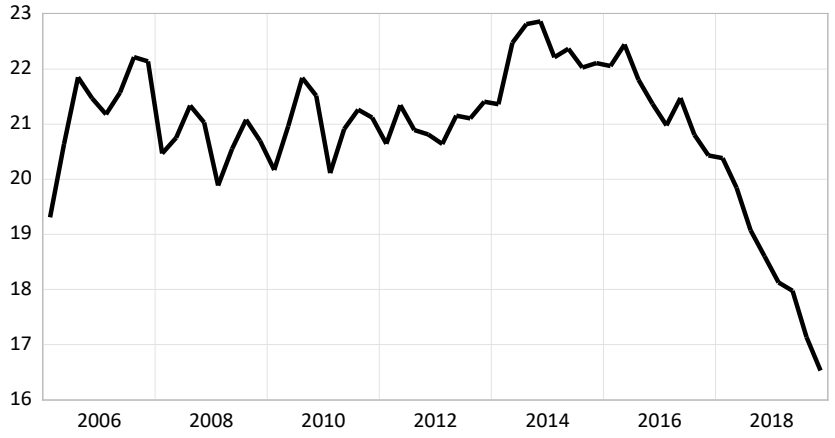

Figure A1. Share of temporary workers in the total employed (in %, aged 15–64)

Source: Eurostat, and own calculations.

Table A1. The GDP growth rate and changes in selected labour market indicators (in 2020 and 2021)

	2020				2021			
Quarter	**I**	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
GDP growth rate (in %)	**2.7**	**–7.8**	**–1.0**	**–1.8**	**0.2**	**12.2**	**6.5**	**8.5**
	date as defined before 2021							
Employment growth rate (in %)	0.9	–1.3	–0.6	0.5				
The employment-to-population ratio (in percentage points)	0.5	–0.6	–0.3	0.3				
Unemployment rate (in percentage points)	–0.8	–0.1	0.2	0.2				
Labor force participation rate (in percentage points)	0.1	–0.7	–0.3	0.5				
	date as defined in 2021							
Employment growth rate (in %)	0.9	–1.7	–0.8	0.4	1.3	3.4	3.1	2.8
The employment-to-population ratio (in percentage points)	0.5	–1.0	–0.4	0.2	1.4	2.6	2.5	2.4
Unemployment rate (in percentage points)	–0.8	0.0	0.2	0.3	0.8	0.3	–0.3	–0.3
Labor force participation rate (in percentage points)	0.0	–1.0	–0.3	0.4	2.0	2.8	2.4	2.3

Note: The change is compared to the quarter of the previous year.

Source: Statistics Poland and own calculations.

Table A2. Descriptive statistics of the variables used (2003–2019)

	Mean	Median	Maximum	Minimum	Std. Dev.	*N*	Mean	Median	Maximum	Minimum	Std. Dev.	*N*
Employed growth rates	aged 15–64						aged 15–24					
Total	1.25	1.07	5.26	–2.55	1.57	68	–0.81	–0.25	8.21	–12.29	4.59	68
Males	1.27	0.89	5.68	–2.83	1.66	68	–0.64	–0.78	10.38	–8.80	4.41	68
Females	1.22	1.10	5.45	–2.22	1.68	68	–0.95	–0.14	9.66	–17.20	6.19	68
Primary education	–4.62	–4.21	6.83	–15.10	4.39	68	–2.37	–4.48	46.65	–20.59	11.04	68
Secondary education	0.01	–0.18	4.86	–5.06	2.20	68	–0.98	–0.20	11.11	–12.25	5.26	68
Tertiary education	6.03	5.35	12.38	1.34	3.05	68	4.31	1.12	48.40	–15.44	13.95	68
Full-time	1.50	1.12	6.24	–1.95	1.77	68	–2.98	–4.14	21.71	–22.04	9.95	68
Part-time	–1.32	–1.34	8.58	–11.34	3.85	68	–0.23	–1.03	12.39	–11.44	5.58	68
Self-employed	–0.32	–0.03	4.12	–7.46	2.10	68	–3.44	–5.98	40.52	–24.96	11.33	68
Employees growth rates	aged 15–64						aged 15–24					
Total employees	1.66	1.31	6.96	–3.72	2.22	68	0.22	0.70	12.52	–12.37	5.58	68
Permanent contract	1.21	1.47	7.18	–5.14	2.91	68	–1.01	–4.34	23.37	–20.61	11.86	68
Temporary contract	4.18	0.87	28.91	–11.53	9.84	68	2.11	–0.76	24.60	–11.25	8.84	68
Δ^2GDP	0.02	0.10	2.40	–2.40	1.02	68	0.02	0.10	2.40	–2.40	1.02	68
ΔGDP_{t-1}	4.09	4.20	7.60	–0.30	1.78	68	4.09	4.20	7.60	–0.30	1.78	68

Source: Eurostat, Statistics Poland, and own calculations.

Table A3. Forecast errors (in percentage points, in 2020)

	Employed persons growth rate									Employees growth rate		
	Gender			Education level			Working time		Status in employment	Contract		
	total	males	females	primary	secondary	tertiary	full-time	part-time	self-employed	total	permanent	temporary
	Aged 15–64											
Mean error	1.31	1.36	1.24	6.11	2.78	–4.16	1.60	–1.40	5.84	0.62	4.95	–16.68
Root Mean Square Error	1.49	1.52	1.70	6.82	3.24	5.00	1.85	2.37	6.42	0.98	5.57	18.72
	Aged 15–24											
Mean error	–4.95	–3.92	–6.33	2.65	–4.97	–9.60	–15.22	–2.54	7.72	–3.80	–16.44	14.66
Root Mean Square Error	6.53	4.24	10.71	17.31	5.96	26.98	24.48	3.40	16.31	6.72	19.13	16.17

Source: Eurostat, Statistics Poland, and own calculations.

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CSR committees and their effect on green practices

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Abstract

This paper explores the relationship between the presence of corporate social responsibility (CSR) committees and the implementation of corporate green practices. Using data from 445 non-financial Japanese firms from 2010 to 2021, we find a positive impact of such sustainability committees on both integrated and three individual aspects of green initiatives, including internal pollution prevention, green supply chain management, and green product innovation. In addition, our evidence demonstrates a variation in the CSR committees—green practices nexus across diverse groups of firms, based on their exposures to environmental risks. Finally, we claim that CSR-linked compensation and CSR strategy can explain how CSR committees affect firms' eco-friendly practices. Generally, our study confirms the crucial role of a governance mechanism—CSR committees—that business organisations and policymakers can exploit to promote sustainable behaviours.

Keywords

- CSR committees
- green practices
- environmentally sensitive sectors
- CSR-linked compensation
- CSR strategy

JEL codes: G34, M14.

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Introduction

In the last few decades, as many reform initiatives on sustainable development have been implemented globally, the demand for companies to endorse the corporate social responsibility (CSR) concept in their business activities has increased. CSR is a self-regulated practice that incorporates sustainable development into business strategy. The goal of CSR is to establish positive public relations and strong ethical standards to diminish risks and enhance shareholder trust, promoting corporate long-term competitiveness and resilience (Han et al., 2016). A company's CSR effort is reflected by its environmental, social, and corporate governance (ESG) activities. The environmental aspect refers to a firm's initiatives to reduce its influence on the environment. The social aspect reflects how well a company maintains its stakeholders' relationships, including employees, customers, suppliers, and communities. Meanwhile, the governance aspect includes practices in leadership, internal control, executive pay, and shareholder rights. Overall, the ESG framework provides specific criteria that can be used to assess a company's commitment to the environment and society.

Alongside this context, discussions and studies on corporate governance to detect which governance mechanisms positively impact firm CSR behaviours have also attracted numerous scholars, practitioners, and policymakers. A literature stream has recently emerged to explore the role of board sustainability committees in CSR-related outcomes (Bifulco et al., 2023; García Martín & Herrero, 2020; Konadu, 2017; Radu & Smaili, 2022). CSR committees are specialised governance mechanisms, voluntarily established by the board of directors to instruct and oversee the information contained in sustainability reports and ensure the proper operation of the organisation's CSR systems and policies (Liao et al., 2015).

However, compared to the comprehensive literature on corporate governance and sustainability or ESG performance, such studies are scarce and demonstrate heterogeneous results. On the one hand, Bifulco et al. (2023), Kend (2015), and Rodrigue et al. (2013) state that the presence of sustainability committees does not play any significant role in enhancing corporate environmental and social outcomes. Other studies, in contrast, provide evidence that such committees positively impact CSR disclosures and performance (Biswas et al., 2018; Córdova et al., 2018; Orazalin, 2020; Román et al., 2021). These inconclusive results lay the foundations for our research, as we wonder whether the concerns of the board of directors on sustainability issues, reflected by the creation of CSR committees, can convert into effective CSR initiatives that promote sustainability performance.

More specifically, in this study, we investigate how the presence of CSR committees in the governance system affects corporate green behaviours.

A few prior studies, for example, García Martín and Herrero (2020), Rodrigue et al. (2013), and Walls et al. (2012) mention the relationship between sustainability committees, as a part of their research on environmental governance mechanisms, and firm green initiatives. Nevertheless, these studies do not draw any unambiguous conclusions.

Besides, Velte and Stawinoga (2020) claim that industry effects, for example environmentally sensitive industries, can lead to mixed results on the relationship between CSR committees and CSR-related outcomes. They also address the lack of studies on the mediator factors in this relationship. As a result, we further explore the variation in the CSR committees—green practices nexus across industrial sectors and potential channels that explain the effect of CSR committees on firms' eco-friendly practices.

To address these purposes, we first self-construct our green practices indices, based on data from 445 non-financial Japanese firms between 2010 and 2021. The relationship between CSR committees and corporate green practices is examined by applying pooled ordinary least squares with industry-fixed and year-fixed effects. We then verify these baseline results with two different regression techniques. In addition, we employ seemingly unrelated regressions and Chow tests to assess the variation in the CSR committees—green practices nexus across business sectors. Lastly, the potential mediating impact of CSR-linked compensation and CSR strategy on the CSR committees—green practices nexus is investigated, following Baron and Kenny's (1986) approach.

Generally, our study makes several contributions to the literature. Firstly, it broadens the literature on the impact of CSR committees. Most of these studies emphasise the relationship between CSR committees and CSR reporting, assurance, and overall performance (Biswas et al., 2018; Burke et al., 2019; Orazalin, 2020). Our paper, distinctive from previous works, examines the association between the CSR committee and corporate green practices. Secondly, we extend the literature on the determinants of green practices. Prior research explores the role of technological, organisational, and environmental factors in adopting green initiatives (Aboelmaged, 2018; Hwang et al., 2016; Qin et al., 2022; Zhu et al., 2008). We investigate whether the existence of sustainability committees could be a driving factor in promoting a company's environmentally friendly behaviours. Finally, as the first study concentrates solely on the CSR committees-green practices nexus, we provide comprehensive evidence of the impact of CSR committees on various aspects of corporate green behaviours, including internal pollution intervention, green supply chain management, and green product innovation. More importantly, we demonstrate that our analysed relationship varies across business sectors, based on their different exposure to environmental risks, and such a relationship is mediated by firms' CSR-linked compensation and CSR strategy.

The remainder of this paper proceeds as follows: Section 1 reviews the related literature and develops a hypothesis; Section 2 describes our sample, variables, and methods; Section 3 presents the empirical results; and the last section discusses and summarises our findings.

1. Literature review and hypothesis development

The CSR committee is a specialised governance mechanism established by the board of directors to address issues on sustainability, health and safety, ethics, and the environment. According to Dixon-Fowler et al. (2017), members of the CSR committee are expected to provide instructions and recommendations to the board of directors in creating tactical CSR strategies and ensure ESG criteria are incorporated into business activities and reporting. Hence, the CSR committee plays a vital role in overseeing and implementing quality CSR practices (Radu & Smaili, 2022).

Studies on the impact of CSR committees on CSR-related activities can be categorised into two streams. One stream explores the relationship between CSR committees and CSR reporting. Pucheta-Martinez and Gallego-Alvarez (2019) examined the effect of board composition on CSR reporting and concluded that CSR board committees encourage the disclosure of CSR matters. Previously, Ruhnke and Gabriel (2013) found a positive impact of CSR committees on the assurance of CSR reports audited by external parties. Another stream investigates how the presence of sustainability committees affects CSR performance. Baraibar-Diez and Odriozola (2019), Biswas et al. (2018), and Orazalin (2020) found a positive relationship between board sustainability committees and overall ESG performance. Furthermore, the evidence from Córdova et al. (2018) and Román et al. (2021) indicated that the presence of a CSR committee reduces firms' carbon emission levels. Nevertheless, some researchers state that CSR committees do not significantly impact CSR reporting and performance (Burke et al., 2019; Kend, 2015). Al-Shaer and Zaman (2018) even found a negative association between sustainability committees and the credibility of sustainability reports.

Meanwhile, corporate green practices, also known as environmentally friendly or eco-friendly behaviours, refer to initiatives undertaken by companies to minimise their influence on the environment and promote sustainable development. Such practices, although diverse, depending on operating sectors and firm size, can be categorised into four main groups: pollution prevention, green supply chain management, green product innovation, and environmental management system standards. Pollution prevention practices are actions that businesses implement to reduce or improve certain environ-

mental performance, such as waste and toxic chemical reduction, air emission reduction, or water and energy efficiency. Green supply chain management includes initiatives to use environmental criteria to select materials and suppliers or to optimise transportation routes. Green product innovation practices refer to actions aiming to reduce the environmental effect of a product, like eco-friendly design. Finally, environmental management system standards indicate the adoption of voluntary standards, such as ISO 14001 into firm environmental management.

Many studies showed the positive impact of green behaviours on ESG and financial performance that can encourage companies to adopt environmentally friendly practices in their daily operations (Erauskin-Tolosa et al., 2020; King & Lenox, 2002; Lin et al., 2013). Others tried to detect drivers that affect the collaboration of green behaviours in corporate activities. These drivers can be classified into three categories: technological, organisational, and environmental factors. According to Hwang et al. (2016), technological factors refer to technological attributes relevant to innovation, organisational factors refer to the firm characteristics, and environmental factors refer to the arena in which a firm conducts its business including its industry, customers, competitors, and the government. The authors indicated that all three aspects influence green supply chain adoption in the semiconductor industry. Similarly, for small and medium enterprises, Alraja et al. (2022) found a strong positive relationship between technological factors and green innovation, organisational factors and green human resource management, and environmental factors and green marketing. Aboelmaged (2018) and Qin et al. (2022) revealed the vital role of management support, internal environment management, and the engagement of employees in green manufacturing practices. Zhu et al. (2008) demonstrated that large and medium-sized firms are more committed to going green than their smaller counterparts. Chege and Wang (2020) stated that technological innovation and firm performance are organisational characteristics that play a key role in the implementation of sustainable practices. However, organisational culture, government support, and employee training do not exhibit any significant links with such practices.

Focusing on environmental management, the resource dependence theory suggests that members of the CSR committee are more inclined to endorse their company's engagement with other eco-friendly enterprises. A collaboration of this type can result in better environmental strategies and performance through sharing environmental experience, skills, and resources between both organisations. Moreover, from the standpoint of stewardship theory, CSR committee members may recognise that their reputations are likely to link with the environmental performance of their companies (Dixon-Fowler et al., 2017). As a result, these directors would persuade other boards of directors to conduct effective environmental tac-

tics that will enhance performance and develop a better corporate social reputation (Konadu, 2017).

Despite being scarce and inconclusive, previous studies demonstrated the potential impact of board sustainability committees on environmental practices. Dixon-Fowler et al. (2017) and Walls et al. (2012) revealed that the environmental committee associates positively with firm environmental strengths, such as the development and marketing of green products and services, the use of pollution prevention approaches in production, recycling, and the use of alternative fuels. García Martín and Herrero (2020) also confirmed the positive relationship between the existence of a CSR committee and the implementation of environmental initiatives. In contrast, Rodrigue et al. (2013) argue that the presence of an environmental committee is not significantly associated with the presence of a pollution prevention policy. Based on these viewpoints and empirical results, we propose our hypothesis as follows: *The presence of the CSR committee is positively related to corporate green practices.*

2. Sample, variables, and methodology

The study is conducted based on a set of non-financial Japanese companies whose CSR and financial data are available in the LSEG Datastream database. The final sample consists of 445 companies from 2010 to 2021. Following Fan et al. (2023), we create a one-year lag for all corporate financial variables to partially mitigate the potential endogeneity in our regression models. Furthermore, all continuous variables are winsorised at 1 and 99th percentiles to alleviate the effect of outliers.

The dependent variables include three indices that represent three types of green practices: the internal pollution prevention index (GP_{IPP}), the green supply chain management index (GP_{GSCM}), and the green product innovation index (GP_{GPI}). These indices are constructed using underlying data points from resource uses, emission reduction, and product innovation categories of the environmental pillar of Datastream ESG data, following the methodology used by Miroshnychenko et al. (2017). Datastream is one of the largest and most popular CSR databases and most importantly, unlike other databases, it provides raw data to users, allowing them to create their own measurements (de Villiers et al., 2022). We also construct an aggregated green practice index (GP) from three individual ones.

The independent variable is the presence of a CSR committee (CSR_{COM}). It is a dummy variable that has a value of one if the company has a CSR committee, and zero otherwise (Baraibar-Diez & Odriozola, 2019; Biswas et al., 2018;

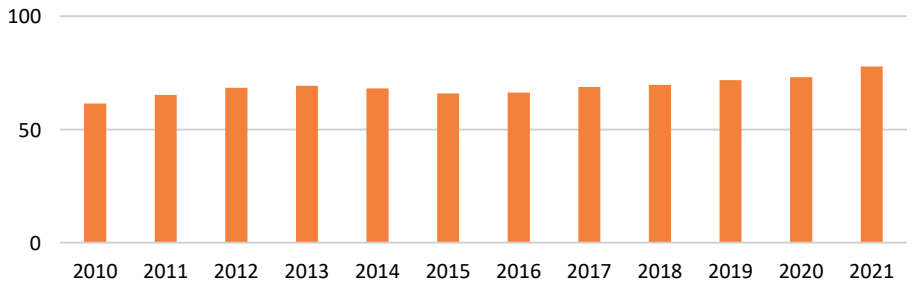

Figure 1. Percentage of Japanese firms with a CSR committee (2010–2021)

Source: own calculations.

Radu & Smaili, 2022). The annual ratios of Japanese companies with a CSR committee among the total sample from 2010 to 2021 are shown in Figure 1. In 2010, the CSR committee existed in approximately 61% of Japanese firms. This ratio increases to about 78% in 2021.

Table 1. Definition of variables

Variable	Description and calculation
Panel A. Dependent variables	
GP_{IPP}	Internal pollution prevention index
GP_{GSCM}	Green supply chain management index
GP_{GPI}	Green product innovation index
GP	Green practice index
Panel B. Independent variable	
CSR_{COM}	A dummy variable equals 1 if the given company has a CSR committee and 0 otherwise
Panel C. Control variables	
B_{SIZE}	Total number of board members
B_{FED}	The percentage of female board members
B_{IND}	The percentage of independent board members
B_{NED}	The percentage of non-executive board members
$SIZE$	Natural logarithm of total assets
ROA	Return on assets; Net profit divided by total assets
LEV	Total debt divided by total assets

Note: The detailed measurements of green practices indices are presented in Appendix.

Source: own elaboration.

Finally, in conjunction with previous studies by Orazalin (2020), Shaukat et al. (2016), and Walls et al. (2012), we employ several control variables that might affect the relationship being analysed. These are firm size ($SIZE$), leverage (LEV), profitability (ROA), board size (B_{SIZE}), board independence (B_{IND}), board diversity (B_{FED}), and non-executive board (B_{NED}). The definition and measurement of our main variables are summarised in Table 1.

To examine how the presence of a CSR committee affects a company's green practices, we first apply pooled ordinary least square (POLS) regressions using industry-fixed and year-fixed effects with Huber-White standard errors. The baseline model is as follows:

$$GP_{it} = \alpha_i + \beta_1 CSR_{COMit} + \sum_{k=1}^{7} \beta_{k+1} CV_{kit} + \varepsilon_{it} \quad (1)$$

where GP_{it} represents the overall green practice index as well as its three dimensions: GP_{IPP}, GP_{GSCM}, and GP_{GPI} of the company i at time t; CSR_{COMit} indicates whether the company i does or does not have a CSR committee at time t; CV_{kit} is the vector of control variables k of the company i at time t; ε_{it} includes an independent idiosyncratic error term u_{it} and unobserved corporate characteristics c_{it}.

Furthermore, two other estimations, propensity score matching (PSM) and generalised method of moments (GMM) are implemented to verify the relationship between CSR committees and green practices. We apply PSM to reduce selection bias in our analyses by aligning firm characteristics between companies with and without CSR committees. Meanwhile, according to Aslam et al. (2021), the GMM estimator is considered one of the most suitable tools to mitigate heterogeneity, endogeneity, and estimation bias issues.

3. Results

Panel A of Table 2 presents the descriptive statistics for the full sample. The mean of CSR_{COM} is 0.691, indicating that on average, nearly 70% of Japanese firms have a CSR committee throughout the period examined. Meanwhile, the mean of GP is 7.323, lower than the neutral score (8.5), implying that such organisations do not perform well in adopting green practices. Furthermore, with a standard deviation of 4.382, the level of adoption of green practices in business activities appears to differ among the organisations being studied. The results from three individual dimensions of green practices lead to a similar conclusion. Regarding corporate governance characteristics, the average board size is 11, with independent and non-executive directors accounting

Table 2. Descriptive statistics

Panel A. Full sample					
	Mean	**Min**	**Max**	**S.D.**	***N***
GP_{IPP}	3.943	0	9	2.382	4,445
GP_{GSCM}	1.789	0	4	1.434	4,445
GP_{GPI}	1.590	0	3	1.169	4,445
GP	7.323	0	15	4.382	4,445
CSR_{COM}	0.691	0	1	0.462	4,491
B_{SIZE}	11.451	1	30	3.859	4,455
B_{FED}	5.170	0	57.14	7.001	4,453
B_{IND}	22.684	0	87.5	16.240	4,451
B_{NED}	33.608	0	100	18.349	4,455
$SIZE$	20.276	16.692	23.533	1.268	5,289
ROA	4.193	–12.65	22	4.645	5,268
LEV	22.349	0	72.241	18.058	5,289

Panel B. Sub-samples								
	Firms without a CSR committee			**Firms with a CSR committee**			**Differences**	
	Mean	**Median**	***N***	**Mean**	**Median**	***N***	***t*-stat.**	***z*-stat.**
GP_{IPP}	1.803	1	1,379	4.906	5	3,066	–50.342***	–38.688***
GP_{GSCM}	0.540	0	1,379	2.351	3	3,066	–48.038***	–38.021***
GP_{GPI}	0.830	0	1,379	1.932	2	3,066	–32.312***	–27.546***
GP	3.172	2	1,379	9.189	10	3,066	–54.835***	–40.195***
B_{SIZE}	11.137	11	1,377	11.595	11	3,075	–3.662***	–4.379***
B_{FED}	3.745	0	1,376	5.810	0	3,074	–9.178***	–9.620***
B_{IND}	19.463	17.65	1,373	24.106	22.22	3,075	–8.889***	–10.244***
B_{NED}	32.808	30	1,377	33.952	33.33	3,075	–1.924**	–2.937**
$SIZE$	19.819	19.729	1,388	20.799	20.673	3,103	–28.401***	–26.247***
ROA	5.115	3.84	1,383	3.698	3.55	3,101	9.830***	6.486***
LEV	19.365	13.056	1,388	23.490	21.312	3,103	–7.262***	–10.600***

Note: Variables are described in Table 1. The last two columns in Panel B show the results of the *t*-test and Wilcoxon rank-sum test to compare the differences in means and medians between the companies with and without a CSR committee. **, and *** indicate significant levels at 5% and 1%, respectively.

Source: own calculations.

for 22.68% and 33.61% of board seats, respectively. In addition, it should be noted that the average ratio of female directors is only 5.17%, demonstrating the predominance of male leadership in Japanese companies.

Panel B of Table 2 presents the descriptive statistics when our sample is divided into two groups: firms without a CSR committee ($CSR_{COM} = 0$) and firms with a CSR committee ($CSR_{COM} = 1$). It also reports the results of *t*-tests and Wilcoxon *z*-tests to compare the differences in means and medians between such groups. Firms with a CSR committee score significantly higher in green practice indices, supporting our hypothesis preliminarily. A CSR committee is also associated with a larger board of directors, a board with more female, independent, and non-executive directors, a larger size, and a higher leverage ratio. Such considerable variances in control variables between our sub-samples might greatly affect our regression results. Consequently, it is necessary to control these variables to obtain more robust empirical evidence.

Table 3 presents the Pearson correlation matrix. As can be seen, the correlation coefficients between CSR_{COM} and all GP indices are significantly positive, indicating that having a CSR committee is correlated with organisations' green behaviours. Furthermore, except ROA, most firm characteristics ($SIZE$ and LEV) and corporate governance devices (B_{SIZE}, B_{FED}, B_{IND}, and B_{NED}) significantly and positively correlate with our dependent variables. Lastly, the correlation coefficients and variance inflation factors (VIFs)[2] between CSR_{COM} and all control variables are less than 0.7 and 3, respectively, signalling that our models do not suffer severe multicollinearity issues.

3.1. Baseline results

Table 4 reports the regression results for Equation (1). For each green practice index, columns (1) and (2) present the results for models without and with control variables, respectively. As can be seen in column (1), the coefficients of CSR_{COM} are positive and significant at the 1% level. When control variables are added to the regressions in column (2), its coefficient is still significantly positive. These results suggest that companies with a CSR committee tend to achieve higher scores in green practice indices, implying that a sustainability board can drive business organisations to act more environmentally responsible. Regarding control variables, larger firms with a more independent board are associated with higher levels of green adoption. In contrast, a board of directors with high percentages of female and non-executive directors, and a higher debt ratio, might negatively affect a firm's green behaviours.

[2] The VIFs' scores are not reported but are available upon request.

Table 3. Correlation matrix

	GP_{IPP}	GP_{GSCM}	GP_{GPI}	GP	CSR_{COM}	B_{SIZE}	B_{FED}	B_{IND}	B_{NED}	$SIZE$	ROA	LEV
GP_{IPP}	1.000											
GP_{GSCM}	0.702***	1.000										
GP_{GPI}	0.602***	0.583***	1.000									
GP	0.934***	0.865***	0.785***	1.000								
CSR_{COM}	0.603***	0.585***	0.436***	0.635***	1.000							
B_{SIZE}	0.060***	0.064***	0.118***	0.085***	0.055***	1.000						
B_{FED}	0.111***	0.115***	–0.044***	0.086***	0.136***	–0.110***	1.000					
B_{IND}	0.164***	0.193***	0.026*	0.159***	0.132***	–0.302***	0.386***	1.000				
B_{NED}	0.045***	0.088***	–0.058***	0.038**	0.029*	–0.220***	0.371***	0.750***	1.000			
$SIZE$	0.416***	0.366***	0.280***	0.421***	0.390***	0.315***	0.085***	0.061***	–0.011	1.000		
ROA	–0.090***	–0.096***	–0.137***	–0.117***	–0.145***	–0.130***	0.042***	0.077***	0.099***	–0.224***	1.000	
LEV	0.067***	0.080***	0.087***	0.086***	0.108***	0.210***	–0.041***	–0.085***	–0.108***	0.395***	–0.408***	1.000

Note: Variables are described in Table 1. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Source: own calculations.

Table 4. CSR committees and green practices – POLS regression

	GP_{IPP}		GP_{GSCM}		GP_{GPI}		GP	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
CSR_{COM}	0.588***	0.488***	0.575***	0.510***	0.424***	0.380***	0.621***	0.534***
	(0.013)	(0.015)	(0.012)	(0.014)	(0.014)	(0.017)	(0.012)	(0.014)
B_{SIZE}		–0.020		0.023*		0.044***		0.009
		(0.014)		(0.014)		(0.015)		(0.013)
B_{FED}		–0.014		–0.011		–0.081***		–0.033**
		(0.013)		(0.014)		(0.015)		(0.013)
B_{IND}		0.093***		0.134***		0.067***		0.112***
		(0.019)		(0.020)		(0.023)		(0.018)
B_{NED}		–0.061***		–0.008		–0.043**		–0.047***
		(0.018)		(0.019)		(0.021)		(0.018)
$SIZE$		0.230***		0.120***		0.139***		0.265***
		(0.016)		(0.017)		(0.019)		(0.015)
ROA		0.002		0.004		–0.056***		–0.013
		(0.013)		(0.013)		(0.015)		(0.013)
LEV		–0.085***		–0.035*		–0.092***		–0.082***
		(0.016)		(0.018)		(0.019)		(0.016)
Const.	0.101*	0.271***	–0.018	0.159***	0.199***	0.226***	0.102**	0.260***
	(0.054)	(0.052)	(0.058)	(0.056)	(0.056)	(0.057)	(0.050)	(0.048)
Obs.	4,445	4,058	4,445	4,058	4,455	4,058	4,445	4,058
R^2	0.3886	0.4436	0.3658	0.4130	0.2727	0.2981	0.4363	0.4871
F-stat.	141.57***	134.23***	155.62***	144.22***	91.08***	81.23***	188.36***	183.33***
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Variables are described in Table 1. Robust standard errors are in brackets. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Source: own calculations.

3.2. Robustness checks

Our preliminary findings imply that differences in firm-specific characteristics between treatment companies with a CSR committee ($CSR_{COM} = 1$) and control companies with no CSR committee ($CSR_{COM} = 0$) may influence companies' intentions to go green. Therefore, we align such characteristics of the two groups

Table 5. CSR committees and green practices – PSM estimation

	First-stage: $y = CSR_{COM}$		Second-stage: y = green practices			
	Logit regression	**Balance test**	GP_{IPP}	GP_{GSCM}	GP_{GPI}	GP
CSR_{COM}			0.503***	0.534***	0.389***	0.552***
			(0.017)	(0.017)	(0.019)	(0.017)
B_{SIZE}	–0.142***	0.011	–0.041*	–0.016	0.033	–0.019
	(0.046)	(0.056)	(0.022)	(0.021)	(0.024)	(0.021)
B_{FED}	0.272***	–0.071	0.020	–0.004	–0.104***	–0.018
	(0.048)	(0.059)	(0.023)	(0.025)	(0.026)	(0.023)
B_{IND}	0.536***	0.022	0.082***	0.072**	0.095***	0.093***
	(0.071)	(0.085)	(0.031)	(0.031)	(0.036)	(0.029)
B_{NED}	–0.325***	0.029	–0.089***	0.013	–0.089***	–0.068**
	(0.060)	(0.073)	(0.028)	(0.028)	(0.032)	(0.028)
$SIZE$	1.406***	–0.038	0.316***	0.164***	0.203***	0.280***
	(0.066)	(0.084)	(0.032)	(0.034)	(0.039)	(0.033)
ROA	–0.330***	0.001	0.012	0.002	–0.050**	–0.006
	(0.048)	(0.056)	(0.022)	(0.021)	(0.025)	(0.022)
LEV	–0.328***	0.067	–0.061**	–0.004	–0.102***	–0.062**
	(0.057)	(0.063)	(0.025)	(0.025)	(0.029)	(0.024)
Const.	1.892***	–0.177	0.199**	0.128	0.293***	0.228***
	(0.186)	(0.235)	(0.088)	(0.097)	(0.107)	(0.085)
Obs.	4,099	1,852	1,852	1,852	1,852	1,852
R^2	0.2084	0.0045	0.3636	0.3800	0.2471	0.4141
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: Variables are described in Table 1. Robust standard errors are in brackets. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Source: own calculations.

using the PSM approach. We first implement logit regression for our full sample to estimate the propensity score for the treatment companies. The results are reported in the first column of Table 5. Then, we apply one-to-one matching without replacement and set the calliper distance at 0.01 to identify a control company for each treatment company. This procedure leads to 926 pairs of companies. The unmatched ones are removed from subsequent analyses.

We re-run the logit regression with the matched sample to check the covariance balance between treatment and control groups. The post-matching results in the second column of Table 5, where all coefficients of the covariances are insignificant, indicate that these two groups align closely. A similar implication can be drawn from Figure 2, which presents the Kernel density of propensity scores of treatment and control groups before and after PSM. As we can see, the Kernel densities are remarkably different between the two groups before matching. However, after matching, the Kernel densities are almost identical, implying that both groups' features become comparable.

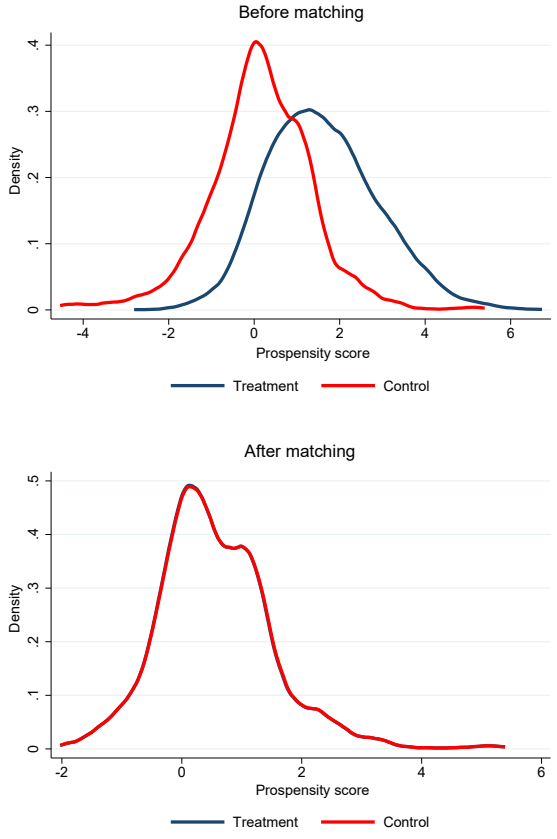

Figure 2. Kernel density of propensity scores before and after PSM

Source: own calculations.

