Contents

Index of Authors

Index

The Use of Regression Panel Analysis with Fixed Effects in International Trade: The Example of Poverty in Africa

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Abstract: *This paper explores the application and potential of panel data regression analysis in international trade. By leveraging panel data, the authors aim to understand the impact of various economic factors on poverty rates in African countries. The study uses fixed effects models to analyze the relationship between gross domestic product (GDP) per capita, foreign direct investment (FDI) inflows, remittances, and export rates on the proportion of the working population living in poverty. The findings indicate that higher GDP per capita and increased remittances reduce poverty rates, whereas FDI inflows and export rates do not show a statistically significant impact. The paper underscores the importance of economic growth and remittances in poverty alleviation and calls for more nuanced strategies to address poverty in Africa effectively. Future research should investigate the structural aspects of exports and regional specificities to enhance the understanding of these dynamics.*

1. INTRODUCTION

International trade and business represent a complex and dynamic world where it is constantly necessary to analyze and predict various economic and commercial phenomena. International trade plays a critical role in shaping economic policies that drive sustainable development. The concept of sustainable development emphasizes economic growth that meets present needs without compromising the ability of future generations to meet their own needs. Within this framework, trade policies and economic strategies should be designed to foster long-term economic resilience, social equity, and environmental sustainability.

Poverty alleviation is a key component of sustainable development and aligns directly with the United Nations Sustainable Development Goals (SDGs). In particular, Goal 1 (No Poverty) seeks to eradicate extreme poverty, while Goal 8 (Decent Work and Economic Growth) aims to promote inclusive and sustainable economic growth, employment, and decent work for all (United Nations, 2024). International trade can contribute to these goals by creating employment opportunities, enhancing economic productivity, and facilitating the transfer of knowledge and technology across nations.

In this context, panel data regression analysis has become an important tool for understanding the relationships between different variables within the framework of international trade and

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business. Panel data regression analysis is a form of analysis that takes into account data from multiple observations over time and across various units. This approach allows the behaviour of countries or companies to be considered over several periods (months, quarters, or years) in the field of international trade, providing insights into the factors influencing business decisions and company performance on an international level. For example, it is possible to analyze the impact of trade policies, economic indicators, technological advancements, competitive environments, and other factors on the development of international trade relations and business activities. This method helps identify key factors that influence success or failure in international trade and business, thereby enabling the formulation of better-informed strategies and business decisions.

Panel data are becoming an increasingly common type of data in empirical research in the fields of economics, social sciences, and medicine. The analysis of panel data represents a fundamental area of modern econometric research and multivariate statistics. Studies focused on these data are gaining increasing importance in research within these disciplines. Panel data regression analysis can address issues that are unsolvable with standard univariate data alone.

2. LITERATURE REVIEW

Regression analysis is a frequently used analytical technique in market research that enables the examination of relationships between dependent and independent variables. It offers several advantages, including the ability to verify whether an independent variable has a significant relationship with a dependent variable, estimate the strength of influence of various variables, and make predictions (Sarstedt & Mooi, 2019). According to Gallo (2015), regression analysis is a mathematical sorting process that selects a group of independent variables that influence the primary objective, the dependent variable. A supplementary definition is provided by Gunst and Mason (2018), who describe regression analysis as consisting of graphical and analytical methods for examining relationships, distinguishing it from other types of statistical analyses by its goal of expressing the dependent variable as a function of predictors.

Panel data combines elements of cross-sectional data and time series (Lukáčiková et al., 2018). These datasets consist of a set of individuals (typically persons, households, or companies) that are measured repeatedly over time, significantly expanding the sample size. This means that for each element in the cross-sectional sample, there is a time series. A common modeling assumption is that individuals are independent of one another, but observations of a given individual are dependent on each other. Compared to cross-sectional data, the advantage of panel data is that attributes expressing change from the original state can also be used in the analysis. On the other hand, compared to time series, panel data are not limited to regular chronological repetitions of individual observations. These data will be the subject of examination in this paper.

The importance of panel data and the significance of their use are discussed by Baltagi and Baltagi (2021), who provide a list of the advantages and limitations of using panel data. Among the advantages, panel data indicate that individuals, firms, states, or countries are heterogeneous. Panel data offer more informative data, greater variability, lower collinearity among variables, more degrees of freedom, and higher efficiency. They allow for more precise identification and measurement of effects that are not easily detectable in pure cross-sectional data or pure time series. The limitations include coverage issues (incomplete consideration of the target population), non-response problems (due to insufficient respondent cooperation or interviewer error), and the impact of data collection frequency, interview intervals, reference periods, or the use of truncation and time distortion in the sample.

The basic structure of regression models, according to Sul (2019), consists of time-invariant individual-specific variables, time-dependent common variables, and time-dependent individual-specific variables. Based on the structure of regression models, basic regression models for panel data will be gradually derived. Let y_{it} be the data of interest, representing individual i (or firm, group, country) at time t. The index i represents the cross-sectional unit, where the total number of cross-sectional units is denoted as n $(i = 1, ..., n)$. The range of the time indicator is denoted as $t = 1, ..., T$. The variable y must have the same attributes across all i during t. Finally, the following general structure of panel data will be considered:

$$y_{it} = X_{it} + \alpha_i + \mu_{it} \text{ for } t = 1, ... , T \text{ and } i = 1, ... , n \tag{1}$$

Brugger (2021) provides an illustrative example to help understand the individual components of this relationship, where y_{it} represents the level of concentration (the dependent variable) and X_{it} represents coffee consumption (the independent variable). Then a_i is the time-invariant component. This term expresses a certain individual effect of the cross-sectional unit, which in this case could be, for example, a natural ability to concentrate. Furthermore, β represents the estimated parameters (coefficients) for the individual independent variables, and μ_{it} is the idiosyncratic error, which may include factors that change over time for the given cross-sectional unit; in this example, it could be fatigue. Based on the given relationship, three basic types of panel regression models can be used: the fixed effects model, the random effects model, and the pooled regression model. However, the key model for this study will be the fixed effects model, which will be described in more detail in the methodology section.

To choose the appropriate model between the fixed effects and random effects models, the Hausman test is used. This statistical test allows the selection of the most suitable model based on the data and the problem at hand. The test states that if the result is:
- Null hypothesis H0, where $p > 0.05$; then it is more appropriate to use the random effects model.
- Alternative hypothesis H1, where $p < 0.05$; then it is more appropriate to use the fixed effects model (Zulfikar & STp, MM, 2018).

Baltagi and Baltagi (2021) mention several application areas of panel data regression analysis, such as the analysis of macroeconomic panel data, productivity measurement, consumer demand choice analysis, labor market outcomes panel econometrics, or gravity models of international trade.

It is worth highlighting several studies where panel regression analysis was used for international trade and, in some way, may have influenced decision-making or the resolution of situations. Suparman (2022) focused on the relationship between economic growth, income inequality, and poverty (by province) in Indonesia in his article. According to various studies he cites, creating economic opportunities and ensuring equal access are key components of this relationship. Indonesia faces challenges related to transforming its economic model, which is based on natural resources and low wages. A transition to inclusive and sustainable growth is essential. The data used in this study came from the Central Statistics Bureau. Specifically, the data included Gross Regional Domestic Product (GRDP), the number of poor people, and the GINI coefficient, which measured the level of inequality in the expenditures of the Indonesian population by province for the period 2015 to 2020. To analyze the relationship between these data, the author used panel regression analysis in all three forms: the pooled regression model, the fixed effects model, and the random effects model.

An interesting application of panel data regression analysis is found in the publication by Rahman et al. (2022). The authors aimed to verify the relationship between exports, imports, and the consumption of oil reserves on the level of oil production in Southwest Asian countries, where import, export, and income, or rather consumption of oil reserves, are independent variables, and oil production is the dependent variable. The outcome of the analysis was expected to confirm one of the hypotheses: either that the independent variables influence the dependent variable (hypothesis H1) or that the independent variables have no impact on oil production (hypothesis H0). Various tests were employed to select the most appropriate model, leading to the selection and use of the fixed effects model as the best fit for this problem. The analysis concluded that the independent variables have a high predictive ability to explain the dependent variable. Exports, imports, and oil reserves significantly impact oil production in Southwest Asian countries, thereby rejecting hypothesis H0.