Table 6. CSR committees and green practices – GMM estimation

	GP_{IPP}	GP_{GSCM}	GP_{GPI}	GP
L.GP_{IPP}	0.656***			
	(0.073)			
L.GP_{GSCM}		0.849***		
		(0.060)		
L.GP_{GP}			0.961***	
			(0.076)	
L.GP				0.728***
				(0.056)
CSR_{COM}	0.291***	0.168***	0.081*	0.248***
	(0.045)	(0.045)	(0.045)	(0.036)
B_{SIZE}	0.027	0.007	–0.023	0.013
	(0.065)	(0.058)	(0.058)	(0.052)
B_{FED}	0.079	0.013	–0.005	0.040
	(0.075)	(0.061)	(0.056)	(0.050)
B_{IND}	–0.092	0.039	–0.061	–0.039
	(0.097)	(0.077)	(0.089)	(0.069)
B_{NED}	0.165*	0.078	0.056	0.088
	(0.096)	(0.106)	(0.096)	(0.071)
$SIZE$	0.145*	0.028	–0.030	0.108
	(0.081)	(0.070)	(0.062)	(0.070)
ROA	–0.017	0.007	–0.013	–0.007
	(0.013)	(0.012)	(0.012)	(0.011)
LEV	–0.076**	–0.016	–0.006	–0.058**
	(0.038)	(0.038)	(0.031)	(0.029)
Const.	0.165	0.072	–0.061	0.247
	(0.180)	(0.226)	(0.186)	(0.179)
Obs.	3,929	3,929	3,929	3,929
No. of instruments	92	92	92	92
Wald-stat.	1,575.62***	1,205.09***	1,767.99***	2,093.77***
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
AR(2)	0.479	0.670	0.118	0.398
Hansen	0.874	0.486	0.692	0.979

Note: Robust standard errors are in brackets. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Source: own calculations.

Finally, we use the matched sample to re-estimate Equation (1). As is shown in the last four columns of Table 5, the coefficients of CSR_{COM} for the aggregate and three individual green practice indices are still positive and significant at the 1% level. These results indicate that the CSR committees—green practices nexus is robust after considering the impact of different characteristics between companies with and without a CSR committee. Besides, except for the coefficient of B_{FED} becoming insignificant, other control variables show similar results as in the baseline regressions.

Furthermore, endogeneity might be a potential problem when investigating the CSR committees—green practices nexus. As a result, for the second robustness test, we apply two-step GMM estimation to verify our results. The results for re-estimating Equation (1) using the GMM technique are shown in Table 6. Compared to the baseline results, the coefficients of CSR_{COM} are smaller, but still significantly positive, implying that our main findings still hold. In contrast, except for leverage, the impact of other control variables turns out to be statistically insignificant.

3.3. Additional analyses

According to legitimacy theory, the content and scale of CSR activities depend on the relationship between societal expectations, managers' attitudes to what they think are legitimate societal expectations, and business behaviours (Stratling, 2007). Lin et al. (2015) then argue that companies with higher environmental risks, i.e., having more effect on the environment, face more pressure on CSR requirements and expectations than others. As a result, environmentally sensitive firms typically disclose CSR information more frequently and perform better than their non-sensitive counterparts to satisfy and obtain legitimacy from their stakeholders (Brammer & Pavelin, 2008; Garcia et al., 2017; Kilian & Hennigs, 2014; Richardson & Welker, 2001).

Since previous studies demonstrate a possible influence of business sectors on CSR practices, we further investigate the CSR committees—green practices nexus for companies operating under different environmental risks. Following García-Meca and Martínez-Ferrero (2021), we consider firms active in the basic materials, energy, and utility sectors as highly environmentally sensitive firms. To compare the impact of CSR committees on green practices between such firms and low-sensitive firms, first, we re-estimate Equation (1) for each group, using POLS regressions with firm-fixed and year-fixed effects. Then we apply seemingly unrelated regressions and Chow tests to verify the differences in CSR_{COM}'s coefficients of these two groups. The results are presented in Table 7. Column (1) presents the results for the high-sensitive group, whereas column (0) presents the results for the low-sensitive group.

Table 7. CSR committees and green practices – High-sensitive vs. low-sensitive sectors

	GP_{IPP}		GP_{GSCM}		GP_{GPI}		GP	
	(1)	**(0)**	**(1)**	**(0)**	**(1)**	**(0)**	**(1)**	**(0)**
CSR_{COM}	0.391***	0.188***	0.251***	0.141***	0.200***	0.105***	0.348***	0.176***
	(0.050)	(0.019)	(0.052)	(0.020)	(0.048)	(0.020)	(0.039)	(0.017)
B_{SIZE}	–0.067*	0.001	–0.031	0.005	0.040	0.021	–0.036	0.008
	(0.038)	(0.014)	(0.032)	(0.014)	(0.028)	(0.016)	(0.027)	(0.012)
B_{FED}	0.054	0.014	–0.056*	0.027**	–0.001	–0.017	0.011	0.012
	(0.037)	(0.012)	(0.030)	(0.014)	(0.030)	(0.013)	(0.027)	(0.011)
B_{IND}	0.081	–0.034	0.153***	–0.051**	0.015	–0.077***	0.098**	–0.056***
	(0.062)	(0.023)	(0.056)	(0.023)	(0.050)	(0.024)	(0.046)	(0.021)
B_{NED}	–0.002	0.033**	–0.045	0.013	–0.021	0.026	–0.021	0.029**
	(0.057)	(0.017)	(0.052)	(0.017)	(0.043)	(0.019)	(0.042)	(0.015)
SIZE	0.372**	0.200***	0.244	0.394***	0.526***	0.202***	0.422***	0.292***
	(0.180)	(0.051)	(0.166)	(0.071)	(0.167)	(0.070)	(0.150)	(0.053)
ROA	–0.031	–0.001	0.038	–0.024**	0.049	–0.033***	0.008	–0.017*
	(0.038)	(0.010)	(0.035)	(0.012)	(0.032)	(0.011)	(0.031)	(0.010)

LEV	0.098	–0.002	–0.023	–0.021	0.027	0.011	0.053	–0.005
	(0.060)	(0.026)	(0.056)	(0.030)	(0.054)	(0.030)	(0.048)	(0.024)
Const.	0.833***	–0.569***	0.758***	–0.390**	1.227***	–0.927***	1.028***	–0.684***
	(0.167)	(0.191)	(0.148)	(0.184)	(0.138)	(0.178)	(0.132)	(0.136)
Obs.	649	3,409	649	3,409	649	3,409	649	3,409
R^2	0.7825	0.8528	0.7970	0.8449	0.7439	0.8315	0.8352	0.8938
F-stat.	29.09***	52.02***	31.66***	48.97***	23.68***	44.46***	40.56***	75.10***
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Coefficient difference test for CSRCOM								
Difference	0.203***		0.110**		0.095**		0.172***	
Chi2_stat.	14.56***		3.85**		3.28*		16.16***	

Note: Variables are described in Table 1. Robust standard errors are in brackets. The differences between the coefficients of CSR_{COM} of the two groups are examined by the seemingly unrelated regressions and Chow tests. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Source: own calculations.

As can be seen, for GP and three individual indices, the coefficients of CSR_{COM} for highly environmentally sensitive firms are significantly larger than those of low-sensitive firms. These outcomes imply that the positive impact of sustainability committees on green practices comes out stronger for firms exposed to higher environmental risks.

In addition, Radu and Smaili (2022) argue that a CSR committee has both direct and indirect positive effects on firm environmental performance with CSR-linked compensation playing a mediating role. According to the authors, CSR committees and CSR-linked compensation are two vital governance mechanisms that the board of directors establishes to reflect their perceptions and commitments to CSR issues. The CSR committee monitors while CSR-linked compensation incentivises executives to align their interests with those of stakeholders. As the CSR committee is responsible for CSR-related decisions, implementing a CSR-linked executive compensation might be a part of these decisions to enhance CSR performance.

On the other hand, the empirical results from Orazalin (2020) suggest that the effectiveness of CSR strategy can explain the positive relationship between board sustainability committees and corporate environmental performance. Prior studies, such as Aragón-Correa et al. (2008), Helfaya and Moussa (2017), and Shaukat et al. (2016), have shown that companies with efficient and comprehensive CSR strategy are more likely to outperform their competitors in terms of environmental disclosure and performance, while the existence of CSR committees plays a key part in setting CSR strategy and monitoring its implementation in business activities (Mackenzie, 2007).

Such literature streams motivate us to explore the potential effect of CSR-linked compensation and CSR strategy on mediating the CSR committees—green practices nexus, following Baron and Kenny's (1986) approach. The authors suggest that a variable can be considered a valid mediator if it satisfies three critical conditions. First, there is a significant relationship between the independent and dependent variables. Second, there is a significant relationship between the independent and mediator variables. Finally, when both independent and mediator variables are included in one model, the impact of the mediator variable on the dependent variable must be significant and the effect of the independent variable on the dependent variable must be decreased. In our study, these conditions are assessed through 3-step estimations:

Step 1: Identifying the impact of the independent variable (CSR_{COM}) on dependent variables (GP and three individual indicators) via Equation (2.1):

$$GP_{it} = \alpha_i + \beta_1 CSR_{COMit} + \sum_{k=1}^{7} \beta_{k+1} CV_{kit} + \varepsilon_{it} \quad (2.1)$$

Table 8. Potential channels through CSR committees influence green practices

	GP	CSR_{COMPEN}	GP	CSR_{STRAT}	GP
	(Eq. 2.1)	**(Eq. 2.2a)**	**(Eq. 2.3a)**	**(Eq. 2.2b)**	**(Eq. 2.3b)**
CSR_{COMPEN}			0.040***		
			(0.009)		
CSR_{STRAT}					0.448***
					(0.016)
CSR_{COM}	0.534***	0.058***	0.531***	0.559***	0.283***
	(0.014)	(0.014)	(0.014)	(0.012)	(0.017)
B_{SIZE}	0.009	–0.024*	0.010	0.013	0.002
	(0.013)	(0.014)	(0.013)	(0.012)	(0.012)
B_{FED}	–0.033**	0.038	–0.034***	0.019	–0.040***
	(0.013)	(0.023)	(0.013)	(0.013)	(0.012)
B_{IND}	0.112***	0.106***	0.108***	0.094***	0.069***
	(0.018)	(0.027)	(0.018)	(0.018)	(0.016)
B_{NED}	–0.047***	–0.021	–0.047***	–0.024	–0.037**
	(0.018)	(0.022)	(0.018)	(0.016)	(0.015)
$SIZE$	0.265***	0.012	0.265***	0.283***	0.137***
	(0.015)	(0.023)	(0.015)	(0.015)	(0.014)
ROA	–0.013	–0.012	–0.012	0.009	–0.017
	(0.013)	(0.019)	(0.013)	(0.011)	(0.012)
LEV	–0.082***	0.045**	–0.084***	–0.027*	–0.072***
	(0.016)	(0.019)	(0.016)	(0.015)	(0.015)
Const.	0.260***	–0.119**	0.264***	0.177***	0.184***
	(0.048)	(0.050)	(0.048)	(0.050)	(0.044)
Obs.	4,058	4,098	4,058	4,099	4,058
R^2	0.4871	0.0644	0.4888	0.5187	0.5833
F-stat.	183.33***	5.54***	178.72***	310.29***	281.91***
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: Variables are described in Table 1. Robust standard errors are in brackets. *, **, and *** indicate significant levels at 10%, 5%, and 1%, respectively.

Source: own calculations.

Step 2: Identifying the impact of the independent variable (CSR_{COM}) on mediator variables (CSR_{COMPEN} and CSR_{STRAT}) via Equations (2.2a) and (2.2b):

$$CSR_{COMPENit} = \alpha_i + \beta_1 CSR_{COMit} + \sum_{k=1}^{7} \beta_{k+1} CV_{kit} + \varepsilon_{it} \quad (2.2a)$$

$$CSR_{STRATit} = \alpha_i + \beta_1 CSR_{COMit} + \sum_{k=1}^{7} \beta_{k+1} CV_{kit} + \varepsilon_{it} \quad (2.2b)$$

Step 3: Identifying the joint impact of the independent variable (CSR_{COM}) and mediator variables (CSR_{COMPEN} and CSR_{STRAT}) on dependent variables (GP and three individual indicators) via Equations (2.3a) and (2.3b). The impact of CSR_{COM} on GP must be weaker than in Step 1. Meanwhile, the effect of CSR_{COMPEN} and CSR_{STRAT} on GP must be statistically significant.

$$GP_{it} = \alpha_i + \beta_1 CSR_{COMPENit} + \beta_2 CSR_{COMit} + \sum_{k=1}^{7} \beta_{k+2} CV_{kit} + \varepsilon_{it} \quad (2.3a)$$

$$GP_{it} = \alpha_i + \beta_1 CSR_{STRATit} + \beta_2 CSR_{COMit} + \sum_{k=1}^{7} \beta_{k+2} CV_{kit} + \varepsilon_{it} \quad (2.3b)$$

in which: $CSR_{COMPENit}$ is a dummy variable that gets the value of one if the company i has a CSR-linked compensation policy at time t and zero otherwise. $CSR_{STRATit}$ is the CSR strategy score of the company i at time t obtained from the Datastream ESG database. The CSR strategy score indicates a company's efforts to incorporate economic, social, and environmental dimensions into its daily decision-making processes. Other variables are the same as in our previous analyses.

The results are presented in Table 8.[3] As can be seen from the table, both CSR-linked compensation and CSR strategy meet Baron and Kenny's requirements for a valid mediator variable. However, their effect on the CSR committees—green practices nexus is incomparable. Specifically, the coefficient of CSR_{COM} reduces slightly from 0.534 to 0.531 when CSR_{COMPEN} is added to the model. In contrast, there is a remarkable decrease in the magnitude of CSR_{COM}'s coefficient (from 0.534 to 0.283) with the inclusion of CSR_{STRAT}. These results suggest that the existence of sustainability committees can promote the integration of environmentally friendly practices in business activities through two channels: linking CEO compensation to CSR-related provisions and improving CSR strategy, with the improvement of CSR strategy demonstrating a stronger mediating effect.

[3] For brevity, we only present the results for the aggregate green practice index. The outcomes for three individual indices draw similar conclusions.

Conclusions

Using a sample of 445 Japanese companies between 2010 and 2021, the main objective of this research is to investigate the effect of CSR committees on the collaboration of green practices in business activities. We find that firms with a CSR committee are associated with higher scores in three environmentally friendly initiatives, including internal pollution intervention, green supply chain management, and green product development. These results are in tandem with the previous findings of Dixon-Fowler et al. (2017), García Martín and Herrero (2020), and Walls et al. (2012) and indicate the vital role of sustainability committees in promoting corporate green behaviours. Our findings still hold after considering the differences in firm-specific characteristics and corporate governance devices across companies and applying two additional methods, including PSM and GMM.

Furthermore, we claim that the positive impact of CSR committees on corporate green practices is stronger for firms operating in higher environmentally sensitive sectors. In our sample, the proportion of high-sensitive firms with a CSR committee is 79.78%, compared to 67.07% of their low-sensitive counterparts. Such a difference is expected as companies with higher environmental risks face more pressure on CSR requirements and expectations than others (Lin et al., 2015) and the board of directors in those companies can create CSR committees as one of the governance mechanisms to gain legitimacy from their stakeholders (Burke et al., 2019). Our results suggest that the presence of CSR committees in highly environmentally sensitive companies is not just a symbolic factor to control stakeholder perceptions favorably but truly enhances their environmental performance. This contrasts with Rodrigue et al. (2013), who argue that the environmental governance mechanisms in such companies are mostly part of a symbolic nature, having little substantial impact on organisations.

Finally, we suggest that the existence of CSR committees is associated with a CSR-linked compensation policy and an efficient CSR strategy. Furthermore, our results show that firms with CSR-linked compensation and a higher CSR strategy score perform better in green practice implementation. As a result, we assume that the presence of CSR-linked compensation and effective CSR strategy can explain the positive relationship between sustainability committees and firms' eco-friendly behaviours, supporting the results of studies by Aragón-Correa et al. (2008), Orazalin (2020), and Radu and Smaili (2022).

Overall, this study confirms the crucial role of a governance mechanism—CSR committees—that business organisations and policymakers can exploit to promote sustainable behaviours. It enriches the literature on the impact of CSR committees and the determinants of corporate green behaviours. More importantly, our research provides new insights into the CSR committees—green practices nexus, which has been investigated to a limited extent.

However, our findings should be generalised with caution. Firstly, there is no universal organisational arrangement regarding CSR committees. Their roles and responsibilities within different firms also vary. Secondly, the exposure and awareness of industries in the context of social and environmental responsibility are diverse. As shown in our study, CSR committees have a stronger impact on green practices for environmentally sensitive companies. Thirdly, country-specific characteristics might influence the relationship between CSR committees and CSR-related outcomes (Baraibar-Diez & Odriozola, 2019; Velte & Stawinoga, 2020). These matters can lead to heterogeneous results in the CSR committees—green practices nexus across companies, sectors, and countries. Moreover, this study is based on information about the presence or absence of sustainability committees in the corporate governance system. It would be important to consider the characteristics of such committees, for example, their size, composition, number of meetings, and so on. This information can help the board of directors create an effective CSR committee that eventually promotes CSR initiatives and performance. We will leave such issues for future research.

Appendix

Measurement of green practices indices

Variable	Measurement
Internal pollution prevention index (GP_{IPP})	The sum of the following emission and resource reduction underlying points: 1. Policy Emissions (ENERDP0051): Does the company describe, claim to have, or mention processes in place to improve emission reduction? – Yes = 1/No = 0. 2. Nitrogen Oxides (NOx) and Sulfur Oxides (SOx) Emissions Reduction (ENERDP033): Does the company report on initiatives to reduce, reuse, recycle, substitute, or phase out SOx or NOx emissions? – Yes = 1/No = 0. 3. Volatile Organic Compounds (VOC) Emissions Reduction (ENERDP036): Does the company report on initiatives to reduce, substitute, or phase out VOC? – Yes = 1/No = 0. 4. Particulate Matter Emissions Reduction (ENERDP037): Does the company report on initiatives to reduce, substitute, or phase out particulate matter less than ten microns in diameter (PM10)? – Yes = 1/No = 0. 5. Waste Reduction Initiatives (ENERDP062): Does the company report on initiatives to recycle, reduce, reuse, substitute, treat, or phase out total waste? – Yes = 1/No = 0. 6. e-Waste Reduction (ENERDP063): Does the company report on initiatives to recycle, reduce, reuse, substitute, treat, or phase out e-waste? – Yes = 1/No = 0.

Variable	Measurement
	7. Staff Transportation Impact Reduction (ENERDP081): Does the company report on initiatives to reduce the environmental impact of transportation used for its staff? – Yes = 1/No = 0. 8. Policy Water Efficiency (ENRRDP0121): Does the company describe, claim to have, or mention processes in place to improve its water efficiency? – Yes = 1/No = 0. 9. Policy Energy Efficiency (ENRRDP0122): Does the company describe, claim to have, or mention processes in place to improve its energy efficiency? – Yes = 1/No = 0. 10. Toxic Chemicals Reduction (ENRRDP031): Does the company report on initiatives to reduce, reuse, substitute, or phase out toxic chemicals or substances? – Yes = 1/No = 0. The GP_{IPP} index ranges from 0 (highest polluters) to 10 (lowest polluters).
Green supply chain management index (GP_{GSCM})	The sum of the following resource reduction underlying points: 1. Policy Environmental Supply Chain (ENRRDP0125): Does the company describe, claim to have, or mention processes in place to include its supply chain in the company's efforts to lessen its overall environmental impact? – Yes = 1/No = 0. 2. Environmental Materials Sourcing (ENRRDP029): Does the company claim to use environmental criteria (e.g., life cycle assessment) to source or eliminate materials? – Yes = 1/No = 0. 3. Environmental Supply Chain Management (ENRRDP058): Does the company use environmental criteria (ISO 14001, energy consumption, etc.) in the selection process of its suppliers or sourcing partners? – Yes = 1/No = 0. 4. Environmental Supply Chain Partnership Termination (ENRRDP059): Does the company report or show to be ready to end a partnership with a sourcing partner, if environmental criteria are not met? – Yes = 1/No = 0. The GP_{GSCM} index ranges from 0 (lowest GSCM practices) to 4 (highest GSCM practices).
Green product index (GP_{GP})	The sum of the following production innovation underlying points: 1. Environmental Products (ENPIDP019): Does the company report on at least one product line or service that is designed to have positive effects on the environment, or which is environmentally labeled and marketed? – Yes = 1/No = 0. 2. Product Environmental Responsible Use (ENPIDP048): Does the company report about product features and applications or services that will promote responsible, efficient, cost-effective, and environmentally preferable use? – Yes = 1/No = 0. 3. Eco-Design Products (ENPIDP069): Does the company report on specific products which are designed for reuse, recycling, or the reduction of environmental impacts? – Yes = 1/No = 0. The GP_{GP} index ranges from 0 (lowest green product practices) to 3 (highest green product practices).
Green practices index (GP)	The sum of the internal pollution prevention index, the green supply chain management index, and the green product index. GP index ranges from 0 (lowest green practices) to 17 (highest green practices).

Source: Datastream database and own elaboration.

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The role of internationalisation in moderating the impact of ESG disclosure on financial performance

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Abstract

This study aims to determine the influence of environmental responsibility, social responsibility, and governance practice disclosures on the financial performance of non-financial companies listed on the Indonesia Stock Exchange from 2012 to 2021. It employs moderated regression analysis and sub-group regression to explain the relationships between the variables. The results suggest a surprising finding that the indicators of environmental responsibility and governance disclosure practices lead to a decline in corporate financial performance, while the social responsibility indicator does not significantly affect corporate financial performance. Expenditures resulting from ESG practices can be perceived as a misuse of corporate resources, a missed opportunity, or, alternatively, as an overinvestment. However, the decline in performance due to environmental responsibility disclosure and governance practices can be mitigated by companies that engage in internationalisation. To sustain

Keywords

- CSR
- ESG
- corporate governance
- financial performance

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environmental, social, and governance activities over the long term, managers are required to deliver consistently increasing and higher financial performance.

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Introduction

Considerations regarding environmental, social and governance (ESG) practices are becoming increasingly important in modern business discussions. Companies are increasingly aware of the importance of disclosing ESG data amidst rising public expectations about responsible and sustainable business conduct (Finger & Rosenboim, 2022; Fu & Li, 2023). The relationship between ESG practices and corporate financial performance has gained significant attention worldwide, including in Indonesia. Implementing ESG practices is associated with enhanced financial flexibility (Zhang & Liu, 2022), sustainability (de Souza Barbosa et al., 2023), and overall business performance (Zhan, 2023), especially during challenging times, such as the COVID-19 pandemic (Mulyono, 2023).

Theoretical discussions about ESG practices often revolve around stakeholder theory, as proposed by Freeman (1984). This management theory emphasises the importance of considering the interests of all relevant stakeholders in the organisational decision-making process, highlighting the creation of value for stakeholders beyond just shareholders. Stakeholder theory suggests that effective ESG disclosure can have a positive influence on a company's financial performance by reducing information asymmetry and meeting stakeholder requirements (Pulino et al., 2022). Companies that prioritise stakeholder interests through transparent ESG practices and disclosures are better positioned to enhance stakeholder satisfaction and achieve superior financial performance (Wasiuzzaman et al., 2023). ESG disclosure not only increases transparency and reduces information asymmetry but also fosters

investor trust in the company's long-term prospects, resulting in better risk management, increased efficiency, and reduced costs (Pulino et al., 2022).

Several previous studies have highlighted the benefits of ESG practices and disclosures on firm value, cost of capital, and even operational and financial performance (Lubis & Rokhim, 2021; Mohammad & Wasiuzzaman, 2021; Pulino et al., 2022; Ratajczak & Mikołajewicz, 2021; Rohendi et al., 2024; Veeravel et al., 2024). However, these studies have paid less attention to examining the impact of internationalisation on the relationship between ESG disclosures and the financial performance of companies, particularly in emerging financial markets. Internationalisation enables companies to achieve greater economies of scale by meeting foreign market demands (Grünig & Morschett, 2016). Producing at higher volumes can reduce the cost per unit, allowing companies to remain competitive despite incurring additional costs to meet ESG standards.

In accordance with the findings of Plastun et al. (2020), European countries have emerged as global leaders in ESG disclosure. This leadership is primarily due to stringent government regulations and active participation from local stock exchanges. The consistent implementation of ESG practices across European countries has resulted in extremely positive outcomes. The year 2020 represented a pivotal moment in the global adoption of ESG practices. Since then, the issuance of green bonds in Europe has surpassed that in America and Asia, reaching $160 million compared to $60.8 million and $32.7 million, respectively (Marsh, 2020). Furthermore, the ASEAN sustainability report published by the ASEAN CSR Network in 2020 highlighted Indonesia's lowest ranking in corporate sustainability disclosure compared to Singapore, Malaysia, the Philippines, and Thailand (ASEAN CSR Network, 2020). Nonetheless, all ASEAN countries have seen an increase in ESG disclosure from 2018 to 2020. These figures underline the critical role of ESG implementation and disclosure in business operations in both developed and emerging markets, particularly for non-financial companies listed on the Indonesia Stock Exchange (IDX). This has significant implications for financial managers and investors, making it a pertinent subject for academic investigation. ESG disclosure has become a primary means for companies to communicate their ESG management practices and related risks to investors. This disclosure can influence a company's market value and financial performance (Grishunin et al., 2022).

This study presents two significant contributions. Firstly, it enriches the existing literature by expanding the limited research on the correlation between ESG disclosure and corporate financial performance, a topic that is very rarely examined in emerging markets (Lubis & Rokhim, 2021). This is achieved by analysing disclosure across a broader spectrum, encompassing all non-financial sector companies in Indonesia. It contrasts with Zahroh and Hersugondo (2021), who explored the relationship between ESG performance and corporate financial performance among Indonesian manufacturing industries, and

Husnah (2023), who focused on the Indonesian mining sector. Secondly, the present study provides evidence of the influence of internationalisation on the relationship between ESG disclosure and corporate financial performance, following studies by Chen & Xie (2022), which utilised ESG investors, and Elmghaamez et al. (2023), which used board standing committees as moderators. This research also addresses a gap in the existing literature by offering new insights into corporate financial performance based on return on assets and net profit margin using new data from the Indonesia Stock Exchange (IDX) database. It considers ESG dimensions (environmental, social, and corporate governance) separately and analyses the impact of companies' international market expansion policies.

The study aims to examine the impact of ESG dimension disclosures—environmental, social, corporate governance issues—and internationalisation in the form of exports on various corporate financial performance metrics, specifically return on assets and net profit margin. Thus, it can enhance academic discussion and managerial practice. Tentatively, it can be assumed that greater involvement in all ESG disclosure dimensions and market expansion internationally leads to higher corporate financial performance, irrespective of the specific type. In this study, a moderated regression model is employed to explore the relationship between various aspects of ESG disclosures and different types of corporate financial performance. This study was conducted in Indonesia, a developing country with significant potential for economic growth accompanied by suboptimal ESG implementation. Additionally, Indonesia faces the obligation to implement sustainable development goals (SDGs) that have been in effect globally for several years. The background of abundant natural resources, human resources, and geographical advantages positions Indonesia as the largest economy in South East Asia and the tenth largest in terms of purchasing power parity (World Bank, 2023), providing a strong rationale for this research. The research sample includes 580 to 596 companies (depending on specification) obtained from the IDX database from 2012–2021.

This paper follows a conventional structure. Section 1 contains a literature review, Section 2 explains the research design and sample composition, while Section 3 presents the results of the empirical analysis. The final section concludes the paper.

1. Literature review and hypothesis development

The latest trends indicate a significant shift among companies, as they are not only maximising profits but also considering environmental, social, and governance (ESG) impacts in their operations. Although ESG disclosure is wide-

ly recognised as an important measure of corporate sustainability, standardisation of such disclosures has yet to be achieved (Khan, 2022). ESG disclosure can reduce information asymmetry and enhance investor confidence in the long-term prospects of a company, leading to better risk management, increased efficiency, and cost reduction (Pulino et al., 2022), ultimately having a positive impact on financial performance and market value (Grishunin et al., 2022). ESG disclosure also provides valuable insights into how companies manage environmental, social, and governance risks (Buallay, 2019). By proactively addressing these risks, companies can mitigate potential negative impacts on financial performance, thereby avoiding adverse incidents, regulatory sanctions, and reputational damage. Moreover, the implementation of sustainable practices, as revealed in ESG reports, can drive operational efficiency and stimulate innovation (Lian et al., 2023).

A substantial amount of research has been conducted to investigate the relationship between ESG and corporate financial performance, yet it shows conflicting results. In a meta-analysis conducted by Huang (2021), a positive and significant relationship between ESG and corporate performance was found, consistent with theoretical arguments. Other empirical findings by Alareeni and Hamdan (2020), Bahadori et al. (2021), Chijoke-Mgbame et al. (2019), Jaisinghani and Sekhon (2022), Laskar and Maji (2016), and Platonova et al. (2018) confirm a positive relationship between ESG disclosure and corporate financial performance. However, particularly in developing countries, the implementation of ESG standards tends to be minimal, and ESG disclosure might have a negative impact on corporate reputation and financial performance. Additionally, ESG practices and disclosures involve risks and costs, especially in the short term, and these expenditures can affect corporate financial performance (Alareeni & Hamdan, 2020). Fahad and Busru (2021), Sekhon and Kathuria (2019), and Wasiuzzaman et al. (2023) report a negative correlation between ESG disclosure and financial performance. Oware & Mallikarjunappa (2022) assert that increased ESG disclosure can reduce financial performance due to higher corporate costs. Saygili et al. (2022) argue that environmental disclosure has a negative impact on corporate financial performance. Based on a literature review analysis by Khan (2022), it is noted that studies reporting a negative relationship between ESG and financial performance originate from an Asian context, whereas studies conducted in the EU and US report a positive impact.

Although the long-term benefits of ESG practices can enhance financial performance through improved reputation, investor trust, and risk management, there are costs and challenges that may produce short-term financial burdens, particularly in the context of developing countries. Therefore, companies need to strategically balance their ESG practices to optimise financial

performance. Based on these discussions, the main hypotheses of the study were determined as follows:

H1a. Greater disclosure of environmental ESG decreases the financial performance.
H1b. Greater disclosure of social ESG decreases the financial performance.
H1c. Greater disclosure of governance ESG decreases the financial performance.

Export activities represent a form of internationalisation frequently undertaken by companies in Indonesia. The most common factor driving internationalisation is the need to find new customers to generate additional turnover and contribution margins (Grünig & Morschett, 2016; Moghaddam et al., 2014). The second driver of internationalisation is the need to achieve cost savings (Grünig & Morschett, 2016; Guillén & García-Canal, 2009). By opening new markets, fixed costs can be spread over more products. In this context, economies of scale will emerge. The fourth reason for going international is to diversify their operational risk (Gaur & Kumar, 2010; Grünig & Morschett, 2016). By serving a number of different geographical markets, companies can sometimes offset a decline in demand in one region.

The increase in the degree of internationalisation impacts the expansion of economic benefits through market-seeking strategies, the exploitation of economies of scale, and the leveraging of learning experiences (Contractor, 2012). Therefore, these benefits of internationalisation are expected to result in better performance. A study by Manotas and Gonzalez-Perez (2020) shows strong evidence that internationalisation positively impacts the likelihood of better performance, thus enhancing the competitiveness of small and medium enterprises (SMEs). Through internationalisation, companies can achieve greater economies of scale by meeting foreign market demands (Grünig & Morschett, 2016). Production in higher volumes can reduce per-unit costs, enabling companies to remain competitive even if they incur additional costs to meet ESG standards. To the best of our knowledge, this is the first study to collaborate on corporate internationalisation policies with the relationship between ESG disclosure and financial performance, particularly in the largest economy in South East Asia. Based on these discussions, the hypotheses of the study were determined as follows:

H2a. Internationalisation moderates the impact of environmental ESG disclosure on financial performance.
H2b. Internationalisation moderates the impact of social ESG disclosure on financial performance.
H2c. Internationalisation moderates the impact of governance ESG disclosure on financial performance.

2. Data and methodology

2.1. Population and sample

This research focuses on non-financial companies in the manufacturing, mining, trade, and services industries listed on the Indonesian stock market, the largest economy in South East Asia. The study employed an empirical testing approach and spans a 10-year period from 2012 to 2021. The operational activities of non-financial companies often involve physical assets and processes related to the environment and society. For instance, a manufacturing company needs to manage its supply chain, production processes, and waste disposal, all of which have ESG impacts. In contrast, financial companies primarily deal with financial transactions and services, which are less directly related to physical environmental impacts. Therefore, this study of non-financial companies provides a better foundation for this research. The initial population was 662 companies, but due to the unavailability of annual reports and financial records, as well as a lack of ESG data, the final sample was reduced to 580 until 596 companies (depending on specification), which was adjusted to achieve the normality assumption in each equation.

2.2. Dependent variables

Return on assets (ROA) and net profit margin (NPM) were derived from the company's annual report (see Table 1). These variables strictly reflect components of the company's financial performance. Return on assets was calculated by dividing post-tax profit by total assets (Buallay et al., 2020). Meanwhile, net profit margin was estimated by dividing net post-tax profit by total sales or total net revenue (Handoyo & Anas, 2024; Saygili et al., 2022). The use of two dependent variables serves as an effort to enhance the robustness of the testing.

2.3. Independent variables

ESG disclosures were obtained from annual reports, sustainability reports, CSR reports, and corporate websites. ESG is a multidimensional index based on the disclosure of environmental, social, and governance aspects, and the impact of one dimension, which sometimes can overshadow the opposing

impact of another dimension. In such instance, it would be beneficial if separate data are available (Buallay et al., 2021). Therefore, this study considered three separate sub-ESG scores: environmental disclosure (ENVD), social disclosure (SOCD), and corporate governance disclosure (GOVD). This classification made it possible to assess which dimension of the ESG score exerted the greatest impact on a company's financial performance. Saygili et al. (2022) divided ESG disclosure indicators into 21 items with a total of 112 sub-items, each determined by assigning a score of 1 for companies that implement each ESG item and sub-item, and 0 otherwise (see Appendix). Environmental responsibility disclosure used 1 item (EDS) with 15 sub-items, social responsibility disclosure used 5 items (SP, SPM, HRP, RCS, ERSR) with 22 sub-items, and governance disclosure used 15 items (ESR, SIR, GAR, VR, MR, DR, TS, CW, AR, BDF, BDA, BDS, BDM, BDC, BDR) with 75 sub-items. Then, each ESG disclosure indicator, ENVD, SOCD, and GOVD, was summed and divided by the respective number of sub-items (Saygili et al., 2022).

2.4. Moderating variable

Internationalisation (INT) was derived from the company's annual report and financial records. Internationalisation was chosen as the moderating variable affecting the relationship between ESG disclosure and company performance on the basis that internationalisation enables companies to achieve greater economies of scale by meeting the demands of foreign markets (Grünig & Morschett, 2016). Producing in higher volumes can reduce the cost per unit, allowing companies to remain competitive despite incurring additional costs to meet ESG standards. Internationalisation is a dummy variable with a value of 1 for companies that export and 0 otherwise.

2.5. Control variables

Control variables were selected based on a literature review and were consistent with recent research (Alareeni & Hamdan, 2020; Habib & Mourad, 2024; Wasiuzzaman et al., 2023). The current ratio (CR) was measured by dividing current assets by current liabilities, the total asset turnover (TATO) was measured by dividing net sales by the average of total assets at the beginning and end of the year, while the debt-to-equity ratio (DER) was measured by dividing total debt by total equity, and firm size (SIZE) was measured using the natural logarithm of total assets.