In the article by Umar et al. (2020), panel regression analysis is applied to data on international trade in the West African subregion. In addition to trade itself, the authors also focused on foreign direct investment, which represents a significant component of capital flows for developing countries. Therefore, a study was conducted to examine the factors influencing international trade in this region of Africa, creating three models with dependent variables (exports, imports, and trade balance) and the same independent variables for each model (GDP, foreign direct investment, and exchange rate). In this case as well, after testing various types of models, the fixed effects model proved to be the most suitable. The results of the case study indicate that foreign direct investment is a key variable positively influencing international trade policy across West Africa during the observed period.

Another example of regression analysis in the field of international trade is provided by Isik et al. (2016), who examined the relationship between entrepreneurship and innovation in OECD countries from 1990 to 2011. This study utilizes dynamic panel data methods to analyze these relationships. One of the indicators of innovation used in the study is private-sector spending on research and development. The industries considered include pharmaceuticals, computers, electronics and optics, the aerospace industry, and the service sector. The study's results demonstrate that entrepreneurship and innovation have a long-term relationship. Countries that keep pace with trends in innovation and entrepreneurship enjoy greater economic prosperity. An interesting finding by the authors was that Japan was not among these countries; they observed that Japan significantly lagged in terms of overall entrepreneurial activity between 2001 and 2010. On the other hand, the finding that there is no long-term relationship between innovation and entrepreneurship in Turkey is attributed by the authors to the lack of policy frameworks in the country to support scientific and technological studies, which could lead to a greater number of entrepreneurs. This factor is crucial not only in Turkey but must also be considered in other countries.

Xinyan et al. (2023) assessed the impact of exports on the environment in the Beijing-Tianjin-Hebei urban agglomeration. The research article addresses this issue using an improved STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model and panel data from the Beijing-Tianjin-Hebei region for the period 2009-2020. The study also confirmed that GDP per capita and the amount of greenery in these cities have a mitigating effect on environmental pollution. Therefore, promoting ecological development and industrial transformation in this region is important.

From the above examples, it is evident that there are numerous cases and situations within international trade and business where panel data regression analysis is justified. Through this analysis, assumed hypotheses can be confirmed based on the available literature, but some facts can also

be disproved or their certainty reduced. This often leads to interesting insights and reveals new relationships or dependencies. It allows for an in-depth exploration of factors from the perspective of a specific entity (country) and enables decision-making based on the results of the analysis, which could move forward the issue under investigation.

3. METHODOLOGY

This article aims to evaluate the potential and apply panel data analysis in the field of international trade using the quantification of panel analysis with fixed effects, demonstrated through a selected problem.

To achieve the aim, the following hypotheses are set:
- **H1:** With an increase in Gross Domestic Product (GDP) per capita, a decrease in the share of the working population aged 15+ living in poverty is expected.
- **H2:** With an increase in the share of Foreign Direct Investment (FDI) inflows as a percentage of total GDP, a decrease in the share of the working population aged 15+ living in poverty is expected.
- **H3:** With an increase in the share of remittance inflows as a percentage of total GDP, a decrease in the share of the working population aged 15+ living in poverty is expected.
- **H4:** With an increase in the share of total exports of goods and services as a percentage of GDP, a decrease in the share of the working population aged 15+ living in poverty is expected.

The subject of this research (the selected problem) is poverty in African countries. For territorial limitation, the total number of countries in Africa is 54, but due to unavailable data on the dependent variable, which will be introduced later, 47 of them were used in the research. The countries not included in the research are Djibouti, Eritrea, South Sudan, Libya, Equatorial Guinea, Seychelles, and São Tomé and Príncipe. The research is limited to 10 years, specifically from 2013 to 2022.