Table 1. Variable measurement

Variables	Symbol	Measurement
Dependent variables: • return on asset • net profit margin	 ROA NPM	 • dividing post-tax profit by total assets • dividing net post-tax profit by total sales or total net revenue
Independent variables: • environmental disclosure • social disclosure • governance disclosure	 ENVD SOCD GOVD	 • see Appendix • see Appendix • see Appendix
Moderating variable: internationalisation	 INT	 dummy variable with a value of 1 for companies that export and 0 otherwise
Control variables: • current ratio • total asset turnover • debt-to-equity ratio • firm size	 CR TATO DER SIZE	 • dividing current assets by current liabilities • dividing net sales by the average of total assets at the beginning and end of the year • dividing total debt by total equity • the natural logarithm of total assets

Source: own work.

2.6. Empirical model

This study used recent research by Kristaung & Riorini (2020), and Soesetio, Anggraeni, et al. (2023), which employed two moderation regression methods, namely moderated regression analysis and sub-group moderation analysis. The selection of these two moderation regression methods served as an effort towards a robust test. The use of these two analytical tools and different proxies for the same variable was expected to strengthen the results and conclusions regarding the relationships between variables.

Equations 1, 2, and 3 represent the regression equations using the moderated regression analysis method, which allows for testing the independent influence of the moderating variable as well as the interaction between the independent variable and the moderating variable. Therefore, this method can determine whether the moderating variable can directly influence the dependent variable, as well as how the combination of the independent and moderating variables affects the dependent variable. This method comprises three stages: (1) the regression equation of the independent and control variables on the dependent variable, (2) the regression equation of the independent, moderator, and control variables on the dependent variable, and (3) the regression equation of the independent, moderator, interaction, and con-

trol variables on the dependent variable. The equations presented use ROA as the dependent variable, while analogous models were estimated for NPM.

$$ROA_{i,t} = \alpha_{i,t} + \beta_1 ENVD_{i,t} + \beta_2 SOCD_{i,t} + \beta_3 GOVD_{i,t} + \beta_4 CR_{i,t} + \\ + \beta_5 TATO_{i,t} + \beta_6 DER_{i,t} + \beta_7 SIZE_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$ROA_{i,t} = \alpha_{i,t} + \beta_1 ENVD_{i,t} + \beta_2 SOCD_{i,t} + \beta_3 GOVD_{i,t} + \beta_4 CR_{i,t} + \\ + \beta_5 TATO_{i,t} + \beta_6 DER_{i,t} + \beta_7 SIZE_{i,t} + \beta_8 INT_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$ROA_{i,t} = \alpha_{i,t} + \beta_1 ENVD_{i,t} + \beta_2 SOCD_{i,t} + \beta_3 GOVD_{i,t} + \beta_4 CR_{i,t} + \\ + \beta_5 TATO_{i,t} + \beta_6 DER_{i,t} + \beta_7 SIZE_{i,t} + \beta_8 INT_{i,t} + \\ + \beta_9 ENVDxINT_{i,t} + \beta_{10} SOCDxINT_{i,t} + \beta_{11} GOVDxINT_{i,t} + \varepsilon_{i,t} \quad (3)$$

The equations (4) and (5) show the regression equations using the subgroup moderation analysis method, which was used to test whether the effect of the independent variable on the dependent variable differs between subgroups within the sample. In this study, the subgroups were based on whether the company expanded its market share internationally during the study period. This method used the Chow test to determine whether a variable acts as a moderator. The Chow test was employed to ascertain whether a variable acts as a moderator, utilising the method of subgroup regression (Ghozali, 2016; Hair Jr. et al., 2014). Equation 6 shows the Chow test formula used, where $RSSr$ = restricted residual sum of squares for total observations; $RSSur$ = the sum or restricted residual sum of squares for equation (4) and (5); k = total independent variables for equation (4) and (5); $n1$ = total observations for equation (4); $n2$ = total observations for equation (5). The value of F has a well-known Snedecor's F distribution.

$$ROAexport_{i,t} = \alpha_{i,t} + \beta_1 ENVDexport_{i,t} + \beta_2 SOCDexport_{i,t} + \\ + \beta_3 GOVDexport_{i,t} + \varepsilon_{i,t} \quad (4)$$

$$ROAnon\,export_{i,t} = \alpha_{i,t} + \beta_1 ENVDnon\,export_{i,t} + \\ + \beta_2 SOCDnon\,export_{i,t} + \beta_3 GOVDnon\,export_{i,t} + \varepsilon_{i,t} \quad (5)$$

$$F = \frac{\left(\frac{RSSr - RSSur}{k}\right)}{\left(\frac{RSSur}{n1 + n2 - 2k}\right)} \quad (6)$$

Subsequently, to determine the best regression method for each model in order to obtain valid and reliable estimation results in regression analysis,

Chow and Hausman tests were conducted. The Chow test was used to determine the better model between the common effect (CE) model and the fixed effect (FE) model in panel data models. If the p-value was smaller than the significance level α, then H1 was accepted and H0 was rejected, indicating that the chosen model was the fixed effect (FE) model. The Hausman test was used to determine the better model between the random effect (RE) model and the fixed effect (FE) model in panel data models. If the *p*-value was smaller than the significance level α, then H1 was accepted and H0 was rejected, indicating that the chosen model was the fixed effect (FE) model. In this study, the best regression method identified is the fixed effect model.

3. Empirical results

According to Table 2, the average environmental responsibility disclosure rate (ENVD) is only 44.35%, indicating that these companies implement and/or disclose only 44.35% of their environmental responsibilities. It appears that non-financial companies in Indonesia do not place much importance on disclosing their environmental responsibilities. However, social responsibility (SOCD) and governance (GOVD) disclosures are considered important for these companies. The average social responsibility disclosure rate is 85.49%, and governance is 92.03%. This indicates that these companies have implemented and/or disclosed 85.49% of their social responsibilities and 92.03%

Table 2. Descriptive statistics

Variable	Mean	Std dev.	Min	Max
ROA	0.0376	0.3846	–9.1900	8.8900
NPM	–0.0075	0.6728	–9.9139	6.9022
ENVD	0.4435	0.2948	0.0000	1.0000
SOCD	0.8549	0.0331	0.3950	0.9100
GOVD	0.9203	0.0285	0.7187	0.9724
CR	1.9393	1.6666	0.0007	9.8800
TATO	0.8246	0.8445	0.0000	9.7660
DER	1.1386	1.5464	–8.9879	9.8744
SIZE	28.5240	1.6714	23.0822	34.2260
INT	0.5248	0.4994	0	1

Source: own work.

of their governance. Non-financial companies in Indonesia face challenges regarding their performance. Although more than 50% of these companies are involved in internationalisation/export activities, the average Return on Assets (ROA) is 0.0376, and the average net profit margin (NPM) is –0.0075. On average, these companies' current assets are almost double their current liabilities, as the average current ratio (CR) is 1.9393. The average total asset turnover (TATO) is 0.8246, and the average debt-to-equity ratio (DER) is 1.1386, indicating moderate leverage. The average size of these companies is 28.5240, which is relatively large.

Table 3 and 4 demonstrate that environmental responsibility disclosure (ENVD) significantly affects return on assets (ROA) and net profit margin (NPM). These results indicate that when companies disclose more information about environmental responsibility, their performance declines. This finding supports previous research by Lubis and Rokhim (2021), which shows a negative correlation between environmental responsibility disclosure and company financial performance. It also aligns with the study by Buallay et al. (2021), who identify a significant negative relationship between ESG and financial performance in both developing and developed countries. Khan (2022) mentions that research reporting a negative relationship between ESG and financial performance originates from the Asian context, whereas studies based in the European Union (EU) and the United States (US) report a positive impact. Additionally, this study indicates that internationalisation weakens the negative impact of ENVD on ROA & NPM. This suggests that as companies become more involved in internationalisation and disclose information about environmental responsibility, the negative impact of ESG disclosure is reduced.

Disclosure of social responsibility (SOCD) has been found to have no significant impact on financial performance, ROA, and NPM. The level of disclosure of information pertaining to social responsibility does not have a bearing on the financial performance of a company. This result is consistent with the findings of Buallay et al. (2020), who found that social responsibility does not have a significant impact on financial performance. Furthermore, internationalisation does not moderate the influence of SOCD on ROA and NPM. The disclosure of social responsibility does not guarantee that it will strengthen or weaken its impact on the company's financial performance, regardless of whether the company has an international orientation. In many cases, the implementation of CSR remains within the local context of the home country and is not detected by foreign entities.

Disclosure of governance (GOVD) has a negative impact on ROA and NPM. Similarly, corporate governance disclosure can lead to a decline in a company's financial performance, akin to environmental responsibility. The initial costs associated with these changes can negatively impact short-term financial performance (Alareeni & Hamdan, 2020), although they are expected to enhance the company's long-term stability and reputation. However, these

Table 3. Moderated regression analysis results of ROA

Variables	ROA								
	(1)			(2)			(3)		
ENVD	–0.021***			–0.021***			–0.032***		
	(0.006)			(0.006)			(0.007)		
ENVDxINT							0.020**		
							(0.010)		
SOCD		–0.034			–0.034			–0.083	
		(0.081)			(0.081)			(0.104)	
SOCDxINT								0.126	
								(0.169)	
GOVD			–0.466***			–0.466***			–0.392***
			(0.109)			(0.109)			(0.135)
GOVDxINT									–0.162
									(0.225)
INT				0.012***	0.012***	0.013***	0.001	–0.096	0.163
				(0.002)	(0.002)	(0.002)	(0.006)	(0.145)	(0.208)

CR	0.005***	0.005***	0.006***	0.005***	0.005***	0.006***	0.005***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
TATO	0.026***	0.024***	0.024***	0.026***	0.024***	0.024***	0.027***	0.024***	0.024***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
DER	–0.005***	–0.005***	–0.005***	–0.005***	–0.005***	–0.005***	–0.005***	–0.005***	–0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
SIZE	0.001	–0.004	–0.003	0.001	–0.004	–0.003	0.002	–0.004	–0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Constant	–0.026	0.153	0.532***	–0.033	0.146	0.525***	–0.032	0.188	0.457***
	(0.091)	(0.109)	(0.123)	(0.092)	(0.110)	(0.123)	(0.092)	(0.124)	(0.145)
Observations	3,712	3,721	3,713	3,712	3,721	3,713	3,712	3,721	3,713
R-squared	0.095	0.080	0.096	0.095	0.080	0.096	0.098	0.080	0.096
N	592	594	596	592	594	596	592	594	596

Note: Numbers (1), (2), (3) show the equations of each moderated regression analysis method in Section 2.6. The models are estimated as fixed effects panel regression with robust standard errors that are shown in parentheses. Statistical significance levels denoted by **, and *** represent 0.05, and 0.01 levels, respectively. ENVD – environmental responsibility disclosures; SOCD – social responsibility disclosures; GOVD – governance disclosures. ROA is the dependent variable. N denotes the number of companies.

Source: own work.

Table 4. Moderated regression analysis results of NPM

Variables	NPM								
	(1)			(2)			(3)		
ENVD	–0.049***			–0.049***			–0.087***		
	(0.013)			(0.013)			(0.021)		
ENVDxINT							0.065***		
							(0.025)		
SOCD		0.160			0.160			0.091	
		(0.139)			(0.139)			(0.136)	
SOCDxINT								0.170	
								(0.296)	
GOVD			–0.648***			–0.649***			–0.559*
			(0.240)			(0.241)			(0.330)
GOVDxINT									–0.182
									(0.480)
INT				0.051***	0.052***	0.055***	0.014	–0.095	0.221
				(0.013)	(0.011)	(0.011)	(0.021)	(0.255)	(0.439)

CR	0.013***	0.014***	0.013***	0.013***	0.014***	0.013***	0.013***	0.014***	0.013***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
TATO	0.025***	0.024***	0.022***	0.025***	0.024***	0.022***	0.026***	0.024***	0.022***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.008)
DER	–0.004	–0.003	–0.004	–0.004	–0.003	–0.004	–0.003	–0.003	–0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
SIZE	0.009	–0.003	–0.000	0.009	–0.003	–0.000	0.010	–0.003	–0.000
	(0.007)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)
Constant	–0.230	–0.046	0.613**	–0.259	–0.076	0.582**	–0.249	–0.016	0.501
	(0.195)	(0.202)	(0.280)	(0.196)	(0.202)	(0.280)	(0.192)	(0.206)	(0.349)
Observations	3,584	3,582	3,598	3,584	3,582	3,598	3,584	3,582	3,598
R-squared	0.046	0.037	0.039	0.046	0.037	0.039	0.052	0.037	0.039
N	580	582	581	580	582	581	580	582	581

Note: Numbers (1), (2), (3) show the equations of each moderated regression analysis method in Section 2.6. The models are estimated as fixed effects panel regression with robust standard errors that are shown in parentheses. Statistical significance levels denoted by *, **, and *** represent 0.1, 0.05, and 0.01 levels, respectively. ENVD – environmental responsibility disclosures; SOCD – social responsibility disclosures; GOVD – governance disclosures. NPM is the dependent variable. N denotes the number of companies.

Source: own work.

results contradict previous studies that present ESG ratings as a quantitative tool to measure stakeholder satisfaction and a source of competitive advantage in terms of lower capital costs (Ratajczak & Mikołajewicz, 2021) and higher financial performance (Velte, 2017). In the moderation analysis, this study notes that internationalisation does not moderate the effect of GOVD on ROA and NPM. These results indicate that internationally oriented companies do not guarantee that governance disclosure practices will strengthen or weaken their impact on financial performance.

The current ratio (CR) has a beneficial effect on companies, as it positively impacts ROA and NPM. An increase in a company's liquidity will lead to an improvement in the company's financial performance. These results support the ideas put forward by Farhan et al. (2019) and Sudirman et al. (2020) that the current ratio can positively influence a company's financial performance. Additionally, total asset turnover (TATO) significantly impacts the establishment of a company's financial performance. Higher asset turnover indicates that a company is effectively using its assets to generate sales (Soesetio, Rudiningtyas, et al., 2023). These findings confirm previous research by Grozdić et al. (2020) and Le Thi Kim et al. (2021), who report a favourable relationship between asset turnover and business performance.

A negative correlation has been identified between DER and a company's financial performance, as measured by ROA. The statistically significant negative coefficient for the DER at the 0.01 level when the dependent variable is ROA is consistent with the findings of Teoh (2021), indicating that the DER ratio can negatively affect a company's financial performance. Company size (SIZE) does not have a significant impact on either ROA or NPM. These results are in line with those of Meiryani et al. (2020). This implies that while larger companies may have greater assets, this does not automatically translate into higher returns for shareholders.

Tables 5 and 6 corroborate the results of evaluating the role of internationalisation (INT) in the relationship between ESG disclosure and corporate financial performance by separating the sample using dummy variables. Based on the coefficient values, the environmental responsibility disclosure in export-oriented companies (–0.016; –0.021) shows smaller values compared to non-export-oriented companies (–0.037; –0.090). These results indicate that the negative impact of environmental responsibility disclosure on corporate financial performance can be more effectively mitigated in export-oriented companies. Social responsibility disclosure consistently shows no significant impact on corporate financial performance, whether in export-oriented or non-export-oriented companies.

Conversely, the coefficient for governance disclosure in export-oriented companies (–0.736; –0.990) is higher compared to non-export-oriented companies (–0.483; –0.670). This implies that the negative impact of governance disclosure on corporate financial performance can be more effectively mit-

Table 5. Sub-regression of ROA by internationalisation

Variables	ROA					
	(1)	(2)	(1)	(2)	(1)	(2)
ENVD	–0.016*	–0.037***				
	(0.008)	(0.007)				
SOCD			0.011	–0.079		
			(0.167)	(0.055)		
GOVD					–0.736***	–0.483***
					(0.203)	(0.162)
Constant	0.042***	0.041***	0.025	0.094**	0.711***	0.471***
	(0.004)	(0.003)	(0.143)	(0.047)	(0.186)	(0.149)
Observations	1,957	1,755	1,956	1,765	1,956	1,757
R-squared	0.006	0.032	0.000	0.000	0.022	0.013
N	295	298	296	299	296	301
Chow test	18.454		16.933		17.042	

Note: (1) export firms group, (2) non-export firms group. The models are estimated as fixed effects panel regression with robust standard errors that are shown in parentheses. Statistical significance levels denoted by *, **, and *** represent 0.1, 0.05, and 0.01 levels, respectively. ENVD – environmental responsibility disclosures; SOCD – social responsibility disclosures; GOVD – governance disclosures. NPM is dependent variable. N denotes the number of companies.

Source: own work.

Table 6. Sub-regression of NPM by internationalisation

Variables	NPM					
	(1)	(2)	(1)	(2)	(1)	(2)
ENVD	–0.021*	–0.090***				
	(0.015)	(0.021)				
SOCD			0.060	0.081		
			(0.242)	(0.090)		
GOVD					–0.990***	–0.670*
					(0.373)	(0.367)
Constant	0.062***	0.092***	0.001	–0.012	0.963***	0.672**
	(0.007)	(0.008)	(0.208)	(0.076)	(0.343)	(0.337)
Observations	1,999	1,585	2,000	1,582	2,006	1,592
R-squared	0.003	0.035	0.000	0.000	0.012	0.004
N	295	287	295	289	294	289
Chow test	5.613		5.852		0.989	

Note: (1) export firms group, (2) non-export firms group. The models are estimated as fixed effects panel regression with robust standard errors that are shown in parentheses. Statistical significance levels denoted by *, **, and *** represent 0.1, 0.05, and 0.01 levels, respectively. ENVD – environmental responsibility disclosures; SOCD – social responsibility disclosures; GOVD – governance disclosures. NPM is dependent variable. N denotes the number of companies.

Source: own work.

igated in non-export-oriented companies. Overall, based on the results of the Chow test with separate samples, with values of 18.454; 16.933; 17.042; 5.613; 5.852; 0.989 (critical value equal to 3.8), internationalisation occurred to moderate ENVD, SOCD on corporate financial performance. In the case of GOVD, that result applies only to net profit margin.

Conclusions

This research aims to examine the impact of ESG disclosure on financial performance, focusing on the moderating effect of internationalisation in non-financial companies in the largest economies in South East Asia. The findings reveal intriguing insights. Firstly, environmental responsibility disclosure tends to burden corporate profits significantly. Such disclosure often requires a commitment to implementing environmentally friendly practices and technologies (Park et al., 2017), leading to increased costs and a longer return on investment, as companies invest in newer, cleaner technologies, waste reduction measures, or sustainable resources. In the short term, these costs can negatively impact a company's financial performance (Alareeni & Hamdan, 2020). However, it is expected that these policies will be maintained, considering that in the long run, ESG disclosure practices may provide a higher level of business continuity assurance through the achievement of optimal corporate financial performance in accordance with the demands of global climate change requirements.

Secondly, comprehensive governance disclosure has a negative impact on a company's financial performance. Extensive governance disclosure can reveal weaknesses or challenges in the company's governance structure. Improving governance practices often requires the implementation of new policies, procedures, and technologies, which incurs significant costs that ultimately impact the company's profits. Although effective governance disclosure can enhance investor confidence, decision-making, and long-term sustainability, companies with poor governance can trigger negative investor reactions, thereby affecting stock prices or the company's overall financial performance. While improving governance practices is expected to enhance stability and reputation in the long run, the initial costs associated with these changes can impact short-term performance (Alareeni & Hamdan, 2020). Overall, this study is in opposition to stakeholder theory, which suggests that corporate responsibility practices may not always improve relationships with stakeholders, at least not in the short term, although over a longer duration they may align with stakeholder interests.

In developing countries, ESG regulations are not yet mandatory, because the regulations do not fully support companies that implement ESG, espe-

cially in the short term. However, the impact of ESG implementation in developing countries can be mitigated through international market expansion (internationalisation) into countries that more dominantly implement ESG (EU & US), as well as into those that do not. In addition to the market expansion effect, exchange rates also play an important role in mitigating the negative impact of ESG disclosure practices. International expansion enables businesses to enter new markets, reaching a larger customer base (Mutascu & Murgea, 2020), which is particularly beneficial when the domestic market is saturated or growth potential is limited. Operating in multiple countries can help reduce risks associated with economic downturns in specific regions. Diversifying income sources across various markets can contribute to more stable and predictable financial performance. Internationalisation can lead to economies of scale by enabling businesses to expand their production and distribution capabilities, allowing them to meet the demands of a larger and more diverse customer base. Increased production volume often reduces the average cost per unit, thereby improving overall financial performance for export-oriented companies. Therefore, although ESG practices and disclosures negatively impact corporate financial performance, internationalisation has a greater ability to mitigate this impact compared to companies that focus solely on domestic operations.

This study is expected to provide companies with insights regarding the preparation and anticipation of readiness for the implementation of ESG in operational activities. The application of ESG often involves adopting new policies, procedures, and technologies. The initial costs associated with these changes may impact short-term financial performance, although they are expected to enhance long-term stability and reputation. This research has several limitations, particularly in data collection, as not all companies have comprehensive sustainability reports and other detailed reports for each year in the study period. Furthermore, the use of financial performance is limited to the short term, suggesting that the results cannot assess the impact of ESG disclosure on financial performance in the long term. It is anticipated that future research will be developed into a more comprehensive research project by expanding the ESG matrix, the scope of companies, the research period, and the use of long-term financial performance metrics.

Appendix

ESG items and sub-items used in their measurement

Disclosures	Variable Type
ENVIRONMENTAL DISCLOSURES	
EDS – Environmental Disclosure Score **(number of sub-items mentioned in disclosures divided by 15)** EDS1 Reused and recycled materials EDS2 Energy consumption and reductions EDS3 Water recycled and reused EDS4 Protection of biodiversity EDS5 Greenhouse gas (GHG) emissions intensity EDS6 Reductions of GHG emissions EDS7 Emissions of ozone-depleting and other hazardous air pollutants EDS8 Effluents and waste EDS9 Recycled products EDS10 Recycled packaging products EDS11 Compliance with environmental regulations EDS12 Environmental impacts of transporting products EDS13 Environmental protection expenditures and investments EDS14 Supplier environmental assessment EDS15 Environmental grievance mechanisms	continuous between 0 and 1
SOCIAL DISCLOSURES	
SP – Stakeholder Policy **(number of sub-items mentioned in disclosures divided by 5)** SP1 The protection of the rights of stakeholders. SP2 Compensation is offered in cases of violation of the stakeholder rights. SP3 Stakeholder policies that are released on the company's website. SP4 Mechanisms where stakeholders inform the CG or audit committee in ethical breaches. SP5 Policy on conflict of interest among stakeholders.	continuous between 0 and 1
SPM – Stakeholder Participation in Management **(number of sub-items mentioned in disclosures divided by 2)** SPM1 Supporting the participation of stakeholders, primarily employees, in management. SPM2 Stakeholders express their opinions on the significant decisions affecting them.	continuous between 0 and 1
HRP – Human Resources Policy **(number of sub-items mentioned in disclosures divided by 8)** HRP1 Employment policies and career plans that provide equal opportunities. HRP2 Existence of written employment criteria. HRP3 Fairness in staff training programs and meetings. HRP4 Events in which employees or their representatives express their opinions on decisions.	continuous between 0 and 1

Disclosures	Variable Type
HRP5 Description of job, performance, and award criteria. HRP6 Measures to prevent discrimination. HRP7 The rights of association and collective bargaining. HRP8 Health and safety measures are taken in the working environment.	continuous between 0 and 1
RCS – Relations with Customers and Suppliers **(number of sub-items mentioned in disclosures divided by 5)** RCS1 Customer satisfaction with the sale and marketing of goods and services. RCS2 Customer purchases are handled quickly and efficiently. RCS3 Quality standards for goods, services, and guarantees provided. RCS4 A specific quality guarantee is provided. RCS5 Confidentiality of trade secrets of customers and suppliers.	continuous between 0 and 1
ERSR – Ethical Rules and Social Responsibility **(number of sub-items mentioned in disclosures divided by 2)** ERSR1 Ethical rules are released on the official website to the public. ERSR2 Social responsibility and compliance with regulations and ethical rules.	continuous between 0 and 1
GOVERNANCE DISCLOSURES	
ESR – Exercise of Shareholder Rights **(number of sub-items mentioned in disclosures divided by 2)** ESR1 Investor relations department. ESR2 Update reports and disclosures on the corporate website.	continuous between 0 and 1
SIR – Shareholder's Information Right **(number of sub-items mentioned in disclosures divided by 1)** SIR1 Shareholder's right to request information and special audits.	binary
GAR – General Assembly Right **(number of sub-items mentioned in disclosures divided by 11)** GAR1 The GA information shall be provided on the website three weeks before the meeting. GAR2 Submission of each proposal under a separate title on the agenda of the general assembly. GAR3 Shareholders' participation in the GA shall be subject to minimum costs. GAR4 Performance of the chairman in the GA. GAR5 Shareholders are given fair opportunities to express their views and to raise questions. GAR6 Related party transactions are included on the GA agenda. GAR7 The list of insiders is released on the GA agenda. GAR8 The presence of the BoD, the officers responsible for the financial statements and the auditors. GAR9 Issues related to corporate transactions on the GA agenda. GAR10 Approval of the donation and contribution policy in the general assembly. GAR11 The openness of GA to the public including to stakeholders and the media.	continuous between 0 and 1

Disclosures	Variable Type
VR – Voting Rights **(Number of sub-items mentioned in disclosures divided by 3)** VR1 A chance to exercise the right of shareholders to vote, including cross-border voting. VR2 Avoidance of voting privileges. VR3 Avoidance of the right to vote resulting from cross-ownership.	continuous between 0 and 1
MR – Minority Rights **(number of sub-items mentioned in disclosures divided by 2)** MR1 Maximum diligence paid in the exercise of minority rights. MR2 Scope of minority rights for shareholders holding less than one-twentieth of the capital.	continuous between 0 and 1
DR – Dividend Rights **(number of sub-items mentioned in disclosures divided by 4)** DR1 Consistent dividend payout strategy presented at the GA and published on the website. DR2 Forward-looking information related to the distribution of dividends. DR3 Reason for not paying dividends and information on the use of the dividends. DR4 A balanced dividend distribution policy is followed.	continuous between 0 and 1
TS – Transfer of Shares **(number of sub-items mentioned in disclosures divided by 1)** TS1 Free transfer of shares.	binary
CW – Corporate Website **(number of sub-items mentioned in disclosures divided by 4)** CW1 Release of the relevant legislation and information CW2 Shareholding structure, names, number, and share ratio of the corporation. CW3 Notifications of financial statements and disclosures in at least Indonesian and English. CW4 Information in other foreign languages has the same content as the Indonesian version.	continuous between 0 and 1
AR – Annual Report **(number of sub-items mentioned in disclosures divided by 2)** AR1 A detailed annual report issued by the BoD. AR2 Detailed information on corporate governance is included in the annual report.	continuous between 0 and 1
BDF – Board of Directors' Functions **(number of sub-items mentioned in disclosures divided by 2)** BDF1 Strategic decisions and rational risk management publicly disclosed by the BoD BDF2 Strategic objectives, identified by BoD, and the performance audit of the management.	continuous between 0 and 1

Disclosures	Variable Type
BDA – Board of Directors Activities **(number of sub-items mentioned in disclosures divided by 8)** BDA1 Transparency, accountability, and responsibility of BoD operations. BDA2 The duties and authorities of the members of the board are announced in the annual report. BDA3 The internal control system. BDA4 Annual review and disclosure of the efficiency of the internal control system by BoD. BDA5 Separation of the board chairman and chief executive/general manager. BDA6 Disclosure of the duality of CEO. BDA7 The BoD's communication activities between the corporation and the shareholders. BDA8 Insurance above 25% of the capital for damage caused by BoD.	continuous between 0 and 1
BDS – Board of Directors Structure **(number of sub-items mentioned in disclosures divided by 10)** BDS1 Minimum number of five members on the BoD BDS2 The majority of members are non-executive members. BDS3 Existence of independent members among non-executive members. BDS4 Minimum one-third of the board consists of independent members of the board. BDS5 The term of office of the independent members shall be up to three years. BDS6 Independent members meet the legal criteria. BDS7 Evaluation of the applicants for independent membership by the nomination committee. BDS8 Notification of independence revokes. BDS9 The number of female members is more than 25%. BDS10 At least one of the independent members responsible for the audit has financial expertise.	continuous between 0 and 1
BDM – Board of Directors Meetings **(number of sub-items mentioned in disclosures divided by 7)** BDM1 Attendance and declaration of opinions of members at the BoD meetings. BDM2 Agenda of the BoD meeting. BDM3 Written opinions of members who were unable to attend the BoD meetings. BDM4 Each member on the board has one right to vote. BDM5 The written proceedings of the meeting are available online. BDM6 Attendance of non-executive members. BDM7 Disclosure of information on the other duties of the members of the BoD on the GA agenda.	continuous between 0 and 1

Disclosures	Variable Type
BDC – Board of Directors Committees **(number of sub-items mentioned in disclosures divided by 13)** BDC1 Construction of legal committees of the BoD. BDC2 Disclosures of duties, working principles, and members of committees. BDC3 Disclosures relating to the structure of the committees. BDC4 The chief executive / general manager shall have no duties in the committees. BDC5 The members of the board do not have duties in more than one committee. BDC6 Resources provided by the BoD to support committees in carrying out their duties. BDC7 Disclosures of consultancy services are set out in the annual report. BDC8 Written records of committees. BDC9 The audit committee shall follow the legal criteria. BDC10 The corporate governance committee shall comply with the legal criteria. BDC11 The nomination committee shall follow the legal criteria. BDC12 The committee of early detection of risk shall follow the legal criteria. BDC13 The remuneration committee shall follow the legal criteria.	continuous between 0 and 1
BDR – Board of Directors' Remuneration **(number of sub-items mentioned in disclosures divided by 5)** BDR1 Performance evaluation of the BoD. BDR2 Principles on the remuneration of members of the BoD and executives. BDR3 Remuneration of independent members of the BoD which ensures their independence. BDR4 Loans and credits should not be provided to members of the BoD or executives. BDR5 The remuneration of board members and executives shall be disclosed individually in annual reports.	continuous between 0 and 1

Sources: based on (Capital Markets Board of Türkiye, 2014; Saygili et al., 2022).

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Price limit bands, risk-return trade-off and asymmetric volatility: Evidence from Tunisian Stock Exchange sectors

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Abstract

This paper explores the impact of imposing various price limit bands on risk-return trade-off and asymmetric volatility on the Tunisian Stock Exchange (TSE). The study applies the EGARCH-M approach during the period spanning from 2 January 2019 to 31 January 2024, covering the periods before, during, and after the COVID-19 era. During the COVID-19 period, the TSE reduced the per-session price limit to protect investors from severe price fluctuations. Despite this protective measure, the results show that higher volatility is compensated by lower returns on all sectors' returns. After the crisis, as a first step, the TSE widened the price limits, but subsequently, it narrowed them. The results show that the shift from the wider price limit regime to the narrow price limits regime structurally modifies volatility for small and large cap sectors.

Keywords

- wider price limits
- narrow price limits
- risk-return trade-off
- asymmetric volatility

JEL codes: G10, G18.

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Introduction

The 1987 financial market disasters sparked considerable discussion about how to keep markets from experiencing such significant changes in the future. Many studies, including (Berkman & Lee, 2002; Deb et al., 2017; Kim et al., 2013; Lee & Kim, 1995) advocate market-breaker mechanisms via price limits and transaction halts to prevent high stock price volatility. Price limits are now used as a safety net on many stock exchange markets around the world, both in developed and emerging markets. In addition, price ranges present a complicated phenomenon that varies from one market to another and may even vary within the same market from one period to another. Thus, investigating price limit bands, risk-return trade-off and volatility has become an attractive preoccupation for policymakers, researchers, and investors.

The impact of price limits on volatility has been the subject of several contributions to the literature. However, despite the large amount of research that has been conducted, there is no clear consensus on the nature of this relationship. Indeed, several studies, such as (Kim & Rhee, 1997; Lee & Kim, 1995; Spiegel & Subrahmanyam, 2000) showed that price limits promote volatility spillover to subsequent trading days. In turn, several studies presented proof that stock prices become more volatile after reaching limits (see, e.g., Berkman & Lee, 2002; Kim et al., 2008; Li et al., 2014). Other studies, however, found that price limits have a general calming effect on investor behaviour because they reduce volatility once the limits are reached (e.g., Deb et al., 2013; Kim et al., 2013; Wan et al., 2015). There are also studies that examined the effects of narrowing and widening price limits on stock market volatility, such as (Wan & Zhang, 2022) on the ChiNext Market of China (Lin & Chiao, 2020), and (Kim, 2001) on the Taiwan financial market, (Seddighi & Yoon, 2018) on the Korean financial exchange market and (Farag, 2013) on the Egyptian, Thai and Korean stock markets.

All the above studies focused on narrowing and widening price limit effects on stock market volatility and paid little regard to the risk-return trade-off and the specific character of the stocks: large-cap or small-cap stocks. In this paper, we remedy this gap in three ways. First, we study the impact of imposing various price limit bands on asymmetric volatility by activity sector. Second, we decompose the data into large-cap or small-cap sectors. Third, studies that examine the connection between price limit bands and the risk-return trade-off have not received enough attention in the literature. To the best of the authors' knowledge, this is the first attempt to address the relationship between price limit bands and risk-return trade-off.

The Tunis Stock Exchange (TSE) imposes daily static and dynamic thresholds. Thresholds limit the price of an order that can be submitted to the TSE. Static thresholds refer to the lower and upper price limits of a security for a given

trading day. TSE trading rules initially set a ±6.09% static threshold compared to its previous trading session's closing price. These dynamic thresholds are applied during a continuous session. A 15-minute trading pause would be enforced if the stock price increased or decreased by more than ±3% from its reference price throughout the trading session. When the session re-opens and the stock's price exits the ±4.5% band, trading is halted once again for 15 minutes. When the session restarts, if the stock's price exits the ±6.09% band (static thresholds), trading in this stock is stopped until the end of the day.

The spread of COVID-19 cases in Tunisia prompted the Tunisian Stock Exchange to take measures to protect investors from severe price fluctuations. Indeed, the TSE implemented a new price ceiling mechanism from 18 March to 5 June 2020, in which the static thresholds were reduced to ±3%, meaning that if a stock's price increased or decreased more than ±3% from its starting price throughout the trading session, transactions were stopped until the end of the day. As of 8 June 2020, TSE returned to its usual daily price limits (ceiling and floor) of ±6.09%. On 30 August 2021, the TSE reduced the static and dynamic thresholds again; it set ±6% static thresholds and 2% dynamic thresholds. A 10-minute trading pause was enforced if the stock price increased or decreased by more than ±2% from its reference price throughout the trading session.

The contradictory actions taken by the TSE during and post-COVID-19 period, which consisted in reducing the daily static thresholds from 6.09% to 3% (from 18 March to 5 June 2020), then increasing the daily static thresholds from 3% to 6.09% (from 8 June to 30 August 2021), thereafter decreasing the static thresholds from 6.09% to 6% and decreasing the dynamic thresholds from 3% to 2%% (from 30 August 2021) were the motivation for this paper. The main objective of this paper is, therefore, to understand how alternative price limit bands affect the risk-return trade-off, as well as how changing regulatory rules may affect asymmetric volatility. To investigate the impact of imposing various pricing bands on risk-return trade-off on the Tunisian Stock Exchange (TSE), the study estimates an asymmetric volatility EGARCH-M model during the period from 2 January 2019 to 31 January 2024. We divide the overall period into four sub-periods. The sub-periods are set according to changes in the price limits imposed on the market.

The results are summarized as follows: During the quiet period, under the initial rules-set regime, we find evidence of a positive risk-return relationship for all sectors. The results still show that good news has more impact than bad news. As an exception for financial companies, the findings demonstrate that bad news has a bigger impact on volatility than good news. During the COVID-19 period, despite the protective measures taken by the TSE, the results show that higher volatility is compensated by lower returns. In addition, the study findings demonstrate that the stock market's volatility increased during the COVID-19 period, and we find that bad shocks have more impact than good ones on all sectors' returns. The post-COVID-19 period is divided

into two sub-periods, according to the price-limit regime applied. With the wider price limit (WPL) regime, risk-averse investors perceive their investments in small-cap sectors (industrials, consumer services, and basic materials) as relatively riskier compared to large-cap sectors (financial companies and consumer goods). In addition, for large-cap sectors, the results show that positive news has a stronger impact on future volatility than negative news of a similar magnitude. In contrast, for small-cap sectors, negative news has a greater impact on future volatility than positive news. On the other hand, the results show that volatility is extremely high for small-cap sectors compared to large-cap sectors. Thus, under a wider price limit regime, risk-averse investors perceive investments in large-cap sectors as less risky compared to investments in small-cap sectors. The transition to the narrow price limit (NPL) regime radically changes the results. The risk-return relationship becomes weak for large-cap sectors, indicating that under a narrow price limit regime, risk-averse investors perceive their investments in financial companies and consumer goods as relatively riskier compared to the rest of the sub-sectors. Furthermore, the shift from the WPL to the NPL regime structurally modifies volatility for small-cap sectors, suggesting that positive news has a greater effect than negative news. In addition, the volatility of the small-cap sectors decreased within the narrow price limit regime. These implications emphasize the importance of small-cap sectors in attracting investors under the NPL regime.

The paper is organized as follows: Section 1 provides the related literature. Section 2 presents data and methodology. Section 3 provides the empirical results. The final section concludes the paper.

1. Literature review

The emergence of COVID-19 had a deleterious impact on global markets. It is regarded as the world's most catastrophic economic shock (Insaidoo et al., 2021). The disease's emergence harmed the global economy and created uncertainty in global financial markets (Engelhardt et al., 2021). Szczygielski et al. (2021) found that pandemic insecurity had a negative impact on virtually all countries, resulting in lower returns and increased market volatility. Markets became very volatile and unpredictable as a result of the widespread uncertainty about the epidemic and its associated economic disasters (Zhang et al., 2020). Okorie and Lin (2021) found significant fractal contagion on market return and volatility, which supports this finding. Despite the negative effects of the COVID-19 pandemic on global economies and stock exchanges, Fernandez-Perez et al. (2021) demonstrated that culture has a substantial influence on market volatility. They discovered that within the first three weeks after a country's in-

itial COVID-19 case was recorded, stock markets in nations with lower individualism and higher uncertainty avoidance had bigger drops and greater volatility.

During the COVID-19 epidemic, the number of studies on stock market volatility surged dramatically and concerned both developed and developing markets (see, e.g., Alzyadat & Asfoura, 2021; Bora & Basistha, 2021; Chen et al., 2021; Fakhfekh et al., 2021; Lo et al., 2022; Yu et al., 2022). The main findings of these studies show that there has been a substantial shift in volatility during the COVID-19 era.

From a methodological standpoint, the majority of this literature was generated in the time domain using a wide range of time series approaches. Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) techniques are the most popular approaches. Bakry et al. (2022) employed the GJR-GARCH method to analyse the influence of COVID-19 news on stock market volatility in developed and emerging markets. They found major differences between these markets and provided reasons for the differences in terms of country culture and governance quality. Xu (2022) followed Hansen and Huang (2016) and included time-varying factors into the Realized Exponential GARCH method (TV-REGARCH) to investigate the COVID-19 effect on the Canadian Stock Market. The result showed that the COVID-19 pandemic caused a massive rise in market volatility for the Canadian Index. Alzyadat and Asfoura (2021) examined the influence of the COVID-19 epidemic on the stock market in Saudi Arabia. The ARCH model's findings showed that the COVID-19 pandemic had a negative influence on Kingdom of Saudi Arabia (KSA) stock market performance. The results also showed that during the early days of the COVID-19 epidemic, the negative market reaction was considerable. Cepoi (2020) used a panel quantile regression framework and showed asymmetric relationships between stock markets and COVID-19 related news in six developed countries (the USA, UK, Germany, France, Spain and Italy). Just and Echaust (2020) employed a two-regime Markov switching framework in twelve countries, with their findings revealing a significant link between returns and implied volatility.

Another research stream discusses COVID-19's effect on stock markets across sectors. He et al. (2020) employed an event research technique and the market model to investigate Chinese sector industries' returns and tendencies in reaction to COVID-19's emergence. According to this research, the epidemic negatively impacted the transportation, mining, electricity and heating, and environmental industries. On the other hand, the manufacturing, information technology, education, and health-care sectors proved to be resistant to the pandemic. Fakhfekh et al. (2021) examined the volatility oscillations of the Tunisian sectoral stock market indices during the COVID-19 pandemic period, utilizing four GARCH approaches (E-GARCH, FI-GARCH, FIE--GARCH and T-GARCH). They concluded that volatility has persisted longer in all series since the COVID-19 pandemic.

As shown above, the financial market volatility response to the COVID-19 outbreak has been extensively researched in the literature. However, studies that consider price limit bands and asymmetric volatility in crisis periods have been overlooked. Kim and Park (2010) established that stock markets with a higher risk of manipulation can benefit from the adoption of price limitations, since they may give uninformed traders more time to engage in price discovery. Farag (2013) explored the consequences of enforcing different price bands on the performance and volatility of equities on the Egyptian, Thai and Korean stock markets. Employing the asymmetric volatility EGARCH and PARCH approaches, the study proved that the transfer from narrow price limits to wider price limits fundamentally affected asymmetric volatility. Farag (2015) examined the impact of setting various price constraints on the overreaction effect on the Egyptian Stock Exchange (EGX) from 1999 to 2010 and found evidence of the overreaction effect on the EGX under different price limit bands.

According to Berkman and Lee (2002), the expansion of price limits enhances long-term volatility and decreases trade volume. Kim et al. (2013) analysed two eras in the Chinese financial equity market, one with and one without price limits. They discovered that price limits are helpful with regard to price restoration and volatility reduction. Seddighi and Yoon (2018) noted that the Korean financial exchange market gains in efficiency when price limits were expanded from 15% to 30%. Lin and Chiao (2020) studied the repercussions of expanding price limits on the Taiwan financial market from 7% to 10%. Their results showed that the event was detrimental to liquidity but beneficial to price discovery. In a more recent study, Wan and Zhang (2022) examined the effect of relaxing the daily price limit on the ChiNext market in China from 10% to 20% and provided proof that widening the daily price limits does not greatly affect price efficiency, but it does considerably increase liquidity and raises return volatility.

Phylaktis et al. (1999) and Kim (2001) focused on narrowing price limit effects on stock market volatility. Considering the information acquired through the price limit system implemented by the Taiwan Stock Exchange, Kim (2001) discovered that when price limits are narrowed, stock market volatility does not decrease. Phylaktis et al. (1999) analysed shares subject to an 8-percent limit, as well as shares subject to a 4-percent restriction on the Athens Stock Exchange and found that volatility is unaffected by price restrictions.

2. Data and empirical methodology

The data includes daily closing price indexes for five main sectors obtained from the TSE database. The sectors studied are as follows: financial companies, consumer goods, industrial companies, consumer services and basic materi-

als. Financial companies contains banks (77.73% of the market capitalisation of the financial index), insurance companies (14.33% of the market capitalisation of the financial index), and financial service companies (7.94% of the market capitalisation of the financial index); the consumer goods sector contains food and beverage companies (84.06% of the market capitalisation of the consumer goods index) and personal and household goods companies (15.94% of the market capitalisation of the consumer goods index);'Industrial' contains only construction and material companies. Consumer services contain only general retail companies; 'Basic materials' contains only basic resource companies.

TSE initially (before 18 March 2020) introduced symmetric ±6.09% price limits for equity prices in relation to the previous trading day's closing price. From 18 March to 5 June 2020, the TSE regulator narrowed the upper and lower limit boundaries to ±3% in order to avoid high price fluctuations that might be caused by the COVID-19 crisis, protect investors, and reduce any potential volatility. As of 8 June 2020, TSE maintained its usual daily price limits (ceiling and floor) of ±6.09%. On 30 August 2021, the TSE reduced the per-session price limit again, setting a ±6% ceiling/floor limit price compared to its previous trading session's closing price. A 10-minute trading pause was enforced if the stock price increased or decreased by more than ±2% from its reference price throughout the trading session.

To analyse the TSE's asymmetric volatility over various price limit band phases, data were collected from 2 January 2019 to 31 January 2024, for a total of 1196 observations. The dataset is divided into four phases. The initial phase from 2 January 2019 to 17 March 2020 represents the quiet period under the initial rules-set regime (a ±6.09% ceiling/floor limit price). The second phase, from 18 March to 5 June 2020, represents the COVID-19 period under the NPL regime (symmetric ±3% price limits per session). The third phase from 8 June 2020 to 19 August 2021 represents the first post-COVID-19 period, under WPL regime (symmetric ±6.09% price limits per session). Lastly, the fourth phase, from 20 August2021, to 31 January 2024, represents the second post-COVID-19 period under the NPL regime (symmetric ±6% price limits per session).

The main sector indexes are converted to their log return series:

$$r_{it} = 100 \cdot \ln\left(\frac{p_{it}}{p_{i(t-1)}}\right) \tag{1}$$

where p_{it} and $p_{i(t-1)}$ represent the sector index price i on days (t) and $(t-1)$, respectively.

In order to determine how alternative price limit bands affect risk-return trade-off and asymmetric volatility, this study applies EGARCH-M estimation. The GARCH-M model performed by Engle et al. (1987) has been widely employed in modelling risk-return trade-off. The traditional GARCH-M (1, 1) model is defined as follows:

$$r_{it} = \mu_0 + \psi \cdot h_{it} + \varepsilon_{it} \tag{2}$$

where r_{it} is the market return, h_{it} is the conditional variance. The error term ε_{it} is supposed to be normally distributed with a zero mean and constant variance.

The ψ coefficient represents the risk-return link, which indicates the required return for taking each unit of risk. A positive value for ψ implies that the market return is higher as the risk level for the market increases. However, a negative value for ψ indicates that the return is lower as the market risk level increases. Chen (2015) stated that a negative value for the risk-return coefficient in the stock market results from less risk-averse investors.

To treat the effect of negative and positive shocks on the conditional variance function, this study applies the Exponential GARCH approach put forward by Nelson (1991). The EGARCH framework has an advantage over other asymmetric GARCH estimation techniques, since there are no non-negativity restrictions that must be placed on the regression coefficients.

The conditional variance (h_{it}), as revealed by Nelson (1991), is as follows:

$$\ln h_{it} = \alpha_0 + \theta \ln h_{i(t-1)} + \omega \left| \frac{\varepsilon_{i(t-1)}}{\sqrt{h_{i(t-1)}}} \right| + \gamma \frac{\varepsilon_{i(t-1)}}{\sqrt{h_{i(t-1)}}} \tag{3}$$

where: ω is the weight given to recent news from the previous period, θ is the effect of past news on volatility at time $t-1$ transferred to time t (volatility persistence).

The γ coefficient distinguishes between the effects of bad and good shocks by defining the asymmetric effect. A negative γ coefficient suggests that negative news has a stronger impact on future volatility than positive news with a similar magnitude. A positive γ coefficient suggests that good news has a greater effect on future volatility than bad news of a similar magnitude.

A dummy variable is added to the conditional mean and variance equation to examine how alternative price limit bands (NPL and WPL) affect risk-return trade-off and asymmetric volatility for each sub-period. The augmented EGARCH-M framework with dummy variables is specified as:

$$r_{it} D = \mu_0 + \psi \cdot h_{it} + \varepsilon_{it} \tag{4}$$

$$\ln h_{it} = \alpha_0 + \theta \ln h_{i(t-1)} + \omega \left| \frac{\varepsilon_{i(t-1)}}{\sqrt{h_{i(t-1)}}} \right| + \gamma \frac{\varepsilon_{i(t-1)}}{\sqrt{h_{i(t-1)}}} + \lambda D \tag{5}$$

The value of the dummy variable D is 1 for the respective band (NPL COVID-19 period, WPL first post-COVID-19 period and NPL second post--COVID-19 period) and 0 otherwise. As proposed by Bora and Basistha (2021), a statistically significant negative dummy variable's coefficient denotes that

the stock market's volatility decreased during the specified period. Instead, a statistically significant positive dummy variable's coefficient implies that the volatility of the financial market has increased.

3. Empirical results

Table 1 details the TSE sectors (financial companies, consumer goods, industrial companies, consumer services and basic materials), including the number of listed companies, market capitalisation of each sector (percent of the overall market capitalisation) and trading volume of each sector (percent of the overall market trading volume) as of 31 December 2022. Despite the relatively small number of listed companies (82 listed stocks), the market capitalisation is around 24029 million TND (equivalent to 7691.75 million USD). Financial companies represent more than 52.5% of market capitalisation, while consumer goods account for 29.5%. Together, these two sectors represent 82% of market capitalisation, so they are considered large-cap sectors. Industrial companies, consumer services and basic materials companies combined represent about 17.84% of the market capitalisation. They are considered small-cap sectors.

On the other hand, the greatest trading volume is realized by financial companies (49.35%), followed by consumer goods (25.23%). Industrial companies, consumer services and basic materials companies combined account

Table 1. Tunisian Stock Exchange sectors, 31 December 2022

Sectors	Number of listed companies	Market capitalisation of each sector (% of the overall market capitalisation)	Trading volume of each sector (% of the overall market trading volume)
Financial companies	28	52.57	49.35
Consumer goods	15	29.56	25.23
Industrial companies	13	8.52	13.64
Consumer services	12	5.92	8.26
Basic materials	5	3.4	3.5
Other companies*	9	0.03	0.02

Notes: * 0.03% of market capitalisation comes from other companies (9 companies: 1 oil and gas company, 2 technology companies, 3 health companies, 3 telecommunications companies). These companies belong to other sectors. On TSE, only sectoral indices with a minimum of four companies are published.

Source: TSE website.

for about 25.40% of the trading volume. As a result, trade in large-cap sectors is greater than trade in small-cap sectors.

Table 2 shows the descriptive statistics and the diagnostic tests of sector returns during the full period. Apart from consumer goods and consumer services, each sector generates a positive return. The greatest return is realized by financial companies (0.020), followed by industrial companies (0.008) and basic materials (0.003). Basic materials have the highest volatility (0.911), followed by industrial companies (0.832), consumer goods (0.725), consumer services (0.651) and financial companies (0.521).

Daily returns show high kurtosis for all sectors, indicating that their return series have fat tails and strong peaks. All skewness statistics are close to zero. The Jarque-Bera test results disprove the null hypothesis that the return series are normally distributed.

Table 2. Descriptive statistics of stock return over the whole period

	Financial companies	Consumer goods	Industrial companies	Consumer services	Basic materials
Mean	0.020	–0.010	0.008	–0.003	0.003
Median	0.019	–0.020	–0.009	–0.026	–0.013
Maximum	3.516	3.206	3.599	2.559	3.833
Minimum	–3.988	–5.450	–4.135	–2.895	–5.005
Std. Dev.	0.521	0.725	0.832	0.651	0.911
Skewness	–0.453	–0.253	–0.081	0.147	–0.214
Kurtosis	11.024	8.371	5.552	4.162	5.042
Jarque-Bera	3448***	1539***	345***	76***	230***
ADF	–20.300***	–29.218***	–28.644***	–33.862***	–30.851***
Q(36)	118.600***	97.228***	128.450***	61.860***	84.231***
$Q^2(36)$	353.40***	440.27***	826.54***	657.43***	433.92***
LM-ARCH(24)	236.2***	227.1***	288.5***	62.5***	247.9***
SB	0.171***	0.282***	–0.011	0.018	–1.380E–09***
NSB	–0.153	–0.128	–0.540***	–0.377***	–5.900E–05***
PSB	0.624***	0.159***	0.676**	0.335***	1.900E–05***
JT	28.77***	45.68***	101.52****	63.19***	104.01***

Notes: Std. Dev. is the standard deviation. Q(36) is the Ljung-Box autocorrelation test at the 36th lag. $Q^2(36)$ is the autocorrelation test of squared returns at the 36th lag. LM-ARCH(24) is the Lagrange Multiplier test at the 24th lag.ADF is the augmented Dickey-Fuller test. SB is the sign bias test. NSB is the negative size bias test. PSB is the positive size bias test and JT is the test of the joint hypothesis of SB, NSB and PSB. ***, ** indicate significance at the 1% and 5% levels, respectively.

Source: own work.

The Q statistic shows that autocorrelations up to 36 lags is significantly present. The tabulated Q^2 statistics show that conditional heteroscedasticity is significantly present. As well, LM-ARCH statistics are massively significant, which implies that the time-varying conditional variance is confirmed and supports the use of the GARCH framework. The four Engle and Ng (1993)'s sign bias tests' results point to the existence of asymmetric volatility for all series. Therefore, positive and negative shocks have different impacts on conditional variance and the use of the asymmetric GARCH framework is confirmed.

The empirical findings of the risk-return trend and asymmetric volatility are presented in this part for the four sample periods. To choose the best specification of the asymmetric GARCH model, we tested four GARCH asymmetric models (EGARCH (1,1), GJR-GARCH, NARCH and APARCH). The Akaike Information Criterion (AIC) indicator selects EGARCH (1,1). The Broyden--Fletcher-Goldfarb-Shanno (BFGS) numerical optimisation approach is used to estimate the model. Since the return series are not normally distributed, a generalized error distribution (GED) is suggested based on minimum AIC and maximum log-likelihood criteria.

3.1. Pre-COVID-19 period

Table 3 summarizes the findings of the EGARCH-M (1,1) with the initial rules set regime (a ±6.09% static threshold and a ±3 and 4.5% dynamic thresholds) for the period 2 January 2019 to 17 March 2020. From the mean equation, we notice that the ψ coefficient is positively significant at 1% for all sectors.

Table 3. Estimation results of EGARCH-M model in the pre-COVID-19 period

Variables	Financial companies	Consumer goods	Industrial companies	Consumer services	Basic materials
Mean equation					
μ_0	–5.76E–07***	–0.045***	–0.008***	–5.79E–13	4.68E–06***
Ψ	0.001***	2.036***	1.655*	0.063***	0.051*
Conditional variance					
α_0	–2.055***	–2.429***	–0.417***	–2.955***	–0.668***
Ω	0.933***	0.183***	0.081***	0.251***	0.771***
γ	–0.422***	0.194***	0.069***	0.055***	0.202***
θ	0.923***	0.362***	0.921***	0.882***	0.992***

Note: ***, * indicate significance at the 1%, and 10% levels, respectively.

Source: own work.

The positive risk-return relationship in the TSE market during the quiet period suggests that an increase in return is associated with an increase in risk, and vice versa. These outcomes align with the asset price theory. The findings are similar to those of Refai et al. (2017) for the similar emerging market of Jordan. According to Chiang et al. (2015), the positive risk-return connection is more pronounced during quiet times.

We can see from the variance equation that ω, θ and γ coefficients are all significant, indicating that the constant variance hypothesis is invalid and that sector returns are defined by EGARCH-M asymmetric volatility equations. The results show that the conditional variance for all sectors depends significantly on past innovations and past conditional variance values. In addition, the γ coefficients are significant for all sectors. These findings show that market shocks have an asymmetric influence on sector returns. More precisely, the γ coefficients are positive for consumer goods, industrial companies, consumer services and basic materials, which implies that market upswings have a bigger impact than downturns of the same magnitude. The findings are consistent with those of previous studies, such as Refai et al. (2017) for 17 sub-sectors in the Jordan Market and Refai & Hassan (2018) for the industrial sectors of the Qatar market, suggesting that positive news had a greater effect than negative news. However, the γ coefficient is negatively significant only for financial companies. These findings demonstrate that bad news has a bigger impact on volatility than good news. Such results contradict those of a previous study by Refai et al. (2017) for the emerging market of Jordan.

3.2. During the COVID-19 period

Table 4 provides the effects of switching from the initial rules set regime (a ±6.09% static threshold and a ±3/±4.5% dynamic thresholds) to the NPL regime (a ±3% static threshold) on risk-return trade-off and asymmetric volatility using the EGARCH-M asymmetric volatility model. The empirical evidence shows that the ψ coefficients are negative and significant for financial companies and consumer goods. The results point to a negative and strong risk-return trade-off during the period of a market downturn for large-cap sectors. In contrast, the risk-return interaction is insignificant for small-cap sectors: industrials, consumer services and basic materials. The findings are consistent with previous empirical studies in both developed and emerging markets, which show that higher volatility is compensated for by lower returns during periods of market downturn. For developed markets, Salvador et al. (2014) showed that in eleven European markets, the risk-return interaction was insignificant or negative during the 2008 financial crisis. Ghysels et al. (2014) also discovered similar outcomes for the US Stock Market during the 2008

financial crisis. For emerging markets, Refai et al. (2017) showed a negative risk-return interaction for 15 sub-sectors in the Jordan stock market during the 2008 financial crisis. Typically, investors anticipate a smaller return from equities during these periods because they believe the stocks to be riskier than during quiet trading times.

Table 4. Estimation results of EGARCH-M model during the COVID-19 period

Variables	Financial companies	Consumer goods	Industrial companies	Consumer services	Basic materials
Mean equation					
μ_0	1.62E–08	0.001***	5.85E–11	–5.02E–08	5.50E–10
Ψ	–0.442***	–0.581***	–0.175	1.14E–14	2.01E–10
Conditional variance					
α_0	–10.43***	–3.719***	–16.69***	–8.241***	–7.455***
Ω	0.071***	0.087***	0.043	0.076***	0.283***
γ	–0.067***	–0.023*	–0.065	–0.017***	–0.030***
θ	0.610***	0.392***	0.353***	0.550***	0.437***
λ	8.990***	1.373***	18.61***	2.853***	0.828***

Note: ***, * indicate significance at the 1% and 10% levels, respectively.

Source: own work.

From the variance equation, we observe that the γ coefficients are negative and significant for all sectors (except for industrial companies, it is negative but insignificant), implying that equal-sized negative innovations are more volatile than equal-sized positive innovations. In addition, the dummy variable's coefficients λ are positively significant at the 1-percent level for all sectors, demonstrating that the stock market's volatility increased during the COVID-19 period. This finding is in line with the results of Bora and Basistha (2021) for the Bombay Stock Exchange in India. Fakhfekh et al. (2021) found the same result for the TSE during the COVID-19 period.

3.3. During the post-COVID-19 periods

Tables 5 and 6 report the effects of switching from the WPL regime (±6.09% static threshold and ±3/±4.5% dynamic thresholds) to the NPL regime (±6% static threshold and ±2/±4% dynamic thresholds) on risk-return trade-off and asymmetric volatility using the EGARCH-M asymmetric volatility model. The

Table 5. Estimation results of EGARCH-M model during the first post-COVID-19 period

Variables	Financial companies	Consumer goods	Industrial companies	Consumer services	Basic materials
Mean equation					
μ_0	–0.008***	4.72E–05	–4.97E–08	–1.62E–10	–6.79E–13
Ψ	0.170***	0.054***	0.002	0.007	0.036
Conditional variance					
α_0	–2.763***	–3.616***	–11.465***	–5.796***	–18.605***
Ω	0.065***	0.254***	0.414***	0.055	0.480***
γ	0.008***	0.039*	–0.334***	–0.045	–0.044
θ	0.074***	0.487***	0.526***	0.770***	0.221***
λ	0.932***	0.569***	10.877***	6.126***	18.153***

Note: ***, * indicate significance at the 1%, and 10% levels, respectively.

Source: own work.

Table 6. Estimation results of EGARCH-M model during the second post-COVID-19 period

Variables	Financial companies	Consumer goods	Industrial companies	Consumer services	Basic materials
Mean equation					
μ_0	2.18E–10	–3.13E–09	0.056**	0.108**	1.90E–07**
Ψ	0.003	0.001	0.273**	0.629**	2.11E–06
Conditional variance					
α_0	–18.159***	–18.129***	–1.505***	–1.723***	–1.750***
Ω	0.219***	–0.156***	0.076***	–0.002	0.768***
γ	0.007***	0.152***	0.004	0.028	0.027**
θ	0.276***	0.255***	0.050***	0.017***	0.811***
λ	16.990***	18.194***	0.006	0.008	0.025

Note: ***, ** indicate significance at the 1% and 5% levels, respectively.

Source: own work.

post-crisis outcomes are not identical to those from the previous periods in all of the subsectors. Within the wider price limit regime, we see that the ψ coefficients are positive and significant for large-cap sectors: financial companies and consumer goods. However, they are positive and insignificant for

small-cap sectors: industrials, consumer services and basic materials, which implies that the risk-return relationship is weak for small-cap sectors, indicating that within the wider price limit regime, risk-averse investors perceive their investments in industrials, consumer services and basic materials as relatively riskier compared to the rest of the sectors.

On the other hand, the γ coefficients are positive and significant at the 1% level for large-cap sectors, which implies that positive news has a stronger impact on future volatility than negative news of a similar magnitude. For industrial companies, the γ coefficient is negative and significant, which implies that negative news has a stronger impact on future volatility than positive news of a similar magnitude. For consumer services and basic materials, the γ coefficients are negative but insignificant.

We still note that within the wider price limit regime, the dummy variable's coefficients λ for all sectors are positive and significant. In addition, they are extremely high for small-cap sectors (10.877 for industrials, 6.126 for consumer services and 18.153 for basic materials) compared to large-cap sectors (0.932 for financial companies and 0.569 for consumer goods). Farag and Cressy (2012) and Farag (2013) found similar results for small-cap sectors, demonstrating that switching to a WPL band greatly increases volatility. Similarly, this result is in line with that of Wan and Zhang (2022) on the ChiNext market in China. Taking these discoveries into account, under a wider price limit regime, risk-averse investors perceive investments in large-cap sectors as less risky compared to investments in small-cap sectors.

Furthermore, switching from the wider price limit regime to the narrow price limit regime does not have an identical effect on all sectors. The outcomes change radically. Thus, the ψ coefficients become positive and insignificant for large-cap sectors: financial companies and consumer goods. However, they become positive and significant for small-cap sectors such as industrial companies and consumer services, which implies that the risk-return relationship is weak for large-cap sectors, indicating that under a narrow price limit regime, risk-averse investors perceive their investments in financial companies and consumer goods as relatively riskier compared to the rest of the sectors.

The γ coefficients (during the wider limit regime) are negative for small-cap sectors. On the contrary, the γ coefficients (during the narrow limit regime) become positive for small-cap sectors and significant only for basic materials, suggesting that positive news has a stronger effect than negative news. Thus, the adjustment from the WPL to the NPL regime structurally modifies volatility for small-cap sectors. This result is consistent with the study by Farag (2013), who observed that volatility is structurally changed when price limitations are changed on the Thai, Egyptian and Korean Stock Exchanges.

Another notable finding for large-cap sectors includes the increase in dummy variables' coefficients with the NPL regime compared to the WPL regime, implying that the volatility for large-cap sectors increases within a narrow price

limit regime. Our results for the large-cap sector are in line with those of Kim (2001), who claimed that when price limits are narrowed, stock market volatility does not decrease. On the contrary, the λ dummy variables' coefficients for small-cap sectors are positive and significant under a wider price limit regime. A change from the WPL to the NPL regime considerably decreases the volatility for small-cap sectors since the λ dummy variable's coefficients become insignificant. Considering these findings, under a narrow price restriction regime, risk-averse investors believe that investments in small-cap sectors provide potential for lower risk than those in large-cap sectors.

Conclusions

Regarding investing strategies and decision-making, it is crucial for investors and policymakers to comprehend the effects of price limits on risk-return trade-off and asymmetric volatility. In light of this, price limits have been widely contested in the stock market literature due to their role in preventing significant market price volatility and for risk management objectives. However, the majority of studies on this topic are limited by the fact that they fail to take into account how different price limit bands protect investors from severe price fluctuations during crisis periods. In this context, we try to analyse this situation by investigating the impact of imposing different price limit bands on risk-return trade-off and asymmetric volatility on the TSE during the period spanning from 2 January 2019 to 31 January 2024, covering the periods of pre-, during, and after the COVID-19 era. In order to investigate the effects of alternative price limit bands (NPL and WPL) on risk-return and asymmetric volatility, as well as the potential effects of switching regulatory rules from (WPL) to (NPL), this study applies the EGARCH-M model. It uses dummy variables to identify each sub-period.

Our results suggest that risk-return trade-off and asymmetric volatility differ between small and large-cap sectors under both NPL and WPL regimes. This was confirmed by conducting tests for the five major sectors on the TSE under the WPL and NPL regimes. During the quiet period, under the initial rules-set regime, we find evidence of a positive risk-return relationship for all sectors, meaning that an increase in return is associated with an increase in risk, and vice versa. The results still show that good news has more impact than bad news. As an exception for financial companies, the findings demonstrate that bad news has a bigger impact on volatility than good news.

During the COVID-19 period, to protect investors from severe price fluctuations, the TSE implemented a new price ceiling mechanism, in which the per-session price limit was reduced to ±3%. Despite this protective meas-

ure, the results show that higher volatility is compensated by lower returns. Indeed, investors expect lower returns from stocks during this period, as they believe stocks are riskier than during calm trading periods. In addition, findings demonstrate that the stock market's volatility increased during the COVID-19 period and we find that bad shocks have more impact than good ones on all sectors' returns. It is therefore clear that the protective measures taken were insufficient.

The post-COVID-19 period is divided into two sub-periods, according to the price limit regime applied. With the WPL regime, risk-averse investors perceive their investments in small-cap sectors (industrials, consumer services and basic materials) as relatively riskier compared to large-cap sectors (financial companies and consumer goods). In addition, for large-cap sectors, the results show that positive news has a stronger impact on future volatility than negative news of a similar magnitude. In contrast, for small-cap sectors, negative news has a stronger impact on future volatility than positive ones. On the other hand, the results show that volatility is extremely high for small-cap sectors compared to large-cap sectors. Therefore, under a wider price limit regime, risk-averse investors perceive investments in large-cap sectors as less risky compared to investments in small-cap sectors. The transition to the NPL regime radically changes the results. The risk-return relationship becomes weak for large-cap sectors, indicating that under a narrow price limit regime, risk-averse investors perceive their investments in financial companies and consumer goods as relatively riskier compared to the rest of the sectors.

Furthermore, the shift from the WPL to the NPL regime structurally modifies volatility for small-cap sectors, suggesting that positive news has a stronger effect than negative news. In addition, the volatility of small-cap sectors has decreased within the narrow price limit regime. These implications emphasize the importance of small-cap sectors in attracting investors under the NPL regime.

The findings have ramifications for policymakers. Indeed, since the large-cap and small-cap sectors are not equally impacted by the change in price limits, policymakers must take into account the levels of sector capitalisation when making decisions to adjust price limit bands. The findings provide recommendations for investors. Firstly, under the WPL regime, the risk-return relationship is positively significant only for large-cap sectors and the volatility is extremely high for small-cap sectors compared to large-cap sectors. We recommend investors allocate their capital to large-cap sectors. Secondly, the alteration from the WPL to the NPL regime reinforces the positive risk-return relationship and decreases the volatility effect for small-cap sectors. This result recommends investors allocate their capital to small-cap sectors under the NPL regime. In the case of a change in price limits, investors who want to benefit from a positive risk-return relationship and decrease their portfolio volatility should build a portfolio with the same composition (weights of

stocks) of the large-cap sectoral indices, under the WPL regime. However, investors should build a portfolio with the same composition (weights of stocks) of the small-cap sectoral indices, under the NPL regime.

There are two limitations in this study that could be addressed in future research. Firstly, the study focused on aggregated data indexes (sectoral indexes). Future studies could extend the scope of our analysis by considering individual companies to reduce the aggregation bias. Secondly, we conduct our study on the five main sectoral indices, thus overlooking the nine companies that do not belong to any sector. Disaggregating the data by considering each company separately can provide more robust results that take into account all companies in the market.

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Quantile connectedness between social network sentiment and sustainability index volatility: Evidence from the Moroccan financial market[1]

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Abstract

The goal of this paper is to investigate the connectedness between investor sentiment and volatility on the environmental, social, and governance index (ESG) in Morocco. Therefore, on the basis of an investor sentiment index constructed from the X platform, and using quantile and frequency connectedness approaches, the findings reveal a significant connectedness between sentiment and ESG volatility, particularly during turbulent events. Although sentiment acts most of the time as a net receiver of shocks, notably during the COVID-19 pandemic and geopolitical crises, it sometimes becomes a net sender of shocks. Furthermore, the spillovers between sentiment and ESG volatility are determined mainly by the long-term component, especially during extreme events, implying the persistence of shock transmission due to high uncertainty. The results also illustrate the impact of market conditions on the spillovers

Keywords

- COVID-19
- ESG
- frequency spillovers
- quantile connectedness
- sustainability

[1] This article is a complementary version of the paper entitled 'Investor sentiment and sustainable investment: evidence from North African stock markets' accessible at: https://doi.org/10.1186/s43093-024-00349-x. The main contributions of this manuscript with respect to the previous manuscript are as follows. Firstly, while the previous manuscript develops an aggregate sentiment index from three sentiment proxies, the present manuscript focuses only on the social media sentiment index. This allows us to compare the results from these sentiment indices used and to assess the robustness of social media sentiment as a representative indicator of investor sentiment and, consequently, its relevance in predicting investor behaviour and its impact on market risk. Secondly, while the previous manuscript integrates the frequency connectedness approach with the time connectedness approach, the present paper integrates the frequency connectedness approach with the quantile connectedness approach. Finally, the present manuscript discusses in detail the practical implications of the findings for investors, companies and policy makers.

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between sentiment and ESG volatility. The conclusions of this study provide useful guidance for pro-ESG investors, policymakers, and companies.