In the case of proving the hypotheses (H1-H4), the fixed effects model (FEM) will be used. Fixed effects regression (FE) is a method suitable for analyzing causal effects in the social sciences. This method provides unbiased estimates of causal effects even when there are unobserved factors that may influence the outcomes. These unobserved factors are common in the social sciences, making the fixed effects model an important tool in modern social research. These are individual characteristics, such as certain abilities or preferences, that cannot be observed, assuming these characteristics remain constant over time.

To analyze the obtained data using panel data regression analysis, the statistical tool GRETL, which offers the fixed effects model, was utilized. In processing the data within this tool, not only the modeling method was used, but also descriptive statistics and various graphical analyses.

FE regression can be applied to various types of data, but it is most commonly used with panel data. Panel data are usually arranged in a long format, where the observations of each subject are chronologically ordered. The main task of FE regression is to estimate the effect of a causal variable on the outcome variable while accounting for individual effects and group-specific factors (Best & Wolf, 2015).

The model assumes that there is a dependency between the independent variables and individual effects. In the case of the FE model, it is also assumed that the bias caused by omitting

individual factors is specific to the group in question. To eliminate this bias, the intercept αi\
alpha_iαi, which is group-specific, is incorporated into the model. This intercept compensates
for the effect of the omitted variable and is assumed to act in the opposite direction compared
to the bias. The implementation of FE regression is therefore crucial in panel data analysis and
allows for the acquisition of reliable estimates of causal effects, even when unobserved factors
are present (William, 1997).

To express the model in a compact form, let i represent the T-dimensional vector of units y_i and X_t

$$y_i = X_i\beta + i\alpha_i + \mu_i \text{ for } t = 1, \dots, \text{T and } i = 1, \dots n \tag{2}$$

Lukáčiková et al. (2018) state that the estimation of the fixed effects model involves estimating the coefficients β and the unit-specific effect α_i for each unit i. In practice, the models of all cross-sectional units are combined into a single common regression model by adding unit-specific dummy variables d_1 to d_n, which take the value $d_{it} = 1$ for the given i cross-sectional unit. All other cross-sectional units have a value of $d_{it} = 0$. Due to the introduction of dummy variables, this approach is also referred to as the Least Squares Dummy Variable method.

The variables included in this research can be seen in Table 1. Due to the diversity of economies and populations across African countries, it was decided to use GDP per capita. Other elements that describe the state of international trade in Africa and could be significant in addressing poverty include FDI and remittances. Both variables are expressed as a percentage of GDP. The last variable in the model is the export of goods and services, also expressed as a percentage of GDP.

Based on the estimates and assumptions, the expected effects of the individual variables were added to Table 1. These effects correspond to the established hypotheses.

Table 1. List of variables for model and their expected effects

GRETL Label	Variable Name	Variable Description	Expected Value of β
Work_pov_rate	Share of Poor Working Population	The variable represents the percentage of the working population aged 15+ living in poverty (i.e., living below the international poverty line - $2.15/day).	
GDP_pc	Gross Domestic Product per Capita	This variable represents the gross domestic product per capita, expressed in current prices in USD.	-
FDI_inflows_rate_GDP	Share of FDI Inflows as a Percentage of GDP	The variable quantifies the inflow of foreign direct investment expressed as a percentage of gross domestic product.	-
Remit_inflows_rate_GDP	Share of Remittance Inflows as a Percentage of GDP	The variable quantifies the total remittance income expressed as a percentage of gross domestic product.	-
EXP_rate_GDP	Share of Total Exports as a Percentage of GDP	This variable shows the value of total exports of goods and services expressed as a percentage of gross domestic product.	-

Source: Own processing

Basic statistical data of the dataset are displayed in Table 2. The dataset entered into the GRETL software contained the same number of cross-sectional units (47 African countries).