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Introduction

The growing awareness of climate change and sustainability issues has prompted many stock markets to introduce sustainability indices. These indices cover only companies that comply with specific environmental, social, and governance (ESG) criteria. Recently, many investments have been reallocated to ESG assets (Gao et al., 2022; Zhan & Santos-Paulino, 2021), representing a high proportion of global equity portfolios (Daugaard, 2020). Therefore, investors' increasing attention to ESG-related stocks might have a positive effect on companies' financial performance (Vuong, 2022; Zhang & Zhang, 2023) and on the returns of ESG indices on financial markets (El Ouadghiri et al., 2021; López-Cabarcos et al., 2019).

Although ESG indices are derived from general indices, they might be more sensitive to market fluctuations than general indices are (Ortas et al., 2014). This is explained by investors' sensitivity to sustainable investment. Some studies have analysed the relationship between sentiment and sustainability indices on the basis of different investor sentiment proxies (El Ouadghiri et al., 2021; Giannarakis et al., 2016; López-Cabarcos et al., 2019; Pitoska et al., 2017). Giannarakis et al. (2016) and Pitoska et al. (2017) revealed that consumer sentiment has a positive effect on sustainability indices. On the basis of the Google search volume index, El Ouadghiri et al. (2021) reported that investors' attention to climate change and pollution has a significant and positive effect on sustainability index returns. López-Cabarcos et al. (2019) indicated that social network sentiment has a stronger effect on the S&P 500 Environmental & Socially Responsible Index than on the S&P 500 Index. Using

event study analysis, Nyakurukwa and Seetharam (2023a) found that investors react strongly to positive ESG news, whereas there is no statistically significant reaction to negative ESG news sentiment.

Investors' overreaction to ESG news could have a significant effect on ESG volatility and risk. However, the relationship between ESG performance and the volatility of ESG returns remains unclear: some studies have shown that ESG performance reduces risk (Li et al., 2022; Shakil, 2021), whereas others have revealed that it increases risk (Khan et al., 2024; Nofsinger et al., 2019). Thus, examining the connectedness between investor sentiment and ESG index volatility can provide a better understanding of this relationship. Furthermore, limited effort has been devoted to investigating the quantile, time, and frequency connectedness between sustainability sentiment and ESG index volatility. Moreover, despite the growing interest in ESG stock indices, little research exists on the connectivity between ESG sentiment and volatility in emerging markets. On the basis of a systematic literature review, Daugaard (2020) noted that there is very little literature on ESG investment in emerging markets. In addition, no research has addressed this connectivity in the Moroccan context, where it is unclear whether the results of previous research apply.

To fill these gaps, this article aims to investigate the dynamic connectedness between the X-based sustainable investment sentiment index and the volatility of the ESG index in the Moroccan financial market. Using quantile and frequency connectedness approaches, the main empirical results show that the connectedness between investor sentiment and ESG index volatility varies over time and depends on certain events. Furthermore, the results reveal that sentiment is a net receiver of shocks from ESG index volatility most of the time, but sometimes becomes a net transmitter of shocks, implying a feedback effect between sentiment and ESG index volatility. The net receipt of shocks is more pronounced during periods of extreme events. Moreover, most of the time long-term spillovers dominate short-term spillovers, especially during distress events such as COVID-19 and geopolitical tensions. With respect to market conditions, the findings show that spillover effects are greater in the upper quantiles than in the other quantiles, and that sentiment is a net transmitter of shocks to ESG index volatility in the upper quantiles, particularly in times of crisis.

We make four main contributions to the literature. Firstly, most research examining ESG investment issues has focused primarily on the US and Europe, where the ESG concept first emerged (Demers et al., 2021; Engelhardt et al., 2021). Nevertheless, related research on certain emerging markets is in noticeably short supply, including countries that are highly vulnerable to climate change and where ESG investment is an extremely critical issue. Morocco is an emerging country that is highly vulnerable to climate change, and where authorities are striving to encourage ESG investments and achieve sustain-

ability goals. Against this backdrop, the Casablanca Stock Exchange recently introduced the ESG index. It is therefore relevant to examine the relationship between investor behaviour and ESG investment in Morocco to determine whether the findings of previous studies apply to Morocco, where the ESG concept has gained momentum in recent years. This study is the first to explore the dynamic and complex interplay between social media sentiment and ESG index volatility in the Moroccan ESG market. We thereby examine whether investors in emerging markets, particularly in Morocco, are committed to sustainable investment and how their behaviour may affect the ESG market. Moreover, this study provides a better understanding of the progress of sustainable markets on the African continent, as the Moroccan financial market is one of the largest in Africa and attracts foreign investors, which can offer investors opportunities for geographic diversification. Secondly, to the best of our knowledge, this is also the first study to examine the bidirectional effect between social media sentiment and volatility on the ESG index, providing a comprehensive examination of this relationship. Thirdly, the sample in this study includes the most recent major events, namely, the COVID-19 epidemic, and the most recent major geopolitical events, such as the Russian-Ukrainian and Israeli-Palestinian conflicts, allowing us to better understand how these turbulent events influence the relationship between sentiment and the sustainability index, and thus help manage the risk propagated by these events. Fourthly, this study extends the literature on the relationship between ESG sentiment and volatility by using a fairly novel connectedness method, the dynamic *QVAR* model proposed by Ando et al. (2022), and by including frequency connectedness in our analysis. This enables us to capture connectivity in the frequency and time domains, as well as the quantile connectivity representing different market states. This is founded on the idea that the extent of connectivity can vary depending on whether markets are bearish, bullish or normal, depending on the time horizon (short or long term), and can also vary over time owing to extreme events. As a result, this allows us to understand the impact of the interaction between heterogeneous investor behaviour (short-term versus long-term investors) on the ESG market, as well as the ESG market risk at different quantiles (bearish, bullish and normal market conditions), which is more beneficial for the management of portfolios and the supervision of financial systems (Liao & Pan, 2022; Londono, 2019). This is especially important as financial markets exhibit structural breaks in return series (Cunado et al., 2023; Suleman et al., 2024) and nonlinearity caused by investor psychology (Lekhal & El Oubani, 2020).

The remainder of this paper is organised as follows. Section 1 reviews recent related literature. Section 2 outlines the methodology and data. Section 3 presents and analyses the empirical results of the paper. Section 4 performs robustness tests. Section 5 discusses the implications of the study. The last section presents conclusions.

1. Literature review and hypothesis development

With a market capitalisation of $35.30 trillion in 2020, ESG investments are expected to reach $50 trillion by 2025 (Lei et al., 2023). This reflects investors' preference for socially responsible investments that focus more on social or ethical utility (Gao et al., 2022; Garel & Petit-Romec, 2021), especially as such investments might be more resilient to turbulent events. Indeed, sustainable investment might continue to increase even in times of crisis, suggesting that investors and companies can be rewarded during crises for environmental sustainability (Garel & Petit-Romec, 2021). This can be explained by the fact that the ESG strategy might strengthen the brand image and loyalty of responsible companies (Pedini & Severini, 2022), helping attract loyal managers, investors, and customers (Boubaker et al., 2022; Isaak & Lentz, 2020). Loyal managers possess desirable capabilities for managing businesses, employees and customer relationships, which could facilitate improved productivity and profitability (Pedini & Severini, 2022). Loyal investors are motivated by nonpecuniary incentives to invest in ESG assets and are therefore unlikely to sell their investments, even in times of crisis (Hartzmark & Sussman, 2019). Loyal customers offer socially responsible companies financial support to overcome the crisis, resulting in higher cumulative abnormal returns (Boubaker et al., 2022). Moreover, firms that report ESG information benefit from financial support (Raimo et al., 2021). In fact, rating agencies have adhered to the principle of responsible investment, where ESG issues are included in their rating methodologies, implying that companies with higher ESG performance receive higher ratings (Bannier et al., 2022) and therefore benefit from lower interest rates. For instance, Phillips has received a EUR 1 billion loan from a syndicate of banks on the basis of sustainability (Klink & Gonciarenko, 2017). As a result, ESG performance could improve companies' resistance to risks. In this vein, Wang et al. (2023) argued that increasing environmental uncertainty drives companies to undergo a green transformation, improving their resistance to risks while enhancing their ESG performance. Li et al. (2022) revealed that ESG ratings reduce a firm's default risk. Murata and Hamori (2021) reported that ESG disclosures lower the risk of future stock price crashes. Thus, the high value placed on ESG assets is explained by their ability to hedge against downside risk during periods of market volatility (Albuquerque et al., 2020; Broadstock et al., 2021).

On the other hand, investor psychology might cause mispricing and high market volatility, which calls into question the efficiency market hypothesis. According to this hypothesis, prices instantly incorporate all available information, because investors can process all this information rationally (Fama, 1970). Nonetheless, investors' rationality is limited (Simon, 1982), and in-

vestors are affected by psychological biases that can influence their decision-making (El Oubani, 2023; Tversky & Kahneman, 1974; Willett, 2024). Behavioural finance studies have shown that investor sentiment can affect stock prices and explain many market anomalies, such as excessive volatility (Chiu et al., 2018; El Oubani & Lekhal, 2022; Lekhal & El Oubani, 2020; Paramanik & Singhal, 2020; PH & Rishad, 2020; Shiller, 1981; Wang et al., 2021).

Consequently, investor sentiment has a major impact on financial markets, and ESG markets might not be an exception or immune to this impact. In fact, investor sentiment could influence the ESG market, leading to market inefficiency and thus price deviation from the intrinsic value. Khan et al. (2024) reported that improvements in ESG profiles increase market prices relative to their true value and that market sentiment plays a moderating role in the link between ESG performance and mispricing, suggesting that ESG performance is a frictional factor for market efficiency. Bofinger et al. (2022) noted that socially responsible stocks tend to be overvalued. Liu et al. (2022) reported that ESG sentiment is positively associated with the volatility risk premium, particularly the impact of environmental and social factors.

The challenge in these studies lies in the fact that investor sentiment is unobservable and must thus be estimated from proxies. These proxies can be divided into three categories, namely, market-based measures, survey-based measures, and text-based measures. Market and survey-based measures are the most traditional methods, but their weaknesses arise from the fact that they indirectly attribute investor sentiment to a particular asset and are measured at low frequencies, which might not explain stock prices determined at high frequencies. The textual method is a relatively new way of extracting sentiment from news texts or social media posts. Accordingly, a large body of research uses social media and news-based sentiment in connection with ESG returns, trading volume and volatility. Through bibliometric analysis, Nyakurukwa and Seetharam (2023b) revealed that social media has emerged as an important facet of financial market understanding. Several measures of social media sentiment have been used in this context, including sentiments derived from the X platform (Abdollahi et al., 2024; Shutes et al., 2016), Facebook (Siganos et al., 2017) and Reddit (AlZaabi, 2021). Many studies confirm the impact of social media sentiment on returns and volatility. Indeed, Nyakurukwa and Seetharam (2024) reported a more powerful effect of social media sentiment on stock market returns in the US than did news media. Using textual analysis from news and social media, Abdollahi et al. (2024) found that media sentiment induces market volatility. Haroon and Rizvi (2020) showed that media-generated panic is correlated with increased volatility in global stock markets. This evidence suggests that part of financial market volatility is connected to media sentiment. As a result, the following hypothesis is formulated:

Hypothesis 1. There is a significant connectedness between social media sentiment and ESG volatility.

Within this connection, ESG volatility can transmit shocks to investor sentiment, which in turn can transmit shocks to ESG volatility. Dhasmana et al. (2023) asserted that the ESG index influences investor sentiment. In fact, as the ESG index increases, investor sentiment weakens; in contrast, poor ESG index performance strengthens investor sentiment. Ford et al. (2022) revealed that optimistic investor sentiment is driven by the highest-rated ESG portfolio. Chen and Yang (2020) found that investors are optimistic (pessimistic) about companies with higher (lower) ESG scores. Therefore, ESG performance or risk could influence investor sentiment.

Reciprocally, investor sentiment can play a dominant role in the ESG market. Indeed, Sabbaghi (2022) observed that the volatility of ESG companies is greater for bad news than for good news. Yu et al. (2023) reported a significant negative relationship between ESG news sentiment and stock market crash risk, suggesting that higher sentiment of ESG news could mitigate the risk of stock market crashes. Specifically, ESG sentiment impacts stock market crash risk by lowering negative ESG incidents, information asymmetry and agency costs. In addition, Liu et al. (2022) noted that news-based ESG sentiment influences the equity volatility risk premium. Wan et al. (2024) noted that high attention to ESG results in high volatility because greater attention to ESG information can lead to a diversity of opinions and disagreements between investors in ESG investment, thus inducing an increase in volatility connectedness. Cheng et al. (2024) pointed out that companies with better-quality sustainability reports receive greater coverage from analysts and positive reactions from investors on stock prices, which is likely to lead to greater volatility. Abdollahi et al. (2024) observed a bidirectional connection between social media sentiment and volatility.

On the basis of the aforementioned literature, we propose the following hypothesis:

Hypothesis 2. There is a feedback channel between investor sentiment and ESG index volatility.

The link between sentiment and ESG volatility can be more pronounced in times of crisis. Indeed, in times of crisis, investors prefer to switch from conventional to sustainable investments, which can cause large movements in stock markets (Wan et al., 2024). Consequently, ESG investments might not hedge against the market shocks propagated by distress events, such as the COVID-19 pandemic and geopolitical risk. Nofsinger and Varma (2014) demonstrated that risk contagion is likely to be more severe during periods of turbulence, including in the ESG market. Döttling and Kim (2022) reported a high sensitivity of sustainable investments to return shocks during crises, especially the

COVID-19 outbreak. In fact, exposure to COVID-19 positively and significantly impacts stock market volatility (Liu et al., 2023). This can be explained by investor perceptions and sentiment, as greater exposure to COVID-19 can be seen as a risk factor, resulting in greater selling pressure and volatility, especially as social media coverage of the COVID-19 outbreak (Umar et al., 2021) increased the sentiment of fear. In this context, Chen and Lin (2022) argued that ESG investment does not hedge against the risks that financial markets commonly experience, as their performance and volatility can be influenced by a variety of extreme events. This contradicts the findings of Albuquerque et al. (2020), who documented that stocks which are better rated in terms of ESG performance showed significantly lower volatility during the spike of the COVID-19 epidemic, because of investor and customer loyalty to sustainability. This also disagrees with Rubbaniy et al. (2022), who concluded that during the pandemic, investors might have shifted their portfolios from risky assets to ESG assets considered to be safe assets.

In addition to COVID-19, geopolitical risks can also have a significant effect on sustainable investment. These risks include the potential disturbance of normal international relations caused by several factors, such as shocks and tensions between nations (Ren et al., 2023), military conflicts, and war and terrorism threats (Caldara & Iacoviello, 2022). Yang et al. (2024) reported that changes in the geopolitical risk index bring about changes in ESG stocks. Sohag et al. (2022) highlighted the negative impact of geopolitical risk shocks on green equity. In this context, investor sentiment can explain the relationship between geopolitical risk and volatility. Guo and Shi (2024) examined the impact of investor sentiment and China-US geopolitical risk on Chinese stock market volatility and found that the interplay effects of China-US geopolitical risk and investor sentiment can further influence industry stock market volatility.

Building on this foundation, we posit the following:

Hypothesis 3. Disruptive events can amplify the connectedness between sentiment and ESG index volatility, creating increased risk in the sustainable market.

Volatility tends to be highly persistent (Wei et al., 2022), a property that is considered a stylised fact of financial markets known as long memory (Shi & Ho, 2015). Investor sentiment could be responsible for this volatility persistence. In fact, the uncertainty that prevails in distressed situations can transmit shocks from investor sentiment to market volatility over longer periods, which can result in low-frequency connectivity. Wu et al. (2023) showed that low-frequency connectedness tends to dominate during conflicts. Abdollahi et al. (2024) found that social media sentiment has a stronger lasting effect than news sentiment for some markets. Wan et al. (2024) found that high attention primarily impacts volatility connectedness at low frequencies. These results are in line with those found in the ESG market. Indeed, Gao et al. (2022) found that medium-frequency volatility connectivity between ESG stock in-

dices from eight regions dominates. This might be explained by the fact that ESG stock indices generate less sudden short-term risk and take longer to absorb risk in the risk transmission process (Wan et al., 2024). El Oubani (2024) found significant connectedness between sentiment and ESG market volatility, and this connectedness is due mainly to the long-term component, especially during extreme events.

On the basis of this discussion, the following hypothesis is formulated:

Hypothesis 4. The connectedness between sentiment and ESG index volatility is created at low frequencies, particularly during extreme events leading to high persistent volatility.

The connectedness between ESG sentiment and volatility might depend on market conditions, which can be captured by calculating this connectedness at different quantiles. In this respect, using the quantile connectedness approach to examine the relationship between sentiment and ESG volatility across different quantiles can be highly relevant. Indeed, conditional mean connectedness may provide limited information on the connectedness between sentiment and ESG volatility as financial markets can experience structural breaks (Cunado et al., 2023). Specifically, the most essential information on negative and positive shocks in financial time series is available in the lower and upper extreme quantiles (Londono, 2019). On the basis of quantile connectedness estimates, Sheikh et al. (2024) showed that the overall connectedness between daily trade policy uncertainty, geopolitical risk, the global financial stress index and the three Australian financial markets (i.e. conventional, sustainable and Islamic stock markets) increases at extreme bearish and bullish quantiles relative to normal market conditions. Guo and Shi (2024) reported that the impact of the interaction effects of Chinese and US geopolitical risk and investor sentiment on market volatility is highly heterogeneous, and that its magnitude lies mainly in the upper and lower tails. El Khoury et al. (2024) found that dynamic spillover effects are greater under extreme market conditions than normal conditions. With respect to the ESG market, Yang et al. (2024) noted that the predictability of ESG returns by geopolitical risk is asymmetric across different ESG return distributions. Dhasmana et al. (2023) found that the relationship between investor sentiment and the ESG index is asymmetric and influenced by extreme market conditions. Therefore, studying the impact of different market conditions can provide in-depth information on the link between sentiment and ESG index volatility, and provide investors with valuable information that could improve their decision-making by trading according to different market conditions, including upper and lower quantiles.

On the basis of the above literature review, we posit the following:

Hypothesis 5. The magnitude of the spillover effects between investor sentiment and ESG index volatility depends on market conditions.

2. Methodology and data

2.1. Methodology

Some approaches consider the mean-based *VAR* (Diebold & Yilmaz, 2012; Baruník & Křehlík, 2018) to examine connectedness between variables, but these approaches do not allow us to assess whether co-movement between variables in the network depends on the extreme quantiles and whether the shock is positive or negative. Furthermore, as the most essential information on negative and positive shocks in financial time series is available at the lower and upper extremes (Londono, 2019), these approaches do not provide sufficient information on the connectedness between sentiment and ESG volatility, especially as financial markets can experience structural breaks (Cunado et al., 2023). Accordingly, in our study we use the quantile connectedness approach developed by Ando et al. (2022), which is an improvement over the mean-based measures version. Quantile connectedness considers both extreme positive structural shocks (upper quantiles) and extreme negative structural shocks (lower quantiles). This allows us to see how normal (median), bullish (right-tail) and bearish (left-tail) market conditions affect spillover effects between variables.

To compute the connectedness measures at each quantile τ, we first estimate a quantile vector autoregression, *QVAR*(p), which is as follows:

$$y_t = \mu(\tau) + \sum_{j=1}^{p} \Phi_j(\tau) y_{t-j} + u_t(\tau) \tag{1}$$

in which y_t and y_{t-j}, $j = 1, ..., p$ are $N \times 1$ dimensional endogenous variable vectors, τ denotes the quantile of interest and lies within [0,1], p is the lag length of the *QVAR* model, $\mu(\tau)$ stands for the $N \times 1$ dimensional conditional mean vector, $\sum_{j=1}^{p} \Phi_j(\tau)$ is an $N \times N$ dimensional *QVAR* coefficient matrix, and $u_t(\tau)$ represents the $N \times 1$ dimensional error vector that has an $N \times N$ dimensional error variance—covariance matrix $\sum(\tau)$. To transform the *QVAR*(p) into its quantile vector moving average representation, *QVMA*(∞), we employ Wold's theorem:

$$y_t = \mu(\tau) + \sum_{j=1}^{p} \Phi_j(\tau) y_{t-j} + u_t(\tau) = \mu(\tau) + \sum_{i=0}^{\infty} \Psi_i(\tau) u_{t-i} \tag{2}$$

Then, we calculate the generalised forecast error variance decomposition (GFEVD) at the forecast horizon H (Koop et al., 1996; Pesaran & Shin, 1998).

The GFEVD indicates the impact of a shock in variable *j* on variable *i* with respect to its forecast error variance share. The GFEVD is given by the following formula:

$$\theta_{ij}^{g}(H)=\frac{\sum(\tau)_{jj}^{-1}\sum_{h=0}^{H-1}\left(e_i'\Psi_h(\tau)\sum(\tau)e_j\right)^2}{\sum_{h=0}^{H-1}\left(e_i'\Psi_h(\tau)\sum(\tau)\Psi_h(\tau)'e_i\right)} \tag{3}$$

in which e_i represents a zero vector with unity at the i^{th} position. In the decomposition matrix, the normalisation of elements is as follows:

$$\tilde{\theta}_{ij}^{g}(H)=\frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{k}\theta_{ij}^{g}(H)} \tag{4}$$

The normalisation is expressed by the following equations:

$$\sum_{j=1}^{K}\tilde{\theta}_{ij}^{g}(H)=1 \quad \text{and} \quad \sum_{i,j=1}^{K}\tilde{\theta}_{ij}^{g}(H)=K \tag{5}$$

Subsequently, according to Diebold and Yilmaz (2012), all GFEVD-based connectedness metrics are estimated as follows. The total connectedness index (TCI) provides the average level of total spillover and is written as follows:

$$TCI=K^{-1}\sum_{i,j=1,i\neq j}^{K}\tilde{\theta}_{ij}^{g}(H) \tag{6}$$

This measure can be seen as an indicator of market uncertainty.

The total directional connectedness TO is defined as:

$$TO_i=\sum_{j=1,i\neq j}^{K}\tilde{\theta}_{ji}^{g}(H) \tag{7}$$

The total directional connectedness $FROM$ is as follows:

$$FROM_i=\sum_{j=1,i\neq j}^{K}\tilde{\theta}_{ij}^{g}(H) \tag{8}$$

The NET total directional spillover is written in the following form:

$$NET_i(H)=TO_i-FROM_i \tag{9}$$

If $NET_i>0$, this indicates that variable i influences all the other variables more than it is influenced by them. The variable *i* is therefore a net transmitter of shocks. It is a net receiver of shocks when $NET_i<0$.

The net pairwise connectedness ($NPDC$) is computed as follows:

$$NPDC_{ij}(H) = \tilde{\theta}^{g}_{ij}(H) - \tilde{\theta}^{g}_{ji}(H) \tag{10}$$

If $NPDC_{ij}(H) > 0$, variable *j* has a greater effect on variable *i* than variable *i* has on variable *j*. Consequently, the variable *j* dominates the variable *i*. If $NPDC_{ij}(H) < 0$, the variable *i* dominates the variable *j*.

We integrate the frequency domain connectedness approach of Baruník and Křehlík (2018) with Ando et al.'s *QVAR* approach (2022). The frequency domain separates spillovers into high-frequency (short-term) and low-frequency (long-term) spillovers. The former indicates that connectedness results from shocks that have a short-term effect on the system, whereas the latter suggests that connectedness results from shocks that have a long-term effect on the variables in the system.

According to Baruník and Křehlík (2018), $\Psi(e^{-i\omega}) = \sum_{h} e^{-i\omega h}\Psi_h$ is the frequency response function generated from the Fourier transform of the coefficient Ψ_h with $i = \sqrt{-1}$. The generalised causation spectrum over frequencies $\omega \in (-\pi, \pi)$ is determined as:

$$\theta_{ij}(\omega) = \frac{\sigma_{jj}^{-1}\left|\Psi(e^{-i\omega})\sum_{ij}\right|^2}{\left(\Psi(e^{-i\omega})\sum\Psi'(e^{+i\omega})\right)_{ii}} \tag{11}$$

in which $\Psi(e^{-i\omega}) = \sum_{h} e^{-i\omega h}\Psi_h$ is the Fourier transform of the impulse response Ψ_h, and $\theta_{ij}(\omega)$ denotes the fraction of the i^{th} variable at a specified frequency ω resulting from shocks to the j^{th} variable.

The generalised variance decomposition at a given frequency band $d = (a, b)$ is as follows:

$$\theta_{ij}(d) = \frac{1}{2\pi}\int_{a}^{b} \Gamma_i(\omega)\,\theta_{ij}(\omega)\,d\omega \tag{12}$$

where $\Gamma_i(\omega)$ denotes the power of the i^{th} variable at a specified frequency and is described as:

$$\Gamma_i(\omega) = \frac{\left(\Psi(e^{-i\omega})\sum\Psi'(e^{+i\omega})\right)_{ii}}{\frac{1}{2\pi}\int_{-\pi}^{\pi}\left(\Psi(e^{-i\lambda})\sum\Psi'(e^{+i\lambda})\right)_{ii}\,d\lambda} \tag{13}$$

The normalised generalised variance decomposition at the frequency band d can be calculated as follows:

$$\tilde{\theta}_{ij}(d) = \frac{\theta_{ij}(d)}{\sum_{j} \theta_{ij}(\infty)} \tag{14}$$

where $\theta_{ij}(\infty)$ represents the contribution over all frequencies.

All measures of connectedness are calculated as in (6)–(10) at a frequency band "d". These connectivity measures are established via a particular quantile τ.

2.2. Data

To measure the spillover effect between investor sentiment and ESG investment volatility in Morocco, we use weekly data from the MASI ESG index, which was introduced in 2018. The goal of this index is to highlight companies performing well in terms of environmental, social, and governance factors relative to their market peers. The data are obtained from the Moroccan stock market website (https://www.casablanca-bourse.com/en/live-market/indices/ESGI) and cover the period from January 2018 to December 2023. This period is instructive in terms of extreme events because it includes the COVID-19 outbreak and subsequent years, as well as the most recent geopolitical conflicts (The Russian-Ukrainian and Israeli-Palestinian conflicts).

The volatility of the ESG index is estimated on the basis of the conditional variance from the univariate *GARCH* model (Bollerslev, 1986). In addition to the ESG index, we introduced the general market index, the Moroccan All Shares Index (MASI), to monitor general market conditions. The standard *GARCH* (p, q) model can be expressed as follows:

$$y_t = x_t\beta + \varepsilon_t,\ \varepsilon_t = h_t e_t,\ h_t^2 = \phi + \sum_{i=1}^{p} \lambda_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \gamma_j h_{t-j}^2 \tag{15}$$

where p represents the order of the moving average $ARCH$ term, q denotes the order of the autoregressive *GARCH* term, y_t stands for the conditional mean, h_t^2 expresses the conditional variance, ε_t^2 is the squared residual, λ_i represents the $ARCH$ parameters, γ_j represents the *GARCH* parameters, e_t denotes a white noise process, and ϕ is a constant.

We use the X (Twitter) sentiment as a proxy for investor sentiment. To construct this sentiment index, we applied the following procedure. We collected daily posts (tweets) related to "sustainable investment in Morocco" from the X platform for the period under investigation. In this context, we employed various related keywords, such as "Sustainable investment in Morocco", "Environmental, social, and governance criteria in Morocco", "Sustainability in Morocco ", and "ESG in Morocco". Once we had cleaned

the raw posts, we attributed a sentiment score to each post on the basis of natural language processing via Python. We obtained the opinion polarity from a total of 11,346 posts indicating whether a person has a neutral, positive or negative opinion toward sustainability. We then calculated the weekly average sentiment to construct a time-series of the weekly sentiment index with the following formula:

$$Tsent_t = \sum_{i=1}^{n} \frac{Sent_{it}}{N_t} \tag{16}$$

where $Tsent_t$ represents the weekly sentiment at time t, $Sent_{it}$ represents the sentiment score of message i posted at time t, and N_t denotes the number of messages posted at time t. The sentiment index ranges from –1 to 1, in which –1 is considered extremely pessimistic, 1 is considered extremely optimistic, and zero is considered neutral.

Table 1. Descriptive statistics of the series

	Sentiment	ESG return	MASI return	ESG_Vol	MASI_Vol
Mean	0.106	–0.0004	–0.0001	0.016	0.015
Median	0.097	0.0013	0.0010	0.013	0.012
Max	0.480	0.0466	0.042	0.062	0.066
Min	–0.156	–0.0973	–0.09	0.009	0.009
Relative Std. dev.	1.037	48	179	0.521	0.549
Kurtosis	3.011	8.7355	10.144	13.130	18.038
Skewness	0.727	–1.4070	–1.6622	2.9781	3.557
JB	23.158***	549.68***	831.97***	1801.2***	3609.7***
ADF	–6.64***	–13.58***	–12.80***	–4.49**	–5.34***
ARCH–LM		56.18***	50.54***		

Notes: JB represents the Jarque and Bera (1980) test for normality; ADF represents the augmented Dickey and Fuller unit root test; ARCH-LM represents Engle's (1982) ARCH-LM test. (***) and (**) denote significance at the 0.01 and 0.05 levels, respectively. Returns are calculated via the following formula: $R_t = \ln(p_t/p_{t-1})$, where p_t is the closing price of the index at time t and p_{t-1} is the closing price of the index at time $t-1$.

Source: own elaboration.

Table 1 shows summary statistics for the sentiment, return, and volatility series. The ESG and MASI returns have a negative mean, indicating that the indices are losing value on average. However, the positive mean of the sentiment series implies that investors are, on average, optimistic about sustain-

able investment. Furthermore, we note that the relative standard deviation[3] of the sentiment series is lower than that of the ESG and MASI returns, indicating that sentiment is less volatile than returns. We also notice that the returns are negatively skewed due to their negative variations. The sentiment index is positively skewed, which means that the distribution is skewed to the right due to positive sentiment variations. The kurtosis is greater in all series than in the normal distribution. The distributions are therefore non-Gaussian. The nonnormality of all variables is also validated by the Jarque-Bera normality test. All these characteristics support the adoption of the *QVAR* connectedness approach.

To verify the stationarity of the variables, we employ the ADF test. All the series exhibit stationarity, as the ADF unit root test is highly significant. Finally, the significant ARCH-LM test suggests the presence of heteroscedasticity in the return series, supporting the use of the *GARCH* model in volatility estimation.

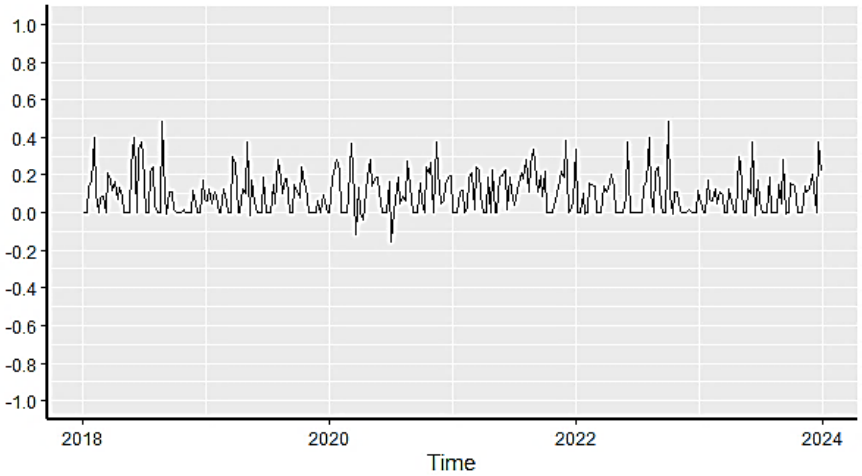

Figure 1. Dynamics of the investor sentiment index

Source: own elaboration.

Figure 1 illustrates the dynamics of the investor sentiment index. The results indicate that social media sentiment varies over time, ranging from –0.2 to 0.5. A negative value means that people are pessimistic about ESG investments, a positive value means that they are optimistic, and a zero means they are neutral. Specifically, we observe positive values most of the time, with important levels during crises, notably at the start of COVID-19, after the beginning of the war between Russia and Ukraine, and at the end of 2023,

[3] The relative standard deviation stands for the standard deviation divided by the absolute mean.

which corresponds to the Israeli-Palestinian conflict. Nevertheless, during the COVID-19 pandemic, there were a few brief periods of negative sentiment, implying that during the crisis period, negative sentiment can occur due to significant negative shocks and uncertainty (Zribi et al., 2024). However, negative shocks in sentiment are short-lived, and people quickly switch to optimistic sentiments as the crisis raises awareness of the need for sustainability-related investments.

3. Results and discussion

In this section, we examine the static and dynamic connectedness between sentiment and ESG index volatility. Table 2 shows the static connectedness at three quantiles, namely, the median ($\tau = 0.5$), the lower quantile ($\tau = 0.05$), and the upper quantile ($\tau = 0.95$).

The results show that the total connectedness index (*TCI*) is 37.42% at the median (normal market conditions), 41.06% at the lower quantile (bearish market conditions) and 64.10% at the upper quantile (bullish market conditions), which means that the *TCI* is higher under extreme quantiles than under the median, and that it is greater at the upper tail than at the lower tail. Furthermore, the findings show a significant feedback channel between ESG sentiment and volatility, particularly at the 95th quantile (where spillover effects range from 30.25% to 30.73%). This confirms that the risk in the upper tails is greater than that in the lower tails.

However, the static measurement of spillovers assumes that the coefficients of the model remain constant for the entire study period, which does not allow us to capture the structural breaks that occur because of extreme events. Moreover, numerous studies show that the impact of investor behaviour on financial markets evolves over time (El Oubani, 2022; Lekhal & El Oubani, 2020; Lo, 2004). To overcome this drawback, we re-estimate the time-varying connectedness between ESG sentiment and volatility.

Figure 2 shows the *TCI* in the time and frequency domains between investor sentiment toward sustainability, ESG index volatility, and MASI index volatility. The findings indicate that the *TCI* varies over time and depends on certain events. Indeed, notable peaks are observed in March 2020 (67%), February 2022 (66%), and October 2023 (60%), coinciding with the COVID-19 pandemic, the Russian-Ukrainian conflict, and the Israeli-Palestine conflict, respectively. Thus, during the crisis, the shocks created additional uncertainty, which was then transmitted to the entire system, leading to significant spillover into the system and thereby extremely high market risk. These results confirm those of Mensi et al. (2021), who argue that intense economic

Table 2. Sentiment and ESG volatility connectedness at the median, 5th quantile and 95th quantile

	Sent.	ESG	MASI	*FROM*
Panel A: Connectedness at the median				
Sent.	83.50	8.58	7.92	16.50
ESG	2.35	52.83	44.82	47.17
MASI	1.93	46.67	51.40	48.60
TO	4.28	55.25	52.74	112.27
NET	–12.22	8.08	4.14	**37.42**
Panel B: Connectedness at the 5th quantile				
Sent.	79.05	11.08	9.88	20.95
ESG	6.69	48.58	44.73	51.42
MASI	6.02	44.80	49.18	50.82
TO	12.71	55.88	54.60	123.19
NET	–8.24	4.46	3.78	**41.06**
Panel C: Connectedness at the 95th quantile				
Sent.	37.18	30.73	32.09	62.82
ESG	30.25	34.60	35.15	65.40
MASI	30.13	33.94	35.93	64.07
TO	60.37	64.67	67.24	192.29
NET	–2.45	–0.73	3.18	**64.10**

Notes: The variance decomposition is based on the *QVAR* approach, estimated at the median, lower quantile, and upper quantile, with a lag order of 1 chosen according to the Bayesian Information Criterion (BIC). The total connectedness index (*TCI*) in bold in the lower right corner is calculated via Eq. (6). The *TO*, *FROM*, and *NET* are calculated via Eq. (7), Eq. (8) and Eq. (9), respectively. The ij^{th} value is the directional connectedness from variable *j* to variable *i* and is calculated via Eq. (3). The results are expressed as percentages.

Source: own elaboration.

periods create feelings of fear and uncertainty, which results in strong spillover effects. The results also support the findings of Liu et al. (2023) that exposure to COVID-19 increases stock market volatility. Nevertheless, they do not confirm some earlier studies suggesting that companies with better ESG scores have lower stock price volatility in times of crisis, such as COVID-19 (Albuquerque et al., 2020; Broadstock et al., 2021) or that ESG stocks have a safe-haven property (Rubbaniy et al., 2022).

A decline in spillover effects was observed during stable periods coinciding with the recovery of the economy from the COVID-19 epidemic (at the end

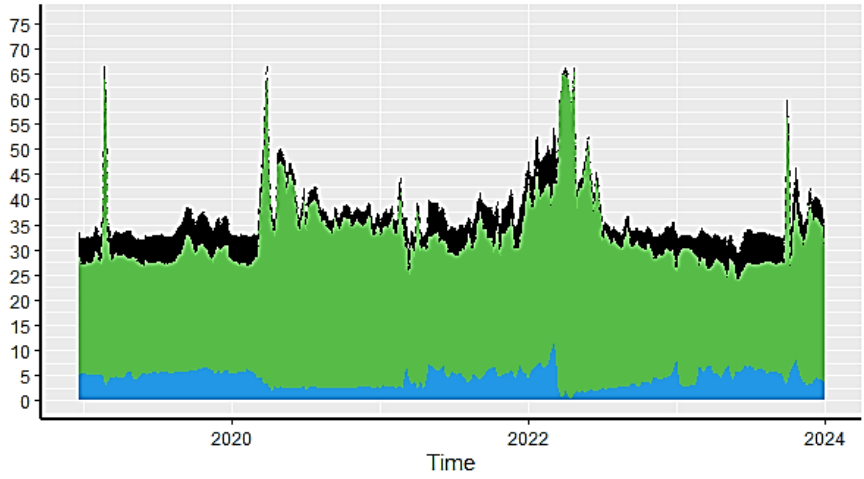

Figure 2. Short-term, long-term, and overall dynamic total connectedness

Notes: The results are estimated via the median *QVAR* model with a 52-week rolling window, a lag length of order 1 (BIC) and a generalised forecast error variance decomposition at 100 steps forward. The black area represents the time dynamic connectedness, the green area represents the long-term connectedness, and the blue area represents the short-term connectedness.

Source: own elaboration.

of 2021). This is due to lower uncertainty transmission, leading to low connectivity. Our results thus support Hypotheses 1 and 3.

To understand how the time horizon of investments can explain the origin of spillovers in the system, we investigate the frequency dynamics of connectivity. Market participants have heterogeneous expectations and therefore heterogeneous frequency responses to shocks. Ferrer et al. (2018) argue that diverse market participants have distinct goals, priorities, risk appetites and institutional constraints. While institutional investors prioritise long-term market returns, individual traders and hedge funds focus on short-term returns on assets, which results in heterogeneity in their frequency responses. Thus, asset prices, driven by fluctuations in demand involving multiple cyclical components, trigger shocks with different frequency responses, producing both short- and long-term spillovers.

The results in Figure 2 show that dynamic spillovers are induced by heterogeneous frequencies, in line with investors' heterogeneous perceptions and preferences. Nevertheless, spillovers are driven mainly by the long-term component, as they are concentrated at low frequencies, implying that the connectivity between ESG sentiment and volatility occurs mainly in the long term. These results are consistent with the fact that volatility connectedness is generally more persistent than return connectedness is (Wan et al., 2024; Wei et al., 2022), and that volatility often shows strong persistence, which is

a stylised fact in financial markets. This characteristic was more pronounced during the COVID-19 epidemic and during the Russian-Ukrainian and Israeli-Palestinian conflicts. This can be explained by the fact that investors react very slowly to news, due to the important level of uncertainty during the crisis period, resulting in the shock being transmitted over a longer period and hence longer-term spillover effects. These results are consistent with those of Baruník and Křehlík (2018). They also align with the results of Wan et al. (2024), according to which attention to ESG has a significantly positive effect on the *TCI* of volatility in the low-frequency domain, suggesting that high attention to ESG results in strong volatility connectivity in the long term. These findings support Hypothesis 4.

To focus on the relationship between investor sentiment and ESG index volatility, we calculated the net pairwise spillover effect between these variables. The results in Figure 3 show a feedback channel between sentiment and ESG index volatility, in which investor sentiment toward sustainability acts as a net receiver of ESG volatility shocks most of the time, but becomes a net sender of shocks during certain periods. Interestingly, the net reception of shocks by investor sentiment is more pronounced during periods of extreme events, namely, the COVID-19 health crisis and geopolitical crises such as the Russian-Ukrainian and Israeli-Palestinian conflicts, suggesting that during these periods, shocks in the ESG index volatility prompt investors to pay

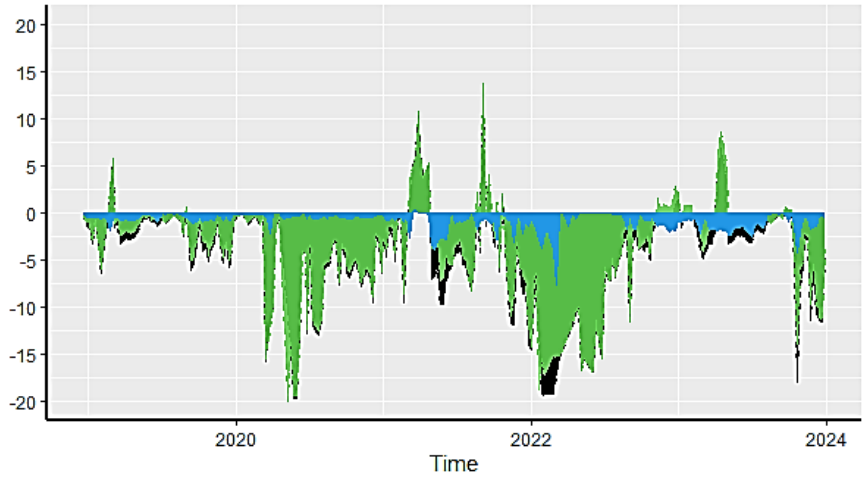

Figure 3. Short-term, long-term, and overall dynamic net pairwise connectedness between sentiment and ESG index volatility

Notes: The results are estimated via the median *QVAR* model with a 52-week rolling window, a lag length of order 1 (BIC) and a generalised forecast error variance decomposition at 100 steps forward. The black area depicts the time dynamic connectedness values, whereas the green and blue areas represent the long-term and short-term connectedness values, respectively.

Source: own elaboration.

more attention to what is being said about sustainable investment in social media. This finding is in line with that of Wan et al. (2024), who found that the level of attention given to ESG has risen sharply since 2020, implying that ESG attention has been strongly influenced by the pandemic. The high attention given to ESG investing can generate shocks in sentiment and therefore encourage more investors to include ESG stocks in their portfolios, leading to significant movements in ESG index returns, with sentiment thus becoming a net sender of shocks to ESG market volatility. This validates the conclusions reached by Li et al. (2023), who emphasised that investor panic caused by the COVID-19 epidemic is a possible trigger for risk spillovers in the stock market. Our findings also validate those of Liu et al. (2022), who found that ESG sentiment is positively related to the volatility risk premium, particularly the impact of environmental and social factors. Nevertheless, these results are not consistent with those of Dhasmana et al. (2023), who found that investor sentiment does not affect the ESG index in the Indian context, nor with those of Boubaker et al. (2022), who showed that responsible investment improved companies' resilience to the negative shocks of the COVID-19 health crisis. Therefore, our results confirm Hypothesis 2.

Like the total connectedness index, the net pairwise spillovers between ESG sentiment and volatility are also concentrated at low frequencies. This suggests that this interconnection is driven mainly by long-term fluctuations, indicating that markets do not react quickly to change. This observation is in line with the findings of El Oubani (2024), who found that the connectivity between ESG sentiment and volatility is due mainly to the long-term component. It also highlights the prevalence of strong risk aversion, an inherently unstable financial market, and a significant level of uncertainty, as confirmed by Baruník and Křehlík (2018). Together, these elements lead to slower shock transmission and more persistent investor reactions to these shocks. Consequently, these findings also validate Hypothesis 4.

To examine the dynamic connectedness between investor sentiment and ESG index volatility under different market conditions, we utilise the quantile connectedness approach of Ando et al. (2022). The empirical results in Figure 4 show that the *TCI* is stronger in the upper quantiles than in the other quantiles. This phenomenon can be attributed to investors' tendency to overreact to extreme shocks in the ESG market, as shown by previous studies (Dhasmana et al., 2023; Guo & Shi, 2024; Yang et al., 2024). Notable episodes include the COVID-19 health crisis in the first part of 2020 and the war between Russia and Ukraine in 2022, which caused disruptions in the supply of oil and other raw commodities. This means that periods of crisis are accompanied by high volatility and therefore high connectivity in the system, indicating high market risk. This contradicts some views that regard ESG stocks as safe havens (Rubbaniy et al., 2022). Importantly, investing in ESG stock indices does not protect against the risks that financial markets confront uniformly,

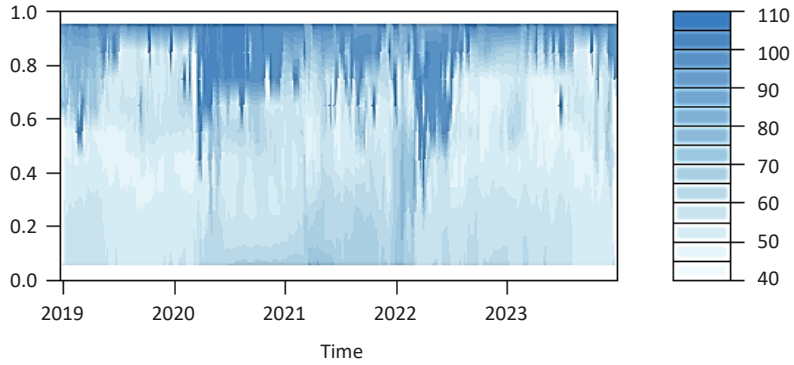

Figure 4. Quantile total connectedness between sentiment and volatility

Notes: The results are estimated via the median *QVAR* model with a 52-week rolling window, a lag length of order 1 (BIC) and a generalised forecast error variance decomposition at 100 steps forward. Warmer shades on the graph reflect greater levels of connectedness.

Source: own elaboration.

as their performance and volatility can be affected by a variety of extreme events (Chen & Lin, 2022). This encourages investors to implement effective risk management measures when investing in ESG markets, and to proactively hedge against potential shocks.

Now, we concentrate the analysis on the pairwise connectivity between sentiment toward sustainability and ESG volatility under different market conditions. On the basis of Figure 5, the estimation results show that investor

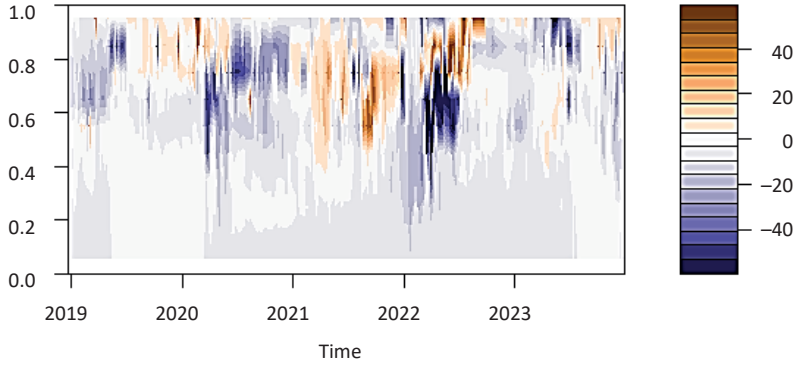

Figure 5. Quantile net pairwise connectedness between ESG sentiment and volatility

Notes: The results are estimated via the median *QVAR* model with a 52-week rolling window, a lag length of order 1 (BIC) and a generalised forecast error variance decomposition at 100 steps forward. Warmer shades indicate net-transmission.

Source: own elaboration.

sentiment transmits shocks to ESG index volatility mainly in the upper quantiles, implying that the impact of investor sentiment on ESG index volatility is more pronounced during positive extreme market conditions. In line with our previous results, the most notable events are the COVID-19 epidemic and the war between Russia and Ukraine, both of which are characterised by uncertainty and therefore high volatility. Indeed, media-generated panic during crisis periods is associated with increased market volatility (Haroon & Rizvi, 2020). These results are consistent with those of Naeem et al. (2020), who reported that investor sentiment plays a leading role in stock market volatility. These findings corroborate Hypothesis 5 and suggest that sentiment could be used to predict ESG volatility in the Moroccan stock market, particularly in the upper quantiles, to achieve abnormal returns. Consequently, investors need to make timely adjustments to their ESG portfolios on the basis of investor sentiment. Policymakers also need to consider extreme positive tails when making regulatory decisions.

4. Robustness tests

We complete our analysis by conducting some robustness tests on our results. First, we focused our analysis on social media sentiment to capture investors' attention to sustainability. However, this could be biased in terms of representing a broader investor population. To diversify the data sources and confirm the robustness of our results, we use online search attention as an alternative to social media sentiment. Second, we consider whether our findings differ if we change certain parameters of the *QVAR* method. The analyses are repeated to check whether the same results are obtained.

4.1. Online search attention and ESG volatility

Following Da et al. (2011) and Duc et al. (2024), we employ the Google Volume Search Index (*GVSI*) using sustainability-related terms obtained via Google Trends, to assess investors' attention to ESG investing. In fact, the *GSVI* for the topic "Environmental, social and governance criteria"[4] in Morocco is used. Next, an abnormal *GSVI* (*AGSVI*) is calculated via the following formula:

[4] To check the robustness of the results, other keywords closely related to sustainable investment were used. However, the results for these keywords were not significant.

$$AGSVI_t = \frac{Weekly\,GSVI_t}{Mean_t^{24}} \tag{17}$$

in which $Mean_t^{24}$ is the 24-week moving average before time t.

We then test the dynamic interplay between investor attention to ESG, captured by online search intensity, and ESG volatility via the *QVAR* approach. The results reported in Figure 6 are consistent with those observed when we consider social media sentiment. This confirms the relevance of using social media sentiment to track people's attitudes toward sustainability.

4.2. Changes in the *QVAR* parameters

To check the robustness of the method used in this study, we re-estimate the connectedness between ESG sentiment and volatility via the *QVAR* with the modification of certain parameters such as the forecast horizon, the rolling window size, and the model selection criterion. The results presented in Figure 7 show consistency between the results when the forecast horizon, the rolling window size, and the model selection criterion are modified in the *QVAR* method, implying that the choice of these parameters does not significantly affect the conclusions of the baseline study.

5. Study implications

The outcomes of the study are beneficial for pro-ESG investors, companies, and policymakers. The results suggest that investors should consider what is posted on social media when investing in the ESG market to strategically manage their portfolios, as social media sentiment influences returns and risks in this market. This can help investors build profitable investment strategies, such as momentum strategies (Lekhal & El Oubani, 2020). Indeed, investors systematically exaggerate ESG information disclosed by companies, leading to ESG momentum effects in financial markets that can translate into substantial short-term profits (Chen & Yang, 2020). Additionally, the results help investors manage their ESG portfolios in times of crisis by considering arbitrage opportunities. In fact, we find that sentiment amplified long-term risk in the ESG market during the COVID-19 pandemic because sentiment transmitted persistent shocks to volatility. This finding is confirmed in the US, Europe and emerging markets, where the panic index induced by the COVID-19 pandemic had a significant effect on ESG volatility (Umar et al., 2021). However, this finding does

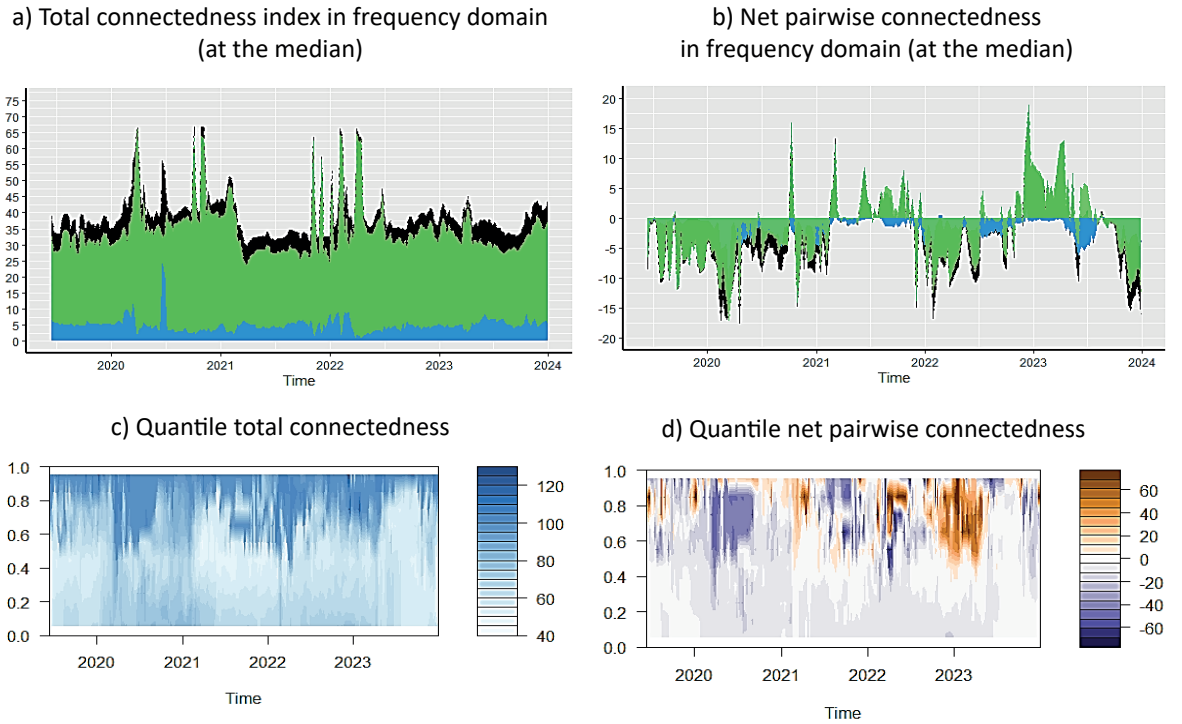

Figure 6. Spillover effects between online search attention and ESG volatility

Notes: The results are estimated via the *QVAR* model with a 52-week rolling window, a lag length of order 1 (BIC) and a generalised forecast error variance decomposition at 100 steps forward. In *a* and *b*, the black area depicts the time dynamic connectedness, whereas the green and blue areas represent the long-term and short-term connectedness, respectively. Warmer shades reflect greater levels of connectedness in *c*. Warmer shades indicate net-transmission in *d*.

Source: own elaboration.

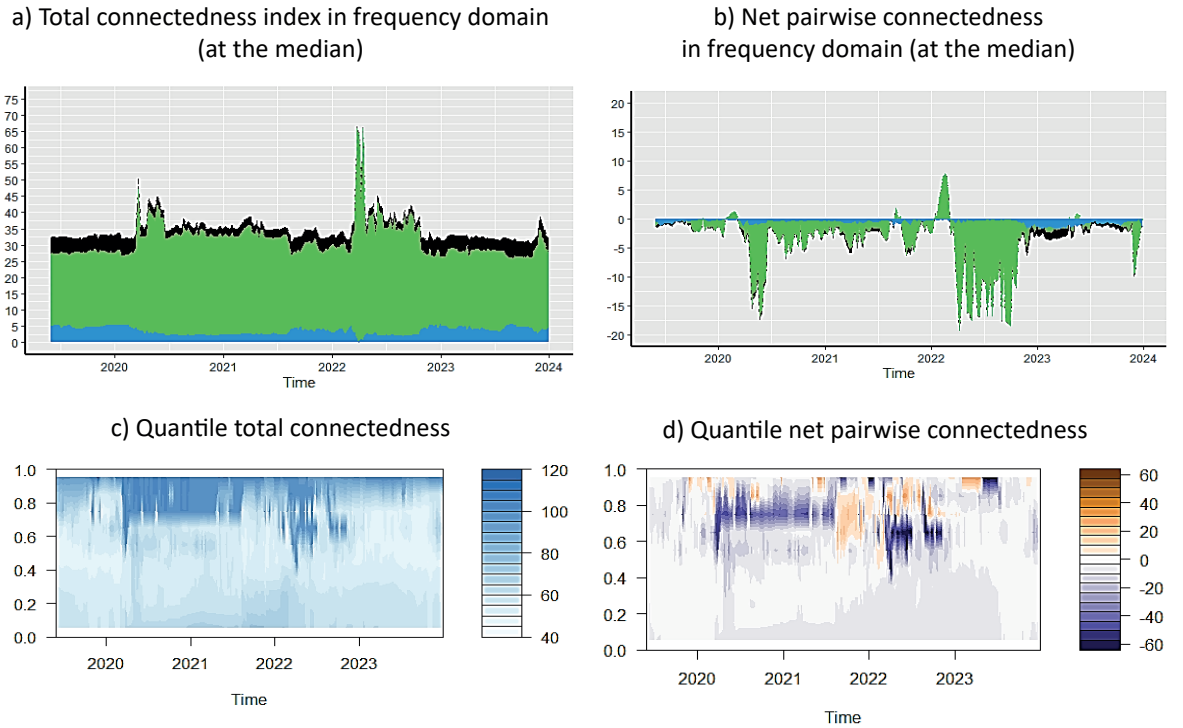

Figure 7. Spillover effects between ESG sentiment and volatility

Notes: The results are estimated via the *QVAR* model with a 100-week rolling-window size, a lag length of order 1 (AIC), and a generalised forecast error variance decomposition at 200 steps forward. In *a* and *b*, the black area depicts the time dynamic connectedness, whereas the green and blue areas represent the long-term and short-term connectedness, respectively. Warmer shades reflect greater levels of connectedness in *c*. Warmer shades indicate net-transmission in *d*.

Source: own elaboration.

not agree with the findings of Liu et al. (2023), according to which strong ESG performance contributed to enhancing stock market stability in Japan during the COVID-19 pandemic. Consequently, the extent to which sentiment influences decision-making and therefore market risk depends on cultural differences. This enables investors to take advantage of cultural differences by using arbitrage strategies. In this context, Naeem et al. (2023) found that the COVID-19 outbreak generated arbitrage opportunities in the ESG markets of the US, Latin America and Asia-Pacific region, but not in Europe. It is therefore important to consider the specific characteristics of each market when investing in ESG indices. Furthermore, our results enable investors to detect under which market conditions sentiment can strongly predict movements in ESG markets. We find that in times of health or geopolitical crisis, the spillover effects between sentiment and volatility are greater in the upper quantiles than in the other quantiles, suggesting that profitable trading strategies can be conceived in such times to exploit the large price movements triggered by sentiment.

Furthermore, our results suggest that companies should consider sentiment when communicating their ESG performance. In fact, financial performance depends not only on a company's ESG score, but also on investor sentiment, particularly during turbulent events. Specifically, the findings show that sentiment influences volatility, notably during the COVID-19 health crisis and geopolitical crises such as the Russian-Ukrainian and Israeli-Palestinian conflicts. This could be explained by the fact that uncertainties prevailing in such periods make investors more sensitive to environmental and social risks, leading to a shift in investor attention from traditional investing to ESG investing and therefore to greater trading activity in the ESG market, which could cause significant fluctuations in stock prices. However, this greater attention might make it easier to raise funds in the market.

As far as regulators are concerned, the results suggest that they should strengthen communication on sustainability guidance, and use social media to draw investors' attention to ESG, particularly during periods of crisis such as the COVID-19 pandemic. This could be a signal to the government to encourage a green recovery in times of crisis, promoting ESG practices and thus fostering sustainable economic growth (Liu et al., 2023). In other words, the government should focus on leveraging the pandemic crisis to advance climate activism, develop a circular economy, and move toward resilient social and economic models capable of resisting disasters and infectious diseases (Taghizadeh-Hesary & Rasoulinezhad, 2023), thereby achieving UN's objectives. However, the strong connectedness observed between sentiment and volatility, particularly during extreme events, increases risk in the ESG market and makes it inefficient and unstable. In this context, policymakers should implement measures and regulations that encourage investors to undertake long-term investment instead of engaging in speculation that causes market instability and inefficiency. In addition, the implementation of standard

frameworks and guidelines for ESG reporting might improve transparency and comparability between companies, providing investors with trustworthy information on companies' environmental and social performance, thereby facilitating better decision-making and lowering market volatility (Liu et al., 2023). In fact, ESG commitments contribute to strengthening public confidence in a company, providing the prospect of significant protection against losses in times of crisis. Lins et al. (2017) asserted that ESG advantages are not constant over time, but are linked to the general level of confidence in companies and financial markets, and that these advantages tend to be greater when confidence is at its lowest. Furthermore, stock exchanges need to strengthen ESG disclosure requirements to enable investors to make informed decisions and reduce the market uncertainty that prevails in times of crisis.

Conclusions

The aim of this study is to examine the dynamic interplay between investor sentiment toward sustainable investment and the volatility of the ESG index in the Moroccan financial market. To this end, we constructed an investor sentiment index from the X platform (Twitter) and used *GARCH*-based ESG index volatility derived from weekly returns, as well as quantile and frequency connectedness approaches. The results show that the spillover effects between investor sentiment and ESG index volatility evolve over time, depending on distress events like the COVID-19 health crisis and geopolitical crises. Moreover, most of the time sentiment acts as a net receiver of shocks from ESG market volatility, mainly in times of crisis, but sometimes becomes a net sender of shocks. Furthermore, the results reveal that long-term spillovers dominate short-term spillovers, particularly during extreme events, implying the persistence of shock transmission due to high uncertainty. Finally, we observe that connectedness is stronger in the upper quantiles than in the middle or lower quantiles, suggesting the impact of extreme positive market conditions on spillover effects between ESG sentiment and volatility.

We investigated the connectedness between investor sentiment and the volatility of the ESG index in Morocco, but it would also be interesting to examine this connectedness across different developed and emerging countries. Additionally, it would be highly representative to use different ESG sentiment proxies, or to construct an aggregate ESG sentiment index combining the most relevant sentiment indicators. Moreover, it would be particularly useful to measure how sentiment expressed in social media improves the predictability of returns and the volatility of the ESG market. These questions could provide important directions for future research.

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CEO pay ratio versus financial performance in Polish public companies

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Abstract

In this paper, we aim to investigate the relationship between CEO pay ratio and corporate financial performance in Polish public companies. Using a sample of 259 companies listed on the Warsaw Stock Exchange, we demonstrate that links between the pay gap and accounting measures of performance differ from market ones. Our findings indicate a negative correlation between CEO pay ratio and return on sales. This implies that companies pay executives less during periods of high profitability, possibly to avoid the negative impact of excessive pay on firm performance. We also discover that the pay gap, measured by CEO pay ratio, is positively linked with Tobin's *Q* and annual stock returns. A high CEO pay ratio signals strong incentives for top executives to perform, potentially leading to better strategic decisions and, consequently, higher Tobin's *Q* ratios and annual stock returns.

Keywords

- executive compensation
- pay disparities
- corporate governance
- financial performance

JEL codes: G32, G38, M52.

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Introduction

Over the past 40 years, the richest 1% of the world's population income share has increased from 16% to about 21%, while the middle-class share has decreased from 64% to 61% (Alvaredo et al., 2018). In terms of income, it is becoming increasingly difficult to advance to the group of extremely rich, while it is becoming easier and easier to fall below the level of wealth already gained (Mroczek-Dąbrowska & Shemesh, 2020). At the same time, corporate boards overseeing the operations of the biggest publicly quoted companies in the US are granting excessive compensation packages to their top executives, who have experienced a significantly greater growth rate compared to the stock market and the remuneration received by average workers, college graduates, and even individuals within the top 0.1% income bracket (Bivens & Kandra, 2022). The CEO-to-average-employee remuneration ratio rose from 20:1 in the early 1960s (Bivens & Kandra, 2022) to 399:1 in 2021 (D'Mello et al., 2024). Ineffective remuneration policies for chief executives in financial services institutions have been noted as one of the reasons of the recent financial crisis. They encouraged risky decisions focused on short-term results, which guaranteed high bonuses for management (Kirkpatrick, 2009). In US Dodd-Frank Wall Street Reform and Consumer Protection Act passed in the aftermath of the 2008 financial crisis states that the company should disclose information on the relationship between the executives' current remuneration and the company's financial performance as measured by changes in the company's share price including dividends. The company should additionally disclose: (a) the median annual remuneration of all employees of the company except for the CEO (or equivalent), (b) the total annual CEO remuneration (or person in equivalent position), (c) the ratio of the amount described in clause (a) to the amount described in clause (b) (Act, 2010). European measures differ primarily because of the form of the regulation. While remuneration regulations in the United States take the form of laws, in Europe they are primarily recommendations incorporated into national codes of good practice.

As far as theory is concerned, the pay gap is explained by two alternative models, tournament theory and equity fairness. These two theoretical approaches offer different explanations for the wage differential. Tournament theory assumes that wage disparities improve the company's performance because they encourage employees to be promoted (Lazear & Rosen, 1981). To promote motivation throughout the organizational structure, the reward at every stage of the tournament ought to rise, with an additional award for the general winner (i.e., the CEO) (Rosen, 1986). The other theory suggests that wage differences are detrimental to the company because they foster feelings of inequality, deprivation and reluctance among employees, which

can lead to decreased effort or cooperation (Akerlof & Yellen, 1988; Edmans, Gosling et al., 2023). Adams (1963) posits that the attitudes and behaviors of individuals are influenced by the process of comparing rewards with those of others. The prestigious CEO awards play a significant role as a benchmark that influences employees' reactions to their own remuneration when making these comparisons (Wade et al., 2006).

Though, the empirical research does not allow for a clear understanding of wage inequalities at company level. The authors dealing with this issue in their publications focused mainly on examining the impact of wage disparities on the company's financial results (Dittman et al., 2023; Fan et al., 2019; Imai, 2017; Rouen, 2020) or the staff productivity (Bao et al., 2020; Chi et al., 2018). So far, the empirical research has mainly concerned companies operating in the USA (Rouen, 2020) and China (Fan et al., 2019). There are very few papers on Germany (Dittman et al., 2023) and the UK datasets (Imai, 2017), a fact that can be explained by the lack of a European equivalent to the US Dodd-Frank Wall Street Reform and Consumer Protection Act, which explicitly requires the disclosure of remuneration and the structure of remuneration.[3] However, there are numerous studies (Andres & Aperte, 2018; Duffhues & Kabir, 2008; Khenissi et al., 2022) examining the relationship between executive pay and firm performance in Western European settings, but very few on Central and Eastern Europe (Haid & Yurtoglu, 2006; Mäkinen, 2007; Sajnóg & Rogozińska-Pawełczyk, 2022). Our paper adds to the existing research in multiple ways. First, we analyse wage discrepancies on the Polish capital market. Existing papers focus on compensation. Furthermore, we expand current evidence on the effect of profitability on the CEO pay ratio that to date has focused on the US market. Our findings demonstrate that pay equity is associated with accounting performance measures, as well as the link between executive remuneration and market valuation.

The remainder of this paper is organised as follows: Section 1 provides hypothesis development. The research methodology and data are presented in Section 2. The analysis of the empirical results is included in Section 3, while last Section concludes the paper.

[3] The European Corporate Governance Forum's statement on directors' remuneration (https://ec.europa.eu/commission/presscorner/detail/en/IP_09_459), as well as the amendments to the German Corporate Governance Code, the Government Commission (https://www.ecgi.global/sites/default/files/codes/documents/220627_german_corporate_governance_code_2022.pdf), the UK Corporate Governance Code (https://www.frc.org.uk/library/standards-codes-policy/corporate-governance/uk-corporate-governance-code/) and Best Practice for GPW Listed Companies (https://www.gpw.pl/pub/GPW/files/DPSN2021_EN.pdf), are the only recommendations on remuneration policy for managers in Germany, UK and Poland.

1. Hypothesis development

The level of compensation and wage disparities at the company level have been extensively debated in management science, human resources, and corporate finance. Studies in the first stream deal with organisational decision-making. According to Yanadori and Cui's (2013) research, wage disparities in R&D teams have a negative impact on company innovation. However, the study was restricted to high-tech companies and concentrated on horizontal rather than vertical wage disparities. Similarly, Chan et al. (2020), referring to Pay Equity Theory, find a negative link between R&D efficiency (R&D efficiency is defined as the percentage increase in revenue from a one-percent increase in R&D spending) and CEO-employee pay gaps, implying that larger pay gaps reduce employee motivation and effort.

Human Resources scholars also examine the CEO pay ratio frequently. Chi et al. (2019) argue, in reference to Tournament and Income Comparison theories, that a larger pay gap has a greater impact on employee productivity than a smaller pay gap. Moreover, they discovered that the link between pay gap size and employee productivity is nonlinear. The rate of productivity growth decreases as the pay gap widens. According to Bao et al. (2020), the degree of management entrenchment and involvement in high-tech industries determines the negative indirect impact of pay inequality on firm performance via employee satisfaction.