Table 2. Descriptive Statistics of the Variables in Model

Variable Label / Statistic Name	Work_pov_rate	GDP_pc	FDI_inflows_rate_GDP	Remit_inflows_rate_GDP	EXP_rate_GDP
Mean	29,674	2 124,5	3,6876	4,1603	26,564
Median	28,28	1245	2,398	2,217	24,961
Minimum	0,04	241,95	-6,37	0	5,546
Maximum	79,71	11 376	37,336	26,752	84,18
Standard Deviation	22,59	2 156	5,441	5,2027	12,639
Skewness	0,42531	1,8937	3,4195	1,8878	0,75187
Kurtosis	-0,88833	3,4046	15,13	3,3929	0,61865

Source: Own processing

When examining the data, the economic diversity across African countries can be confirmed. GDP per capita shows a high maximum value compared to the average. The statistical data on FDI inflows and remittances are comparable, with minimal differences between their mean and median, which is also true for the standard deviation. A noticeable difference is seen in the minimum values, where FDI values can even be negative. However, negative values for remittances are not possible, so the minimum value is 0. Regarding probability distribution, both variables exhibit right-skewness, meaning most values are left of the mean. On the other hand, the difference in kurtosis coefficients is larger, but this does not change the nature of the probability distribution. In both cases, the distribution is more peaked than a normal distribution, as the kurtosis values are positive. The distribution of export values for goods and services shows a wide variance, with the smallest value at around 5% and the highest reaching 84%, while the mean and median are very close. Considering both the skewness coefficient and the standard deviation, it can be inferred that the distribution is slightly right-skewed, with the most frequent values likely falling in the 10% to 40% range (mean value - standard deviation; mean value + standard deviation).

Based on the selected variables, which were introduced and described through statistical data, we proceeded to define the equation. The final form for the fixed effects model can be seen in the attached equation (3). Based on the descriptive statistics, it would have been appropriate to log-transform the remittance and FDI inflows; however, these data contain zero and negative values. Log-transforming these variables would result in the loss of these values, thereby reducing the total number of observations. Therefore, we chose to use the original data, despite knowing that the variables do not follow a normal distribution.

$$Work\_pov\_rate_{it} = \alpha_i + \beta_1 GDP\_pc_{it_1} + \beta_2 FDI\_inflows\_rate\_GDP_{it_2})$$
$$+ \beta_3 Remit\_inflows\_rate\_GDP_{it_3} + \beta_4 Exp\_rate\_GDP_{it_4} + \mu_{it} \qquad (3)$$

All data on individual African countries used in the model estimates were obtained from the OECD.Stat (2024) statistical database, specifically from the African Development Dynamics section. The complete database contains 31 tables with various attributes across different areas, of which, of course, not all were used.

4.   RESULTS AND FUTURE RESEARCH DIRECTIONS

After defining the model equation, we proceeded to the actual model in GRETL. The results of the fixed effects panel data regression analysis can be seen in Table 3 below. First, it is important to note that the analysis covered nearly all observations from the available data source, excluding only one observation. The total number of observations was 469. GRETL included all African

7

countries from our adjusted list, which comprised 47 countries. The excluded observation resulted from missing data for one country in one specific year. This conclusion is based on the fact that the period of the model spans a minimum of 9 years and a maximum of 10 years.

We can reject the statistical insignificance with 99% confidence for two of the four independent variables, namely:
- We reject the hypothesis of insignificance for the variable GDP_pc, meaning GDP per capita, and therefore the estimated parameter can be interpreted. With an increase in GDP per capita by 1 unit (1 USD), a decrease in the share of the working poor by 0.003 percentage points is expected.
- We reject the hypothesis of insignificance for the estimate of the variable Remit_inflows_rate_GDP, meaning the share of remittance income expressed as a percentage of GDP. With an increase in the share of remittance income by 1 unit (1 percentage point), a decrease in the share of the working poor by 0.41 percentage points is expected.

For the variables FDI inflows and exports of goods and services, we could not reject the null hypothesis of statistical insignificance, and therefore, we conclude that we were unable to confirm the impact of these elements of international trade on the share of the working poor in African countries.