The third perspective on the CEO pay ratio relates to corporate finance. Drawing on classical economic theory, Lei (2017) suggests that a high CEO-to-worker pay ratio can be explained by CEO bonus-taking, which raises credit risk, or efficient labour cost management, which lowers credit risk. Overall, the findings of his study indicate that a larger gap between CEO and employee compensation correlates with a reduced cost of debt (a higher likelihood of a credit rating upgrade). This relationship is more pronounced for labour-intensive firms than for capital-intensive firms and weakens as the growth rate of average employee compensation increases; this suggests that credit investors include information regarding the efficacy of labour cost management into their risk assessment of the CEO-employee pay gap. Furthermore, when CEO compensation increases substantially, the negative correlation between the change in the cost of debt and the change in CEO-employee pay disparity is diminished (Lei, 2017). Rouen (2020), referring to Tournament theory, observes no correlation between the pay ratio and firm accounting performance as measured by the industry-adjusted return on net operating assets. Cheng et al. (2017) also refer to Tournament theory, arguing that the CEO pay ratio is positively related to firm value and firm performance (measured by ROA) one year ahead. They also note that firms with high CEO pay ratios are more likely to make value-enhancing acquisitions, arguing that high-income

CEOs make better acquisition decisions. According to these authors, an average-high CEO pay ratio is not a symptom of weak corporate governance and excessive profit-making by CEOs. They claim that their results support the notion that high CEO pay ratios are a consequence of market competition for limited director talent (Cheng et al., 2017). Similarly, Uygur (2019) finds that the pay ratio and firm performance are positively related, but only in the case of highly skilled CEOs. At the same time, the sensitivity of pay-performance diminishes when CEOs with low abilities receive excessive compensation. In their recent study referring to pay equity theory, Dittman et al. (2023) also claim that firms with high pay inequality exhibit a higher return on assets than firms with low pay inequality.

Existing literature has mainly focused on US datasets. Furthermore, due to the fact that CEO pay ratios do not have to be disclosed in Europe, the empirical analyses performed on European datasets concentrate on links between CEO compensation (not CEO pay ratio) and performance. Sajnóg and Rogozińska-Pawełczyk (2022), building on agency theory, indicate that there is a positive relationship between higher CEO compensation and the financial performance in companies listed on the Polish Stock Exchange. Duffhues and Kabir (2008), who examined whether executive pay on the Dutch market reflects company performance, concluded that there is a negative association between pay and financial performance, explaining that influential directors can influence their own compensation. Mäkinen's study (2017) finds no evidence of a relationship between changes in CEO remuneration and changes in ROA in Scandinavian countries. However, lagged measures of accounting and stock market firm performance are linked with a change in total CEO remuneration. He also argues that foreign ownership is positively and statistically significantly related to remuneration levels. The study by Raithatha and Komera (2016) suggests that Indian company performance, as measured by accounting as well as market measures, significantly influences executive remuneration; however, they also note a lack of association between remuneration and performance among smaller sample firms and firms associated with business groups.

To the best of our knowledge, links between CEO pay ratio and financial performance of Polish public companies have not been studied yet. As noted above, many studies focus on examining CEO pay ratio in the US context, but the results are not conclusive. Research conducted on datasets from Europe primarily investigates CEO compensation rather than the CEO pay ratio. This pay ratio, which focuses on the relationship between CEO and employee pay, raises the issue of salary stratification, highlighting a fundamental difference between the two. Therefore, we put forward the following hypothesis: *There is a positive relationship between the CEO pay ratio and the financial performance of Polish listed companies.* Investigating this relationship in the Polish context will help fill a gap in the literature and provide practical guidance for compensation and management policies in Polish companies.

2. Methodology and data

Existing literature has demonstrated that there is a wide range of factors that affect wage dispersion in public companies. In our study, we want to capture wage dispersion linked to various types of profitability. The general form of our estimations can be summarised as follows:

$$CEO\ pay\ ratio = a_0 + a_1\ Perf_{it} + a_2\ Size_{it} + a_3\ Leverage_{it} \quad (1)$$

The dependent variable is the CEO pay ratio. Initially, the intention was to construct this ratio by dividing the CEO's compensation by the average employee compensation within the company. However, due to the lack of reliable data regarding the number of employees in each company in our database, we needed to construct an alternative version of CEO pay ratio that could serve in place of unavailable variable. In order to solve this problem and to estimate the average annual employee compensation for each company in the sample, we used the average sectoral[4] salary in the Polish economy, a similar approach proposed by Uygur in his research (2019), which used the average hourly salary of employees for each industry as the average salary of employees. This data was obtained from Statistics Poland, which provides publicly available information on average sectoral salaries. The next step involved determining CEO compensation. The CEO was identified as the director explicitly designated as such in the company's financial statements. CEO compensation data was manually collected from published annual financial statements. Whenever possible, the components of CEO compensation included salary, bonus, restricted stock grants, option grants, and long-term incentive payments. It is important to note that due to the lack of standardized reporting practices for CEO compensation data, it was often challenging to precisely identify the specific components included in the reported compensation, as they were typically presented as a single aggregated figure under the label "compensation." Based on the data described above, we calculated the CEO pay ratio in the following way:

$$CEO\,pay\,ratio\ = \frac{CEO\,pay}{Average\ sectoral\ salary\ in\ the\ Polish\ economy} \quad (2)$$

The explanatory variable of primary concern is the financial performance of the firm (Perf). In our paper, like Rouen (2020), Mäkinen (2007), Raithatha and Komera (2016), Sajnóg & Rogozińska-Pawełczyk (2022), we consider both accounting-based and market-based profitability measures.

[4] PKD code classification.

The application of these two approaches is motivated by their differences. Accounting measures, derived from a company's financial records, offer insights into its historical financial position and performance (Mäkinen, 2007). Market measures convey the market's perception of a company's value, providing real-time insight into current market sentiment and expectations regarding the company's future prospects (Rouen, 2020).

The first accounting measure is industry-adjusted return on net operating assets (Adj RNOA). We chose this measure over simple return on assets (ROA) because it provides a more accurate picture of a company's profitability compared to other companies in the same industry (Rouen, 2020). The second accounting measure is return on sales (ROS), which is defined as operating profit divided by total sales (Duffhues & Kabir, 2008). Lastly, the third accounting measure is change in sales, which represents sales growth (Cheng & Zhang, 2023; Mo et al., 2018). For market measures, we first used annual stock return (RET), which is a purely market measure (Duffhues & Kabir, 2008; Gibbons & Murphy, 1990; Rouen, 2020). The second market measure is the Tobin's *Q* ratio (Duffhues & Kabir, 2017). This is a hybrid measure based on both accounting and market perspective, defined as the ratio of the market value of common equity and the book value of debt to the book value of total assets. These five variables serve as proxies for corporate financial performance and are widely used in studies focusing on corporate performance.

Additional variables controlling the company's internal situation are consistent with existing research. We account for firm size, which is defined as the natural logarithm of total assets (Size). Many studies of compensation show that executives of larger firms receive relatively higher compensation (Zhou, 2000). Next, we account for debt, which is scaled by total assets. Debt holders closely monitor management actions, which can reduce excessive executive pay (Admati et al., 2018). However, higher leverage can also increase the firm's risk, thereby necessitating higher compensation. In Table 1, we present all the financial measures used in the study.

We use data for 259 companies listed on the Warsaw Stock Exchange as of December 31, 2019. The raw data sample consists of 449 firms; however, we exclude all financial institutions and enterprises that do not report CEO compensation. Our sample period is 2015–2019, and we winsorise the financial data at the 1/99 percentile level to remove outliers. Financial information for all companies is sourced from the Orbis database. CEO compensation data for the entire period are manually collected from companies' annual reports and Internet sources. Average workers' compensation was gathered from Statistics Poland.

Average value of CEO pay ratio is 19.961, which means that CEOs earned on average almost 20 times more than their employees. In Figure 1, we present the average CEO pay ratio for the research period.

Table 1. Definition of the variables

Variable	Formula	Data	Reference
Dependent variable			
Proxy CEO pay ratio	CEO pay / Average sectoral salary in Poland	hand collected	Uygur (2019)
Independent variables			
RNOA	operating income x (1 – tax rate))/((total assets – total cash) – (total liabilities – total debt)) – median two digit SIC code RNOA	Orbis database	Rouen (2020)
Q	ratio of the sum of market value of common shares and book value of debt to book value of total assets	Orbis database	Duffhues & Kabir (2008)
ROS	operating earnings over total sales	Orbis database	Duffhues & Kabir (2008)
Sales Change	the percentage difference in sales revenue between one year and the previous year	Orbis database	Mo et al. (2018); Cheng & Zhang (2023)
RET	annual stock return	Orbis database	Rouen (2020); Duffhnues & Kabir (2008); Raithatha & Komera (2016); Gibbons & Murphy (1990)
Control variables			
Leverage	total debt to total assets	Orbis database	Martinez-Ferrero et al. (2024)
Size	natural logarithm of total assets	Orbis database	Firth et al. (2006), Farooq et al. (2023)

Source: own compilation.

The highest CEO pay ratio was 21.600 in 2016, and the lowest was 18.583 in 2019. Overall, the ratio declined slightly over the five-year period. Due to the specific design of the CEO pay ratio in our analysis, the reasons for the observed decline in the CEO pay ratio index in Poland can be attributed to slower growth in average wages in the economy, among other things. Moreover, an increase in public awareness and social pressure regarding inequality and fairness in compensation may have prompted company boards to adopt more moderate compensation for executive directors.

As we have used sectoral data, in Table 2 we present the CEO pay ratios calculated using the average salaries relevant to the specific sectors included in the Polish Classification of Activities.

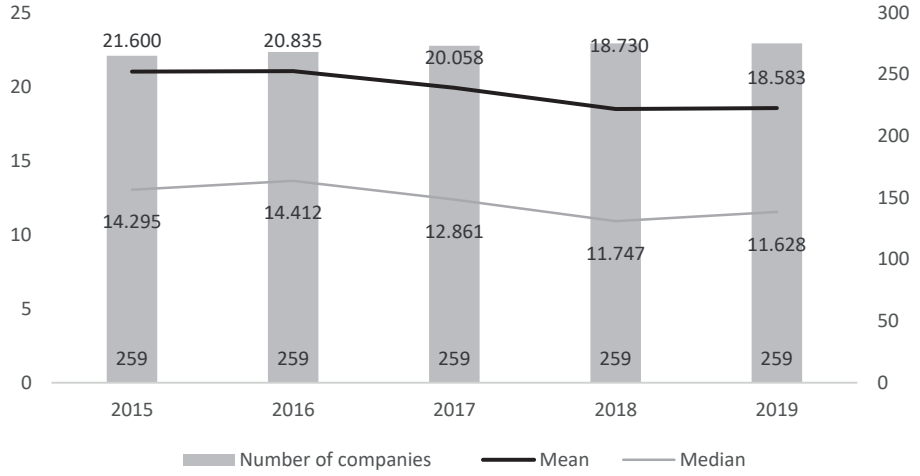

Figure 1. Summary statistics of CEO pay ratio for the sample of Polish listed firms

Source: own compilation.

Table 2. All financial measures used in the study

PKD symbol	Polish Classification of Activities	CEO pay ratio
B	Mining and quarrying	18.704
C	Manufacturing	21.559
D	Electricity, gas, steam, hot water and air conditioning supply	23.210
E	Water supply; Sewerage, waste management and remediation activities	24.817
F	Construction	27.018
G	Wholesale and retail trade; Repair of motor vehicles, including motorbikes	15.338
H	Transport and storage	18.903
I	Accommodation and food service activities	26.632
J	Information and communication	18.186
L	Real estate activities	33.355
M	Professional, scientific and technical activities	11.797
N	Administrative and support service activities	21.708
Q	Health care and social work activities	14.402
R	Arts, entertainment and recreation activities	13.117
S	Other service activities	16.379

Source: own compilation.

We can conclude that the highest wage disproportion occurred in the real estate activities and construction sectors. The lowest recorded wage disproportion was in the professional, scientific and technical activities and arts entertainment and recreation activities sectors.

In addition, in Figure 2 we demonstrate how the CEO pay ratio developed for companies listed on the WIG20 (above) and mWIG40 (below).

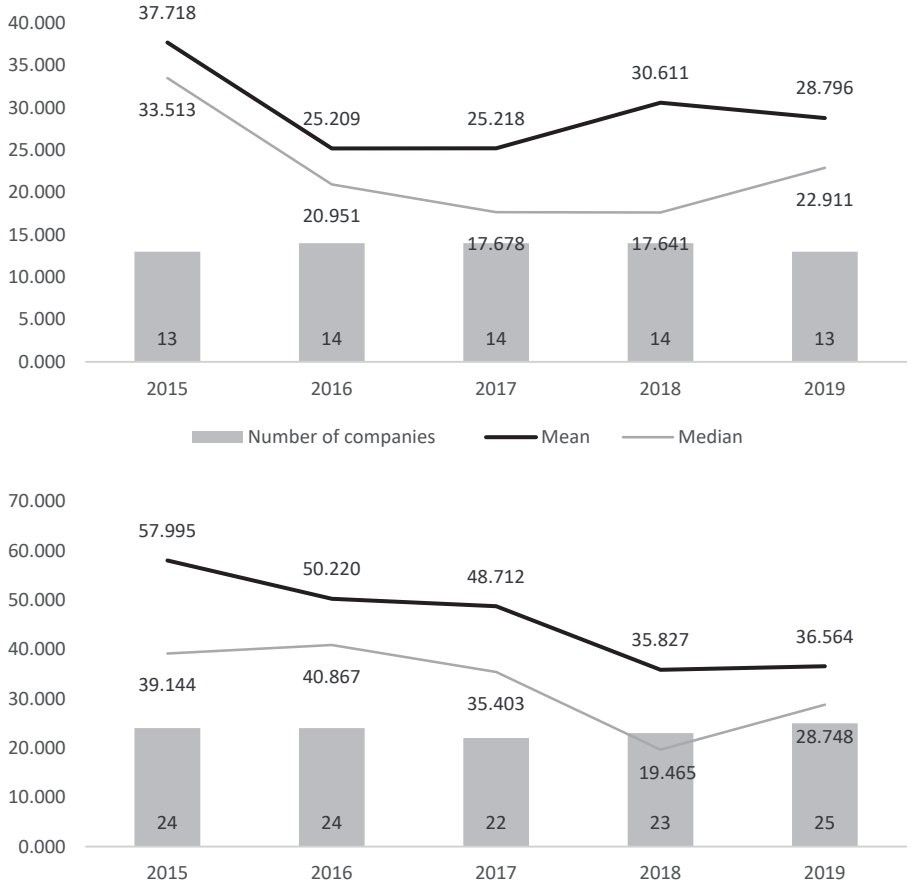

Figure 2. Yearly summary statistics of CEO pay ratio for the sample of Polish listed firms by WIG20 (above) and mWIG40 (below)

Source: own compilation.

In the case of companies included in the WIG20 and mWIG40 indices, the average CEO pay ratio stood at 29.400 for the WIG20 index, and 45.822 for the mWIG40 index. Such a significant difference between the indicated indices and the entire research sample results mainly from the concentration of the largest Polish companies in the mentioned indices, where CEOs

manage much larger assets, which most likely entails higher remuneration. Descriptive statistics of the main variables are presented in Table 3. Notably, we had anticipated that companies in the WIG20 would have a higher CEO pay ratio than those in the mWIG40. However, our research sample does not include companies from the financial sector, which, on average, repre-

Table 3. Summary statistics

Stats	***N***	**Mean**	**SD**	**Median**	**Min**	**Max**
CEO pay ratio	1295	19.961	21.790	12.859	0.348	131.446
RNOA	1295	0.046	0.177	0.051	–1.027	0.722
Q	1293	0.375	1.556	0.004	–0.985	11.415
ROS	1295	0.035	0.212	0.038	–1.201	0.636
S.CHANGE	1294	0.076	0.256	0.046	–0.610	1.234
RET	1276	0.056	0.393	0.013	–0.705	1.396
Size	1295	11.435	1.706	11.258	8.143	16.262
Leverage	1295	0.492	0.198	0.491	0.069	1.054
Stats WIG20	***N***	**Mean**	**SD**	**Median**	**Min**	**Max**
CEO pay ratio	68	29.400	20.737	20.774	5.064	113.735
RNOA	68	0.061	0.068	0.056	–0.094	0.326
Q	68	0.747	2.813	0.010	–0.476	18.921
ROS	68	0.047	0.092	0.063	–0.250	0.336
S.CHANGE	68	0.112	0.299	0.052	–0.217	2.276
RET	68	0.032	0.327	–0.013	–0.661	0.946
Size	68	15.296	1.045	15.512	12.475	16.717
Leverage	68	0.493	0.141	0.481	0.110	0.847
Stats mWIG40	***N***	**Mean**	**SD**	**Median**	**Min**	**Max**
CEO pay ratio	118	45.822	39.366	35.201	4.027	192.365
RNOA	118	–0.084	1.487	0.070	–15.378	2.504
Q	118	0.797	2.001	0.219	–0.561	12.284
ROS	118	0.079	0.204	0.049	–1.287	0.877
S.CHANGE	118	0.114	0.334	0.067	–0.314	3.288
RET	118	0.157	0.623	0.081	–0.631	5.024
Size	118	13.375	1.106	13.457	9.566	15.857
Leverage	118	0.491	0.177	0.501	0.100	0.878

Source: own compilation.

sent 30% of the entire WIG20 index. Furthermore, there were companies in the mWIG40 where the CEO pay ratio exceeded 100.[5] We divided them into presentations of total data for the entire research sample and then distinguished the same data for companies included in the WIG20 and companies included in the mWIG40.

The variables based on book values, namely RNOA, ROS, and S.CHANGE, indicated positive values, which signify the relatively stable financial situation of the companies included in the research sample. However, it should be noted that the standard deviation for this group of variables ranges from 0.177 to 0.256, indicating significant dispersion in these results. The separation of the aforementioned variables for the WIG20 and mWIG40 indexes did not bring significant changes—the ratios, except for RNOA, were only slightly higher in the case of mWIG40 than in the case of the entire research sample.

A Tobin's *Q* ratio value of 0.375 indicates that the market value of the companies' assets is significantly lower than their book value. Such a situation may suggest that investors did not see much growth potential for the companies or that the assets were undervalued in the market. It should be noted that when we divide the research sample into subsamples including companies belonging to the WIG20 and mWIG40, the results undergo a significant change. In the case of WIG20, the Tobin's *Q* ratio is 0.747, while for mWIG40 it is as high as 0.797. A value of the ratio close to 1 means that the market value of the company is equal to its net book value of assets. This may suggest that investors have more confidence in the companies in these indices, recognizing that assets are appropriately valued relative to their book value.

The annual stock return (RET) is 0.056 with a standard deviation of 0.393. The results over that period indicate a general upward trend, while the value of the standard deviation demonstrates a high variability in the data, which is due to the varied research sample. Contrary to the *Q* index, the value of the annual stock return decreases for the WIG20 and mWIG40 subsamples.

Turning to firm characteristics, we use a logarithm of total assets as an indicator of company size. For the entire research sample, the average is 11.435 (billion PLN) and increases markedly for WIG20-only companies to 15.296 (billion PLN). Finally, the average leverage ratio for the companies included in the sample is 0.492, with a standard deviation of 0.198 and a median of 0.491. The results suggest that firms may adopt varied policies regarding the selection of financing sources. Furthermore, the factors that influence the debt and its structure could vary based on the industry of the company under consideration.

[5] Above 100 in 2015, the CEO pay ratio was for: Forte (111), Wawel (169), Comarch (192), in 2016: Forte (128), Comarch (137), Wawel (150), in 2017: Comarch (152), Wawel (146), in 2018: Comarch (128), Wawel (131), in 2019: Develia (101), Comarch (148).

3. Results

In specifications 1 to 5, we present sets of regressions that are similar except for the use of different measures of firm performance. Specification 1 uses the RNOA as the performance measure, specification 2 uses the Tobin's *Q*, specification 3 uses the return on sales (ROS), specification 4 uses the sales change (SCHANGE) and the last specification 5 is based on the annual stock return (RET). In each of these specifications, the dependent variable is CEO pay ratio and we additionally include control variables such as company size and leverage. Table 5 shows the results of the regression analysis for each specification. To test for multicollinearity among the independent variables, we create a correlation matrix, which indicates that multicollinearity among these variables is not an issue. The results are shown in Table 4.

Table 4. Correlation matrix

	RNOA	*Q*	ROS	SCHANGE	RET	SIZE	Leverage
RNOA	1.0000	–	–	–	–	–	–
Q	0.0433	1.0000	–	–	–	–	–
ROS	0.3605	0.2440	1.0000	–	–	–	–
SCHANGE	0.1741	0.0732	0.1922	1.0000	–	–	–
RET	0.1677	0.1976	0.2235	0.1541	1.0000	–	–
SIZE	0.0139	–0.2215	0.0979	0.0322	–0.0082	1.0000	–
Leverage	–0.1262	–0.3873	–0.2478	0.0287	–0.0879	0.1864	1.0000

Source: own compilation.

We use random effects for specifications 1, 2, and 5, fixed effects for specification 3 and pooled OLS model in specification 4. The decision was made using *F*-test statistics, the Breusch-Pagan test, and Hausman test. The *F*-test was employed to test the fixed effect, and the Breusch-Pagan test to check the random effect.

The regression results show that CEO pay ratio is significantly negatively related to ROS. High return on sales (ROS) may indicate operational efficiency and a company's ability to generate profits at relatively low costs. If this is the case, the disparity between executive and employee remuneration may be lower, as the achievement of high profitability may be the result of the effective actions of the company as a whole, and not just the result of individual executive actions. The negative relationship between return on sales and CEO remuneration was found by Duffhues and Kabir (2008), although they do

Table 5. Analysis of the relationship between CEO pay ratio and financial performance

	RE-GLS	RE-GLS	FE-OLS	P-OLS	RE-GLS
RNOA	–2.375				
	(1.923)				
Q		0.892**			
		(0.400)			
ROS			–4.287**		
			(1.796)		
SCHANGE				–1.842	
				(2.158)	
RET					2.346***
					(0.737)
Leverage	–13.407***	–10.627***	–16.952	–5.803***	–12.774***
	(3.183)	(3.257)	(3.775)	(2.839)	(3.155)
Size	4.787***	4.923***	2.572***	5.378***	4.850***
	(0.589)	(0.589)	(1.200)	(0.330)	(0.589)
Observations	1,295	1,293	1,295	1,294	1,276
R-within	0.01	0.01	0.02	–	0.02
R-overall	0.16	0.18	0.11	–	0.17
R-between	0.19	0.21	0.13	–	0.20
R^2	–	–	–	0.17	–
F-Test	18.73	18.24	18.76	18.69	18.70
p-value	0.0000	0.0000	0.0000	0.0000	0.0000
Breusch-Pagan Test	9.27	94.77	14.94	0.05	31.27
p-value	0.0023	0.0000	0.0001	0.8310	0.0000
Hausman Test	1.56	0.00	9.02	0.60	3.69
p-value	0.2122	0.9830	0.0027	0.4394	0.0546

Note: P-OLS – Pooled OLS, without fixed effects or random effects; RE-GLS–model with random effects, FE-OLS – fixed effects model. The superscripts *, **, and *** denote statistical significance (based on standard errors clustered by firm level) at 10%, 5%, and 1%, respectively.

Source: own compilation.

not focus on CEO pay ratio *per se*. They concentrate on directors' remuneration itself and not the pay gap expressed by the CEO pay ratio.

Next, we observed a positive significant relationship between CEO pay ratio and the RET and Tobin's *Q* ratio. The effect of positive annual stock return (RET) on executive compensation may be due to the capital markets' appreciation of the company outcomes. If executives effectively manage the company and contribute to the increase in stock value, they may receive higher compensation in the form of bonuses or profit sharing, compared to the salary of an average employee in the company. Similar results are found in the study by Ozkan (2007), which finds a positive and significant relationship between CEO pay ratio and annual stock return, while Gibbons and Murphy (1990) demonstrate the opposite results. However, it should be noted that both studies looked at the value of the pay itself and not the CEO pay ratio.

The Tobin's *Q* ratio combines both accounting and capital market aspects. If the market value of shares exceeds the book value of assets, it means that investors expect future growth in the company's value. Executives responsible for achieving a high Tobin's *Q* ratio can be rewarded with higher salaries. We can also observe a positive relationship between CEO pay ratio and Tobin's *Q* ratio in the Uygur (2019) study (but only if the CEO's level of skills is high). The opposite relationship was found in the study by Sajnóg and Rogozińska-Pawełczyk (2022), who found that the association between CEO remuneration and the Tobin's *Q* ratio is negative, but significant.

For the control variables, the logarithm of the company's assets (an indicator of the company's size) has proved to be a positive and statistically significant determinant of salary. This positive relationship is consistent with the results reported by Firth et al. (2006). Debt has a significant negative impact on executive compensation, a point in line with the common agency explanation, which argues that a large amount of debt is associated with greater managerial control by debt providers, and thus lowers executive compensation.

Conclusions

In this paper, we examine whether wage disparities are linked to the financial performance of companies listed on the Warsaw Stock Exchange for the period 2015–2019. We find that there is no clear evidence of a positive relationship between CEO pay ratio and various company performance measures in Poland. A positive significant relationship has been observed for the Tobin's *Q* ratio and annual stock returns (RET). This suggests that executive

compensation may be linked to market valuation and expectations of future growth. On the other hand, return on sales (ROS) is negatively related to the CEO pay ratio, indicating that companies may reward executives less when high profitability is achieved through collective efforts rather than individual managerial actions. Overall, the results of this study suggest that Polish companies are trying to comply with the codes of best practice and maintain corporate governance standards by aligning executive compensation with company performance.

As a result, our hypothesis was only partially supported, since market ratios like Tobin's *Q* and RET show a significant positive relationship, whereas accounting measures like ROS indicate a significant negative relationship or no relationship at all (in the case of SCHANGE and RNOA). These results appear to be consistent with the agency theory approach, which assumes that managers will seek to enhance shareholder value to minimize conflicts of interest (Castellanos & George, 2020). Polish companies appear to be seeking to align executive remuneration policies in a way that incorporates shareholder value and reflects their financial performance and market valuation.

Studying this ratio will contribute to a better understanding of the growth of pay inequality across industries and companies. It will also identify potential factors affecting these differences, such as company size, sector of activity or concentration of power. The analysis of the CEO pay ratio will provide scientific evidence on the existence of a link between pay inequality and company financial performance. These results will inform policy decisions on wage regulations and income equality. Appropriate legislation can be developed based on sound data and analysis showing the impact of pay inequality on the financial performance and stability of companies.

The analysis of the CEO pay ratio is particularly important in the context of regulation, as it can provide a basis for introducing appropriate regulations on equal pay in companies. This is particularly relevant in Poland, where there are currently no binding regulations on CEO pay. Possible legislation could require the disclosure of information on the ratio of CEO pay to that of employees at lower levels of the organizational hierarchy, which would increase transparency and openness within companies.

It is important to recognize the limitations of this study. Future research could expand the analysis by covering a longer period, potentially including years affected by events such as the COVID-19 pandemic, where an unexpected shock could change the relationship between CEO pay ratio and performance (Ye et al., 2023). In the future, if more detailed data become available as a result of the Corporate Sustainability Reporting Directive (CSRD), particularly its component, the European Sustainability Reporting Standards (ESRS), the definition of the CEO pay ratio employed in this study should be revised. Further research should also extend the scope of the study throughout Europe in order to compare different economies. Studying CEO pay ratios

in many countries would help us understand how economic, cultural, and political systems influence wage stratification. This analysis would be particularly relevant in light of increased interventionism. Finally, it would be also interesting to investigate how different types of corporate ownership affect CEO pay ratio. Does the presence of foreign investors result in a greater pay gap? This could help us better understand the impact of ownership structures on remuneration in various economic settings. This is important because foreign owners may implement compensation patterns from their countries of origin, potentially aligning CEO pay with the norms of the investor's country rather than the country in which the company operates, thus affecting local pay structures and economic dynamics.

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Innovation and Industry 4.0 in building the international competitiveness of food industry enterprises: The perspective of food industry representatives in Poland

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Abstract

The aim of the research is to determine the impact of innovations and Industry 4.0 solutions on the international competitiveness from the perspectives of representatives of food industry enterprises. The empirical layer used information collected on the basis of a survey using the CATI method conducted on a representative sample of representatives of food industry enterprises. Descriptive statistics, the Kruskal-Wallis test, Mann-Whitney test, multiple comparison test and box-plot plots were used to analyse the data. The study confirmed that implementing certain innovations and solutions, both intangible and tangible, is important for maintaining and improving competitiveness on the international market. This applies particularly innovative, modern ways of reaching the customer, developing innovative products, the use of IT systems and the use of innovative methods in advertising and promotion. The conclusions present direct implications for managers of food enterprises who formulate competitive strategies.

Keywords

- competitiveness
- food industry
- innovation
- Industry 4.0

JEL codes: F00, L66, O30.

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Introduction

The international competitiveness of entities is an important and topical issue of interest to scientists, researchers, economic practitioners and politicians. Its importance was emphasised in many studies, including those on the development strategies of the European Union (EU), including the Lisbon Strategy and its continuation Strategy 2020 (Balcerzak, 2015). The scientific discourse examines various aspects of competitiveness, including competitive potential, competitive strategies and instruments, and competitive position. From a cognitive and practical point of view, an important research problem is to determine the factors that make some entities perform well on the market and be competitive. Łukiewska and Juchniewicz (2021) indicate that permanently changing environmental conditions cause key competitiveness factors to evolve over time. Currently, changes are taking place in global economies, which lead to new conditions for entities to compete on increasingly demanding international markets. There is a rapid development in information and communication technologies, which puts pressure on enterprises to implement innovations and conduct business as part of the fourth revolution (Boikova et al., 2021). As a result, in order to adapt to the changing reality and new requirements of the environment, entities should look for new forms of competition with market rivals. The literature on the subject increasingly emphasises that it is innovations and new technologies that will largely determine the ability of entities to maintain or improve their competitive position (e.g., Baierle et al., 2022; Boikova et al., 2021; Kafetzopoulos et al., 2015; Silva et al., 2023).

New operating conditions also apply to the food industry. Its role in the economy and society is emphasised by many economists (e.g., Bigliardi & Galati, 2013; Gardijan & Lukač, 2018; Turi et al., 2014; Wilson, 2018). They draw attention to the importance of this sector in economic and environmental development, but also in shaping social well-being, meeting the basic needs of the population and ensuring food security. As Stefansdottir and Grunow (2018) and Akyazi et al. (2020) the changing environment and the emergence of new business models also pose new requirements in the agri-food industry. On the one hand, the food industry is not considered by researchers to be a sector with high research intensity (Martinez, 2000), but rather a quite mature and technologically unadvanced industry (Alawamleh et al. 2022). On the other hand, as Hassoun (2024) and Benharkat et al. (2023) point out, the emergence of new solutions in recent years and the rapid development of a wave of advanced technologies have influenced almost every industry, including agriculture and the food industry. According to Herrero et al. (2020) and Sadeghi et al. (2022), advanced technologies have revolutionised food systems and the food system in many countries. Some authors (Galanakis et

al., 2021; Radu et al., 2021; Weersink et al., 2021) indicate that the shift towards greater automation and digitalisation has been accelerated by labour shortages and other disruptions caused by the COVID-19 pandemic.

The changes taking place in the environment have resulted in the emergence of new trends in the food industry, as well as the emergence of new opportunities to introduce innovations and improvements to agricultural production and food processing. This creates unexplored potential that could allow the use of Industry 4.0 innovations and solutions in creating a competitive advantage in the food industry. Hassoun (2024) shows that while intensive research has been undertaken on the potential implementation of Industry 4.0 technologies in various fields, research findings on the application of Industry 4.0 in food-related sectors are still limited.

Therefore, the literature on the subject lacks empirical research confirming or denying the impact of innovative solutions on competitiveness in the food industry. The conclusions that have been formulated for other industries cannot be clearly translated to the food industry. Competitive factors depend on the specificity of production and the market in which the entities operate. Hence, the aim of the research is to determine the impact of innovations and Industry 4.0 solutions on the international competitiveness from the perspective of representatives of food industry enterprises. Additionally, the following research questions were asked:

RQ1: In the opinion of representatives of the food industry, which innovations and solutions in the field of Industry 4.0 are of high, medium and low importance in building international competitiveness?

RQ2: Does the perceived importance of innovations and solutions in the field of Industry 4.0 in building international competitiveness differ in enterprises producing food and those producing beverages?

RQ3: Does the perceived importance of innovations and solutions in the field of Industry 4.0 in building international competitiveness differ in enterprises with small, medium and large exports of food products to foreign markets?

The discussion presented in the article constitutes an attempt to reduce the cognitive gap identified in the literature on the subject. In a practical dimension, learning and applying appropriate innovations and solutions in the field of Industry 4.0 can contribute to better adaptation to the requirements of the environment, as well as gaining an advantage and increasing the international competitiveness of food producing enterprises and the entire food industry.

The article is structured as follows: The literature review indicates the factors affecting the competitiveness of enterprises, the essence of innovation and Industry 4.0, and discusses the connections between these categories and competitiveness. The research methods section presents the methodological

approach, data collection and quantitative tools used. The results are then presented and discussed. The conclusions summarise the article, include implications for practice, as well as highlighting the limitations of the study, and outlining possible directions for further analysis.

1. Literature review

1.1. International competitiveness and the factors that shape it

The complexity and multidimensionality of the competitiveness phenomenon mean that there is no clearly developed and universally accepted definition. At the level of enterprises and industries, it is generally understood as the ability to obtain benefits in a market with increasingly intense competition (Maroto-Sanchez & Cuadredo-Roura, 2013) or the ability to compete in a competitive environment, and to achieve growth and profitability (Sipa et al., 2015). The specificity of market conditions means that competition between enterprises takes place on the international market. Even companies that do not undertake foreign operations compete with foreign rivals on the local and national markets. The international competitiveness of enterprises and industries is shaped by various factors. In the literature on the subject, there are many approaches to determining them, but they are basically divided into external and internal (Bhawsar & Chattopadhyay, 2015; Laureti & Viviani, 2011). The external factors include economic, natural-geographic, political, legal, socio-cultural, and industry factors (Dolzhansky & Zagorna 2006; Jambor & Babu, 2016; Kuchmieiev, 2023). In turn, internal factors most often include organisational and management factors, financial and economic factors, the production potential of the enterprise, logistic components and marketing orientation (Kuchmieiev, 2023; Reshetnikova & Kalyuzhna, 2016; Yankovyj, 2013).

Research by other authors (Szczepaniak & Ambroziak, 2015) shows that the basis for the international success of the Polish food industry was the inclusion of the country in the European Single Market in 2004 with the consequent full opening of markets and freedom of trade with EU countries. The key source of international competitiveness was primarily price and cost advantages. However, the literature on the subject emphasises that these advantages are gradually exhausted, and new strategies are needed to maintain and strengthen the competitiveness of Polish agribusiness (Szczepaniak & Szajner, 2020).

1.2. Innovation and Industry 4.0 as factors of competitiveness

Viewing innovation as a source of competition is a relatively new approach. The forerunner of the concept itself was Schumpeter (1961). Innovations were also discussed by economists such as Drucker (1993), Kotler (1994) and Fagerberg (2005). Currently, in the EU, the so-called Oslo Methodology is used to define, classify and measure innovation. According to the commonly used definition presented in the Oslo Manual (2018, p. 20), innovation is: "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has "has been made available to potential users (product) or brought into use by the unit (process)". Broadly speaking, innovations can refer to the introduction of new products or changes in various areas of an enterprise's activity. As Alawamleh et al. (2022) point out, in the food industry, innovations can occur at any stage across the food chain, but mainly in the following areas: unique ingredients, natural food innovations, new production process, food quality improvements, packaging techniques and preservation technologies, and innovative ways of delivery or marketing.

New opportunities for innovation are being created by the current digital revolution, which is also called the 4.0 revolution. This term, as indicated by Dossou et al. (2022), refers to a new way of working, communicating and relating, based on the connectivity provided by the implementation of the Internet and the use of information through automatic data collection and processing. Characteristics of Industry 4.0 are: automation, digitalisation, decentralisation, virtualisation, big data, acquisition, processing and transmission of data in real time (Gokalp et al., 2016; Koumas et al., 2021). According to Kergroach (2017), Industry 4.0 enables smart production by providing data and tools to streamline factory operations and better manage risks in the supply chain, from product logistics through inventory management to machine maintenance. According to Blunck and Werthmann (2017), this can lead to process optimisation, better asset utilisation, increased production efficiency and improved quality.

At present, many economists emphasise the impact of new solutions on the development and maintenance of a highly competitive position of economic entities (including Hermundsdottir & Aspelund 2021; Montobbio, 2003; Pereira et al., 2013; Porter, 2000). Although innovation is widely considered to be a way to improve the competitiveness of enterprises, this relationship is not clearly supported by empirical research. The limited number of analyses in this area do not resolve the impact of innovation on competitiveness. A review of the existing literature on the subject shows that there are studies confirming such a relationship. These include the study by Kafetzopoulos et al. (2015) among Greek manufacturing and service enterprises, which shows

that there is a positive and significant relationship between product innovations and process innovations and competitive advantage. The relationships were examined on the basis of 433 surveys using exploratory factor analysis, confirmatory factor analysis and structural equation modelling. Some studies also confirm the positive impact of innovation on company results, including their efficiency, export volume or market position (Evangelista & Vezzani, 2010; Gonzalez & Chacon, 2014; Gunday et al., 2011, Martinez-Costa & Martinez--Lorente, 2008). However, the literature on the subject also includes studies stating that there is no evidence of the impact of innovation on the competitiveness of entities. A study by Łukiewska and Juchniewicz (2021) conducted using panel models did not confirm any causal relationship between innovation and the international competitive position of the food industry in EU member states. At the same time, the relationship between labour productivity, labour costs and competitive position was confirmed. This study contributes to existing knowledge by examining and presenting the impact of Industry 4.0 innovations and solutions on the competitiveness of the food industry based on an original, nationwide empirical study on a representative sample. It not only systematises the current state of literature on this issue, but also includes economic practitioners, i.e. representatives of food industry enterprises, in the discussion.

2. Research methods

In the research procedure used in this study, the first stage involved analysing and critiquing international literature (Figure 1). This analysis of scientific achievements regarding the issues of competitiveness and competitiveness factors allowed the categories affecting the international competitiveness of the food industry to be determined, including Industry 4.0. innovations and solutions. A further review of the literature (including Kosior, 2018; Oslo Manual, 2018; Ustundag & Cevikcan, 2017) led to the development of a list of 15 factors in this field that may be important in building international competitiveness of food industry enterprises. These include:

- C01 – development of innovative products,
- C02 – use of innovative raw materials (e.g., spirulina, chia seeds),
- C03 – implementing innovative intelligent packaging,
- C04 – implementing innovative packaging made of renewable or biodegradable raw materials,
- C05 – the use of nanotechnology in creating packaging,
- C06 – creating new technologies and manufacturing techniques, including production automation,

– C07 – the use of intelligent robots and machines,
– C08 – computerisation of logistics,
– C09 – innovative, modern ways of reaching the customer,
– C10 – innovative, modern management systems,
– C11 – application of IT systems,
– C12 – starting cooperation with research centres,
– C13 – implementing innovative methods of distribution,
– C14 – use of innovative methods in advertising and promotion,
– C15 – applying data mining analysis and evaluating large databases.

On the basis of the literature review, an original structured interview questionnaire was developed as a research tool.

The next stage involved running the survey. In the survey conducted in 2022, the target group includes representatives of economic entities whose activities are included in section C of PKD 2007 Industrial processing, Division 10. Production of food products and Division 11 – Production of beverages. To obtain representative data, a stratified random selection of the research sample was used. The criteria for stratification were the Polish Classification of Activities and the size of the enterprise. In addition, the size of the research sample, in the course of calculations using the formula for the minimum sample size and adopting the confidence coefficient at the level of 95%, and the maximum estimation error of 5%, were established at 376 units (enterprises food industry). The enterprises were located all over Poland. The sample structure was dominated by those employing fewer than 10 people (82%). The second group consisted of small enterprises (14%). The smallest group were medium-sized and large enterprises (4%). It should be emphasised that such an asymmetry in the size of enterprises is consistent with the average size of

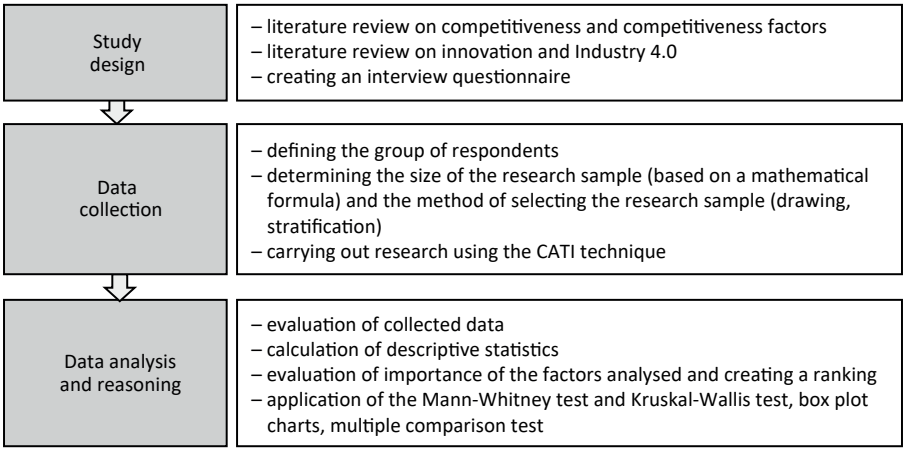


Figure 1. Research process

Source: own study.

the population of Polish enterprises in the food industry. When examining the structure of the sample according to the period of operation on the market, it was found that most of them had at least twenty years of experience (75%). Almost 16% of the entities surveyed had operated on the market for 10–20 years, and 9% for less than 10 years. Beverage producers accounted for over 5.05%, and food producers almost 94.95%. The study was performed using the CATI – Computer Assisted Telephone Interviewing technique.

A five-point Likert scale was used to assess the importance of components. Descriptive statistics were used to assess the significance of the elements, including the arithmetic mean and the median, lower quartile, upper quartile, dominant, standard deviation and coefficient of variation. Based on the arithmetic mean, a ranking of the analysed components was created and grouped according to their importance in building international competitiveness (Table 1).

Table 1. The importance of factors in building international competitiveness

Range of arithmetic mean scores	Importance of competitiveness factors
4.20–5.00	very high
3.40–4.19	high
2.60–3.39	medium
1.80–2.59	low
1.00–1.79	very low

Source: own elaboration based on Çelik and Oral (2016), and Renault et al. (2018).

The responses were then analysed taking into account the subsector (food and beverage producers) and the share of exports in the company's sales (< 10%, 10–40%, > 40%). The statistical tests were applied to determine whether there were any statistically significant differences between the groups in their assessment of competitive factors. In the first case, the non-parametric Mann-Whitney test was used to test the equality of distribution of the two populations:

$$\begin{aligned} H_0&: \theta_1 = \theta_2 \\ H_1&: \theta_1 \neq \theta_2 \end{aligned} \tag{1}$$

Test statistics takes the form:

$$Z = \frac{R_1 - R_2 - (n_1 - n_2)(n_1 + 1)/2}{\sqrt{(n_1 n_2 (n+1)/3}} \tag{2}$$

where: n_1, n_2 – number of samples, n – number of all observations, R_1 – sum of ranks awarded to the values of the first attempt.

When differences in assessment between factors were observed based on the test, the median, quartiles, minimum and maximum for the individual analysed groups (food producers and beverage producers) were presented on box-plot charts.

In the second case, the Kruskal-Wallis test was used. This test is the non-parametric analogue of a one-way ANOVA, which can be used when assumptions of normality and/or homoscedasticity were not met (Hecke, 2012; Muhammad et al., 2021). The test allowed for testing the null hypothesis that the k samples are from the same population (with the same medians θ):

$$H_0: \theta_1 = \theta_2 = \cdots = \theta_k$$
$$H_1: \text{not all } \theta_i \text{ are equal } (i = 1, 2, \ldots, k) \tag{3}$$

The test statistics take the form:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{R_i^2}{n_i} - 3(N+1)$$
$$N = \sum_{i=1}^{k} n_i \tag{4}$$

where: n_i – number of observations in i group, N – number of all observations, k – number of compared groups, R_i – sum of ranks in i group.

The H statistic has an asymptotic distribution with the degrees of freedom equal to the number of groups k minus 1. In the events of differences in factor assessments, a multiple comparison test was used to check which groups had differences. The test involves comparing the average ranks for each pair of groups. On this basis, p-value matrices were created. The assessments of the analysed groups were also presented in box-plot plots.

3. Results

In the empirical study, representatives of food industry enterprises were asked for their opinion on the importance of Industry 4.0 innovations and solutions selected based on the literature in building the international competitive advantage of the enterprise (on a 5-point Likert scale). A ranking of elements was created based on the arithmetic mean (Figure 2), the distribution of responses was presented (Figure 3) and the basic positional measures of the received ratings were determined (Table 2). The assessment of factors was analysed, also taking into account the specificity of production (food production and beverage production) and the share of exports in sales (Table 3, Figure 4, Table 4, Figure 5).

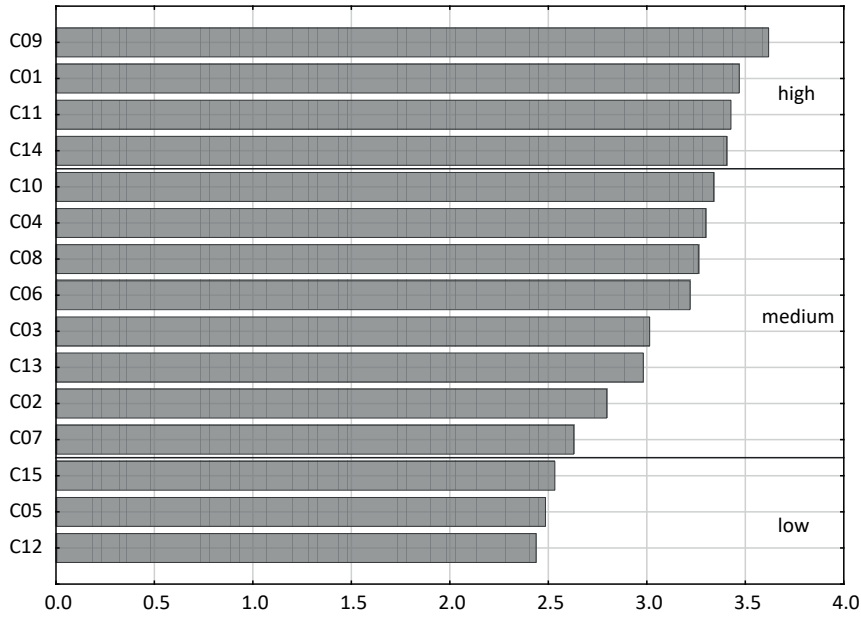


Figure 2. Ranking of the importance of Industry 4.0 innovations and solutions in the competitiveness of food industry enterprises according to the arithmetic mean

Source: own calculations based on research.

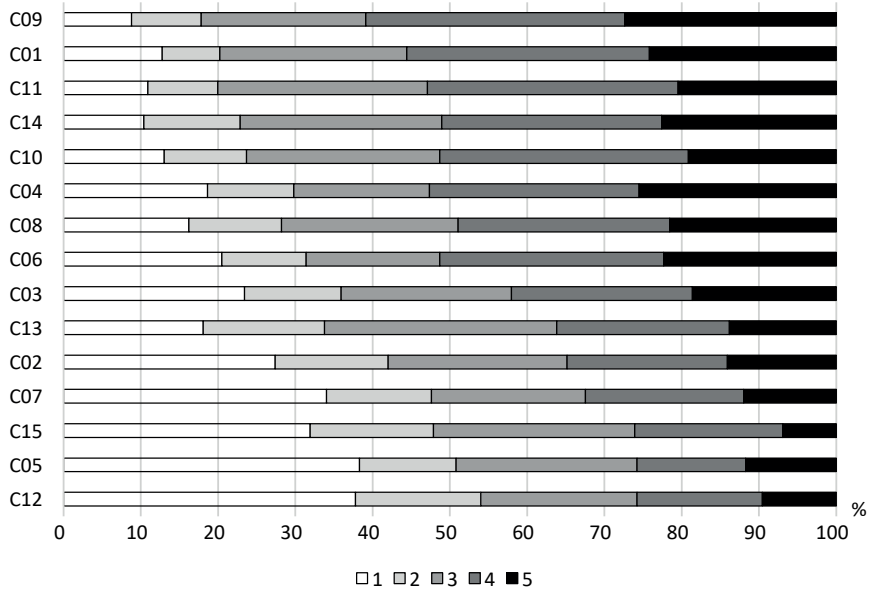


Figure 3. Distribution of assessments of the importance of innovations and solutions of Industry 4.0 in the competitiveness of food industry enterprises

Source: own calculations based on research.

Table 2. Descriptive statistics assessing the importance of Industry 4.0 innovations and solutions in the competitiveness of food industry enterprises

Component	M	Me	Q1	Q3	D	SD	CV (%)
C09	3.62	4	3	5	4	1.22	33.81
C01	3.47	4	3	4	4	1.29	37.06
C11	3.43	4	3	4	4	1.22	35.67
C14	3.40	4	3	4	4	1.25	36.80
C10	3.34	4	3	4	4	1.27	37.96
C04	3.30	4	2	5	4	1.44	43.58
C08	3.26	3	2	4	4	1.36	41.62
C06	3.22	4	2	4	4	1.44	44.70
C03	3.01	3	2	4	4	1.43	47.46
C13	2.98	3	2	4	3	1.29	43.23
C02	2.80	3	1	4	1	1.41	50.30
C07	2.63	3	1	4	1	1.43	54.46
C15	2.53	3	1	4	1	1.30	51.34
C05	2.48	2	1	4	1	1.42	57.00
C12	2.44	2	1	4	1	1.38	56.66

Note: M – arithmetic mean, Me – median, Q1 – lower quartile, Q1 – upper quartile, D – dominant, SD – standard deviation, CV – coefficient of variation.

Source: own calculations based on research.

3.1. Factors of high importance in building international competitiveness

The study shows that, in the opinion of respondents, the most important element in building international competitiveness were innovative, modern ways of reaching customers (C09). The arithmetic mean of the ratings for this factor was 3.62. The most frequently assigned answer was a rating of 4 (33.51% of respondents), but over 27.39% of the respondents assigned a rating of 5. Respondents also attributed great importance in building international competitiveness to the development of innovative products (C01), the use of IT systems (C11) and the use of innovative methods in advertising and promotion (C14). The arithmetic mean score was 3.40–4.47. The median indicates that 50% of respondents rated the importance of these factors as at least 4.

Table 3. Mann-Whitney test results and arithmetic mean by subsector

Component	Subsector	Mann-Whitney test			Arithmetic mean
		sum of rank	Z	*p*-value	
C01	F B	66969.50 3906.50	3066.50	0.48	3.46 3.63
C02	F B	67212.00 3664.00	3309.00	0.86	2.79 2.84
C03	F B	66348.00 4528.00	2445.00	0.04**	2.98 3.68
C04	F B	66307.50 4568.50	2404.50	0.03**	3.26 4.00
C05	F B	66460.00 4416.00	2557.00	0.07*	2.45 3.05
C06	F B	66549.00 4327.00	2646.00	0.11	3.19 3.79
C07	F B	66852.00 4024.00	2949.00	0.34	2.61 2.95
C08	F B	66657.00 4219.00	2754.00	0.17	3.24 3.68
C09	F B	66441.00 4435.00	2538.00	0.06**	3.59 4.16
C10	F B	66840.50 4035.50	2937.50	0.33	3.32 3.63
C11	F B	66705.00 4171.00	2802.00	0.20	3.41 3.79
C12	F B	66192.50 4683.50	2289.50	0.02**	2.39 3.21
C13	F B	66556.50 4319.50	2653.50	0.11	2.96 3.47
C14	F B	66538.00 4338.00	2635.00	0.10*	3.38 3.89
C15	F B	66312.50 4563.50	2409.50	0.03**	2.50 3.16

Note: F – food producers, B – beverage producers; ** and * significances at the 0.05 and 0.1 levels, respectively.

Source: own calculations based on research.

Based on the Mann-Whitney test, significant differences were observed in the perception of innovative, modern ways of reaching the customer among food and beverage producers. A *p*-value of less than 0.1 allowed the null hy-

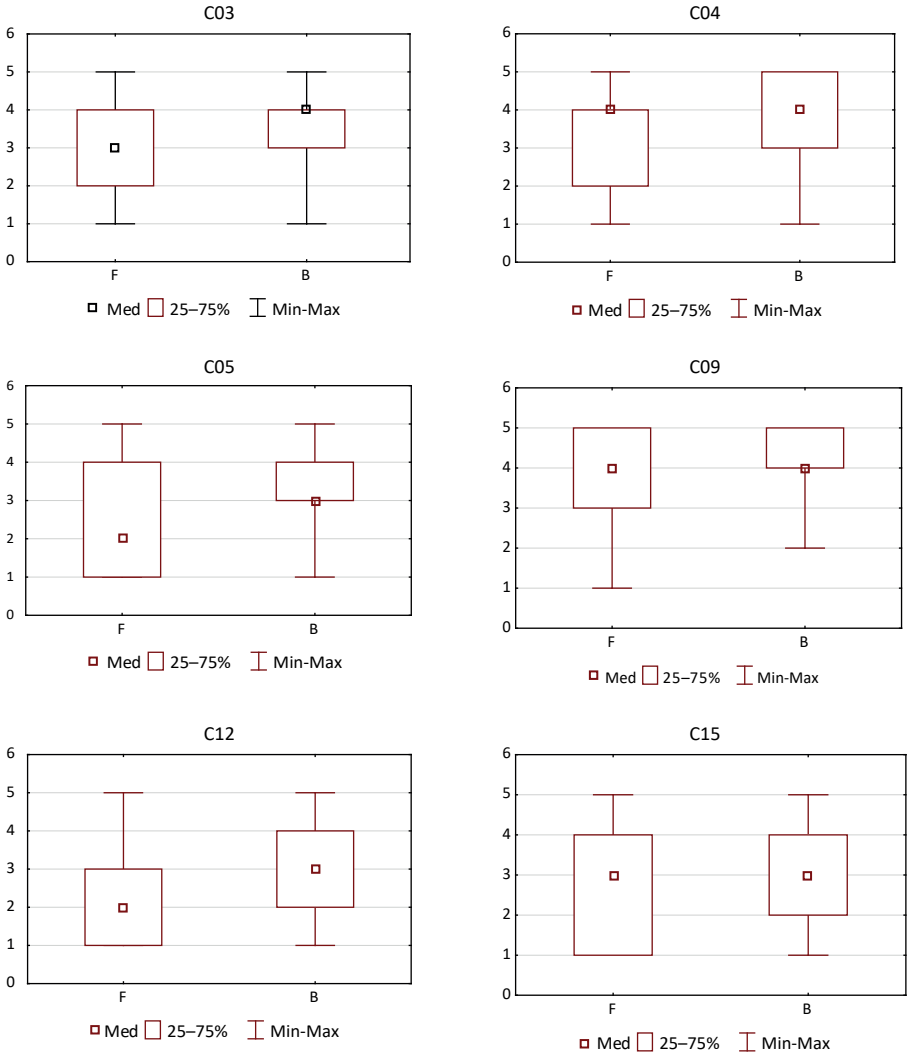


Figure 4. Box-plot charts by subsector

Note: F – food producers, B – beverage producers.

Source: own calculations based on research.

pothesis to be rejected in favour of the alternative hypothesis about the significance of differences between the ratings of this factor from both groups. Based on the arithmetic mean and positional measures presented in box-plot charts, it can be concluded that beverage producers attributed greater importance to innovative, modern ways of reaching the customer than food producers. The arithmetic mean of the grades in the first group was 4.16,

and the first quartile was 4. In the second group, the arithmetic mean of the grades was 3.59, and the first quartile was 3.

Moreover, based on the Kruskal-Wallis test, significant differences were observed in the perception of the importance of using IT systems among enterprises with a small, medium and large share of exports (*p*-value = 0.0233). The multiple comparison test does not clearly determine which groups have differences. However, based on the arithmetic mean and positional measures presented in the box-plot chart, it can be concluded that respondents representing enterprises with a small share of exports assigned the least importance to this factor (arithmetic mean 3.37, median 3).

3.2. Factors of medium importance in building international competitiveness

The study shows that, according to representatives of food industry enterprises, the average importance in building international competitiveness is played by innovative, modern management systems (C10), the implementation of packaging made from renewable or biodegradable raw materials (C04), computerisation of logistics (C08), and the creation of new technologies and techniques manufacturing, including automation (C06). The arithmetic mean of the ratings for the indicated factors was 3.22–2.34, and the median was 3–4. Respondents also assigned average importance to factors such as implementation of intelligent packaging (C03), implementation of innovative distribution methods (C13), use of innovative raw materials (e.g., spirulina, chia seeds) (C02), and the use of intelligent robots and machines (C07). Based on positional measures, it can be concluded that 50% of respondents rated these indicators at least 3, and 25% at least 4.

Table 4. Kruskal-Wallis test results and arithmetic mean by share of exports in sales (< 10%, 10–40%, > 40%)

Component	Export	Kruskal-Wallis test				Arithmetic mean
		sum of rank	mean of rank	H	*p*-value	
C01	< 10% 10–40% > 40%	60958.50 5512.50 4405.00	186.42 220.50 183.54	2.4910	0.2878	3.44 3.84 3.50
C02	< 10% 10–40% > 40%	61193.50 5408.00 4274.50	187.14 216.32 178.10	2.0049	0.3670	2.78 3.16 2.67

cont. Table 4

Component	Export	Kruskal-Wallis test				Arithmetic mean
		sum of rank	mean of rank	H	*p*-value	
C03	< 10% 10–40% > 40%	60979.00 5157.00 4740.00	186.48 206.28 197.50	0.9909	0.6093	2.99 3.24 3.13
C04	< 10% 10–40% > 40%	61593.50 5085.50 4197.00	188.36 203.42 174.88	0.8934	0.6397	3.30 3.48 3.13
C05	< 10% 10–40% > 40%	61466.50 4883.50 4526.00	187.97 195.34 188.58	0.1155	0.9439	2.47 2.60 2.50
C06	< 10% 10–40% > 40%	59802.50 5730.50 5343.00	182.88 229.22 222.63	7.1081	0.0286**	3.15 3.64 3.75
C07	< 10% 10–40% > 40%	59754.00 5218.00 5904.00	182.73 208.72 246.00	9.0475	0.0108**	2.55 2.92 3.42
C08	< 10% 10–40% > 40%	60239.00 5094.50 5542.50	184.22 203.78 230.94	4.8985	0.0864*	3.20 3.48 3.83
C09	< 10% 10–40% > 40%	60749.50 5403.50 4723.00	185.78 216.14 196.79	2.1075	0.3486	3.59 3.88 3.71
C10	< 10% 10–40% > 40%	60263.00 5317.00 5296.00	184.29 212.68 220.67	4.0719	0.1306	3.29 3.56 3.71
C11	< 10% 10–40% > 40%	59767.50 5565.00 5543.50	182.78 222.60 230.98	7.5213	0.0233**	3.37 3.72 3.92
C12	< 10% 10–40% > 40%	60391.00 5148.00 5337.00	184.68 205.92 222.38	3.6374	0.1622	2.39 2.72 2.83
C13	< 10% 10–40% > 40%	60723.00 5404.00 4749.00	185.70 216.16 197.88	2.1229	0.3460	2.95 3.28 3.08
C14	< 10% 10–40% > 40%	62228.50 4947.00 3700.50	190.30 197.88 154.19	2.8244	0.2436	3.43 3.44 3.04
C15	< 10% 10–40% > 40%	60392.50 5352.50 5131.00	184.69 214.10 213.79	3.2920	0.1928	2.48 2.88 2.83

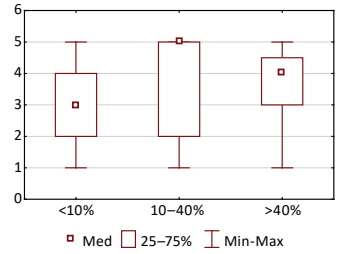
Note: ** and * significances at the 0.05 and 0.1 levels, respectively.

Source: own calculations based on research.

C06

Multiple comparison test (*p*-value)

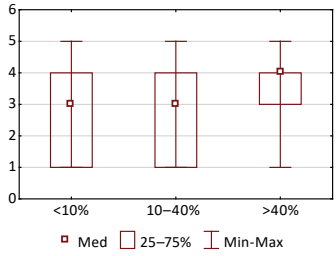
Export	< 10%	10–40%	> 40%
< 10%	–	0.12	0.25
10–40%	0.20	–	1.00
> 40%	0.25	1.00	–



C07

Multiple comparison test (*p*-value)

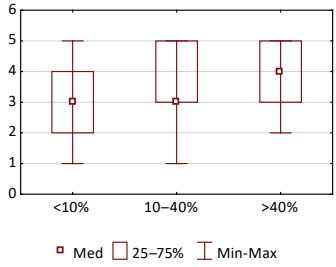
Export	< 10%	10–40%	> 40%
< 10%	–	0.75	0.018**
10–40%	0.75	–	0.69
> 40%	0.018**	0.69	–



C08

Multiple comparison test (*p*-value)

Export	< 10%	10–40%	> 40%
< 10%	–	1.00	0.13
10–40%	1.00	–	1.00
> 40%	0.13	1.00	–



C11

Multiple comparison test (*p*-value)

Export	< 10%	10–40%	> 40%
< 10%	–	0.23	0.11
10–40%	0.23	–	1.00
> 40%	0.11	1.00	–

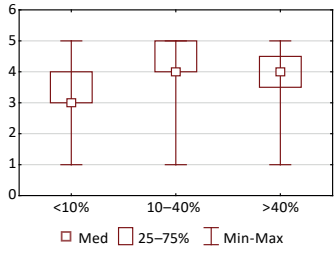


Figure 5. Multiple comparison test and box-plot charts by share of exports in sales (< 10%, 10–40%, > 40%)

Source: own calculations based on research.

The results of the Mann-Whitney test indicate differences in assessing the importance of implementing smart packaging and implementing packaging from renewable or biodegradable raw materials among food and beverage producers. The arithmetic mean and positional measures indicate that beverage producers rated the importance of both factors higher. Based on the Kruskal-Wallis test, significant differences were also observed in the perception of the importance of computerisation of logistics, the creation of new technologies and manufacturing techniques, including automation and the use of intelligent robots and machines, depending on the level of exports in the company's sales. The multiple comparison test indicates that in enterprises with a low proportion of exports, the importance of using intelligent robots and machines is significantly lower than in enterprises with a high share of exports. This is also confirmed by the box-plot plot. Positional measures also indicate that representatives of enterprises with a small share of exports attribute relatively less importance to the computerisation of logistics and the use of intelligent robots and machines in building international competitiveness.

3.3. Factors of low importance in building international competitiveness

In the study, respondents assigned the least importance to solutions such as the use of data mining analysis and the evaluation of large databases (C15), the use of nanotechnology in the creation of packaging (C05), and commencing cooperation with research centres (C12). The arithmetic mean of the ratings for the indicated factors was 2.44–2.53, and the median was 2–3. It is also worth emphasizing that these factors were characterised by the greatest diversity of responses. The coefficient of variation was 51.34–56.66%. The results of the Mann-Whitney test indicate differences in the assessment of the importance of the above factors among food and beverage producers. The arithmetic mean and positional measures indicate that their importance was rated higher by beverage producers. However, no statistically significant differences were found in the perception of these factors among enterprises with small, medium and large levels of exports.

4. Discussion

The results of the analysis confirm the observations of Muszyński and Muszyński (2018), according to which appropriate actions towards the recip-

ient contribute to increasing profits. According to Vecchio et al. (2022), the concept of customer relationship management (CRM) is becoming increasingly popular, in which a set of procedures and tools is used to build long-term relationships with customers. It is also noted that new or improved products meet the requirements of current and potential customers and ensure diversity of the offer (Hoonsopon & Ruenrom, 2012). Thanks to this, the company can expand its target audience, introduce new distribution channels, strengthen its market position, increase profitability and, consequently, improve its competitiveness (Li et al., 2012; Mu et al., 2009; Sethi & Sethi, 2009). The importance of information systems has been highlighted by Triantafyllou (2022), among others, according to whom such systems can help manage information from both the internal and external environment of the business and thus increase its efficiency and competitiveness. In turn, innovative methods of advertising and promotion help facilitate communicate with customers, change purchasing behaviour and increase competitive advantage (Ali & Maryam, 2012; Ulanat & Jacob, 2017).

In the literature on the subject, considerable attention is paid to innovations in production processes, mainly relating to new technologies and production techniques, including automation. According to Gunday et al. (2011), innovations of this type lead to an increase in total sales and exports and an increase in product innovation, and according to Gonzalez and Chacon (2014), also to an increase in the company's efficiency. According to Bahrin et al. (2016), introducing innovations in production processes in the food industry can involve loading/unloading, assembly, packaging, palletizing, pick-and-place, sorting, stacking and placing operations at very high speeds and significantly impact food safety and cleanliness, increasing resource efficiency, simplifying maintenance, and reducing human injuries. Some authors also emphasise the importance of intelligent solutions in the food industry. According to Barbara et al. (2022), the use of artificial intelligence reduces costs by optimizing operations and improves profitability. Artificial intelligence can detect, predict or diagnose undesirable situations in industrial systems, replace or reduce human controls in food production and delivery processes that are often unreliable and time-consuming (Kumar et al., 2021), and minimise downtime and the persistence of unsafe situations (Bécue et al., 2021). The use of smart sensors in food packaging has a positive impact on food safety and quality, and provides customers with appropriate information (Benharkat et al., 2023). It is also indicated that new innovative enrichment of food with nutritional values allows the creation of products that can meet the requirements of modern customers (Alawamleh et al., 2022). For many years, the literature on the subject paid much less importance to non-technological innovations (Juchniewicz, 2011). However, as the importance of knowledge increases and paradigms change, their role in the functioning of enterprises is increasingly recognised.

The literature on the subject recognises the potential of big data analytics, especially in the context of improving the operational efficiency of the food supply chain or understanding the market and consumer trends, as well as developing new products and services (Jagtap & Duong 2019; Kamilaris et al. 2017). Constantiou and Kallinikos (2015) show that a growing number of companies are accelerating the implementation of their big data analytics initiatives to develop critical insights that can ultimately provide them with a competitive advantage. In terms of nanotechnology, great potential is seen in food production. As indicated by Chausali et al. (2022), packaging based on nanotechnology enables safe transportation of food products without spoiling the taste, nutritional properties and quality, and also prevents contamination and sustains mechanical, physiological, physical and chemical properties of food products. According to Cerqueira et al. (2018), knowledge of the use of nanotechnology in food packaging is growing and is expected to have a significant impact on the operations of food companies in the future. The literature on the subject also indicates that cooperation with research units is particularly important for small and medium-sized enterprises because it provides an opportunity to implement research projects, transfer knowledge and gain an advantage on the market. As Milczarek and Gręboszk-Krawczyk (2019) point out, in practice, however, barriers to cooperation exist between entrepreneurs and representatives of science, and these are mainly of a communication nature, such as a negative image of science in the opinion of entrepreneurs or the perception of activities resulting from cooperation with scientists as not being significant for running a business.

To sum up, it can be noted that in the literature there are mentions of the positive impact of selected innovations and solutions of Industry 4.0 on the functioning and results of enterprises. This study confirms the importance of these elements for building the international competitiveness of food industry enterprises (in the opinion of their representatives). An important added value is also the creation of a ranking of the importance and gradation of these factors (high, medium, low importance).

Conclusions

The study fills the gap in the literature on the impact of innovations and solutions of Industry 4.0 on the international competitiveness of food industry enterprises. The study shows that, according to representatives of food industry companies, the use of some innovations and solutions of Industry 4.0 can significantly contribute to boosting the international competitiveness of this entities. This applies in particular to innovative, modern ways of reaching

the customer, developing innovative products, the use of IT systems and the use of innovative methods in advertising and promotion. According to the respondents, there is also the relationship between international competitiveness and such elements as innovative, modern management systems, implementation of packaging made of renewable or biodegradable raw materials, computerisation of logistics and the creation of new technologies and production techniques, including automation, implementation of intelligent packaging, implementation of innovative distribution methods, use of innovative raw materials, and the use of intelligent robots and machines. However, this relationship can be considered medium importance. In the study, the respondents attributed the least importance to solutions such as the use of data mining analysis and the evaluation of large databases, the use of nanotechnology in the creation of packaging, and the initiation of cooperation with research centres. It was also observed that innovative, modern ways of reaching the customer, implementing intelligent packaging, implementing packaging from renewable raw materials, using data mining analysis and evaluation of large databases, using nanotechnology in creating packaging and starting cooperation with research centres will be relatively more important for beverage producers than food producers. Moreover, in enterprises with a low importance of exports in their sales, relatively less importance in building international competitiveness was attributed to the use of IT systems, computerisation of logistics, and the use of intelligent robots and machines.

The research carried out here has not only cognitive but also practical value. The conclusions provide direct implications for managers of food enterprises who formulate competitive strategies. The primary message is that implementing innovations and solutions, both intangible and tangible, is important for maintaining and improving competitiveness on the international market. In particular, new solutions should concern practices related to reaching customers, promotion and advertising, products and computerisation. The study is important not only for companies operating on the foreign market, but also those on the domestic market when competing with food importers.

The study has some limitations. Firstly, it uses subjective and qualitative data based on surveys. To increase credibility, the study was conducted on a relatively large, representative group. Moreover, the analysis carried out does not take into account the full profile of the activities of food industry enterprises. For this reason, future research should be extended to include, for example, the age or size of the enterprise and/or should consider these factors simultaneously. The assessment of the innovations and solutions of Industry 4.0 presented here should be treated as part of research on the factors impacting international competitiveness of enterprises producing food and beverages and the entire food industry. Further research should also analyse other factors, including competitive potential, current food trends and contemporary economic processes.

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Aims and Scope

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