Table 3. Fixed Effects Panel Data Regression Model

Time-series length: minimum 9, maximum 10				
Dependent variable: Work_pov_rate				
Standard errors clustered by unit				
	Coefficient	*Std. Error*	*t-ratio*	*p-value*
const	37,8687	3,12387	12,120	<0,0001 ***
GDP_pc	−0,00345	0,00108	−3,2070	0,0024 ***
FDI_inflows_ rate_GDP	−0,07182	0,07981	−0,8999	0,3728
Remit_inflows_rate_GDP	−0,41254	0,14266	−2,8920	0,0058 ***
Exp_rate_GDP	0,03903	0,09364	0,4168	0,6788
Mean dependent var	29,57198	*S.D. dependent var*	22,50582	
Sum squared resid	10 327,69	*S.E. of regression*	4,970654	
LSDV R-squared	0,956432	*Within R-squared*	0,093807	
Log-likelihood	−1 390,552	*Akaike criterion*	2 883,10	
Schwarz criterion	3 094,78	*Hannan-Quinn*	2 966,39	
rho	0,766184	*Durbin-Watson*	0,262509	

Source: Own calculations

Given that the fixed effects model assumes the heterogeneity of individual cross-sectional units (African countries), we examined whether this holds true for our model. We used a test statistic (F-test), which was also part of the model output, as shown in Table 4. The software calculated that the value of the F-statistic is 742.321, which is greater than the tabulated F value of approximately 1.37 at the 0.05 significance level for F(46; 146.4). Based on this relationship and the p-value (7.05893e-153), we were able to reject the null hypothesis (H0: The cross-sectional units have the same intercepts). This confirmed the appropriateness of the FEM model for our dataset. It indicates that individual African countries have different effects on the resulting share of the working poor and that the values of α_i from equation (3) are different for each country.

This model aimed to examine the effects of selected elements of international trade and business on the rate of so-called working poverty in Africa, specifically in individual countries on the continent. The parameter estimates were interpreted during the research process, but the evaluation will be addressed in this section, where they will also be compared with other studies. Hypothesis

H1 is confirmed, leading to the conclusion that as GDP per capita increases, a reduction in the proportion of the working population living in poverty is expected. This finding underscores the importance of economic development in improving living conditions for the population. However, it is essential to recognize that economic growth alone is not sufficient to solve the problem of poverty. It is presumed that multiple factors, not just an increase in GDP per capita, need to be aligned. A comprehensive approach to poverty reduction is crucial for achieving sustainable and inclusive economic development.

Table 4. F-test

Robust test for differing group intercepts:
Null hypothesis: The groups have a common intercept
Test statistic: Welch F(46; 146,4) = 742,321
with p-value = P(F(46; 146,4) > 742,321) = 7,05893e-153

Source: Own calculations

Hypothesis H2 is rejected, as the study was unable to demonstrate the statistical significance of the estimate regarding Foreign Direct Investment (FDI) on the share of the working poor. Thus, the claim that an increase in FDI inflows would lead to a reduction in poverty rates is rejected. Magombeyi and Odhiambo (2018) examined the impact of FDI on poverty reduction in South Africa. Their results indicate that FDI has a positive impact on poverty reduction in the long term and a negative impact in the short term. The study recommends that poverty reduction policies based on FDI should focus on strengthening social infrastructure, investing in productive sectors of the economy, and examining the impact of other economic variables. Overall, it is concluded that FDI plays a less significant role in poverty reduction in South Africa, and its effect depends on the poverty reduction indicators used. Arogundade et al. (2022) explored the role of FDI in the context of poverty in Sub-Saharan African countries. Their findings suggest that FDI does not have a direct impact on the incidence and intensity of poverty, but its impact on poverty alleviation varies across different regions, indicating the need for specific regional policies. On the other hand, contrasting views are presented by Gohou and Soumaré (2012), who investigated whether FDI can reduce poverty rates in Africa and whether there are regional differences in these effects. This article evaluates the impact of FDI on welfare in African regions. The research used welfare indicators such as the Human Development Index (HDI) and real GDP per capita. A strongly positive connection between FDI and welfare improvement was found across Africa, although the impact varies between regions and is greater in poorer countries. It is assessed that FDI can be particularly beneficial in more productive sectors and less developed countries. To achieve balanced welfare across countries within regions, appropriate regional policies must be established to attract these investments. In further research on the impact of FDI, it would be appropriate to focus on individual economic sectors and examine them in detail. Many African countries have monocultural economies, and the inflow of FDI into unpopular sectors may not have a significant impact on welfare growth. Therefore, it is believed that when considering investments, it would be more appropriate to assess the correct sectors based on the specific country, particularly those crucial for its economy.

The influence of remittance inflows was confirmed, allowing the authors to validate Hypothesis H3. With an increase in the share of remittance inflows relative to total GDP, a reduction in the proportion of the working population aged 15 and above living in poverty is expected. This conclusion underscores the importance of linking economic flows, such as remittances, with social indicators like poverty rates. The results demonstrated that, in the short term, poverty drives remittance inflows when infant mortality is used as an indicator of poverty. However, when household consumption

expenditures were used, no causality between poverty and remittances was found in South Africa, regardless of the time horizon analyzed. Akobeng (2016) observed similar effects in Sub-Saharan African countries, reaching conclusions consistent with those of this research, which utilized the Fixed Effects Model (FEM). The study found that remittances significantly impact poverty and inequality, contributing substantially to their reduction. The study recommended that South Africa continue to support policies that reduce costs and simplify migration processes, thereby stimulating emigration and increasing remittance inflows. Collaboration with emigrant countries is also crucial to streamline policies related to sending money back to South Africa. Remittances also affect poverty reduction and income equalization from a macroeconomic perspective, with these effects being amplified by financial development. The International Monetary Fund should ensure the inclusion of informal and non-financial methods of sending remittances. Policymakers in Africa should consider remittances as a tool for reducing poverty and inequality and prioritize ensuring favorable conditions and policies aimed at lowering remittance costs.

The final hypothesis, H4, was also rejected due to the confirmed insignificance of the *"Exp_rate_GDP"* parameter. Although the hypothesis was rejected based on the available data and analysis, this does not mean that the issue is closed. On the contrary, the authors reviewed studies by other researchers. Skae and Barclay (2007) discuss the need for a comprehensive response to manage the connection and ensure efforts to reduce poverty within the context of a national export strategy. This framework aims to address issues of assignment and aggregation of poverty reduction goals, assign organizational responsibility, and evaluate the impact of initiatives. Balat et al. (2009) examined the impact of exports in rural parts of Africa and concluded that trade has a significant effect on poverty reduction in Uganda. The availability of export opportunities, such as access to markets in developed countries or high international prices for major export crops, can be potentially advantageous.

In future research, it would be beneficial to examine the structure of exports—specifically, what types of goods and services are exported, and whether these products have high added value or are primarily raw materials with low added value. It is also important to determine how export revenues are distributed across different segments of the population. Investigating the impact of institutional factors, such as corruption, political stability, and the quality of government policies, on the effectiveness of exports in reducing poverty is crucial. Analyzing case studies of African countries where exports have contributed to poverty reduction, and identifying key differences from countries where this effect has not been confirmed, would provide valuable insights. Regional differences within Africa should also be considered, as individual countries have different economic conditions and needs. This research should contribute to a better understanding of the complex relationships between exports and poverty, and help create more effective policies for combating poverty.

5. CONCLUSION

This article aimed to assess the potential and apply a panel data analysis in the field of international trade, focusing on the example of poverty in African countries. Through the analysis of fixed effects models, the study found that an increase in GDP per capita is associated with a decrease in the proportion of the working population living in poverty, highlighting the importance of economic growth in improving living conditions. However, it also emphasizes the need for a comprehensive approach to poverty reduction beyond merely increasing GDP per capita. The study did not find statistically significant evidence that an increase in FDI inflows reduces the proportion of the

working poor, suggesting that while FDI may play a role in economic growth, its direct impact on poverty reduction in the context of the African countries studied is not evident. The inflow of remittances, expressed as a percentage of GDP, significantly reduces the proportion of the working poor, emphasizing the crucial role that remittances play in alleviating poverty and highlighting the need for policies that facilitate and maximize remittance inflows. The study did not find significant evidence that an increase in the share of total exports in GDP reduces the proportion of the working poor, indicating that merely increasing export volume without considering the nature and distribution of export revenues may not be sufficient to reduce poverty. Furthermore, this study highlights the critical role of economic development in addressing poverty. The findings emphasize the need for policies that align with the broader objectives of sustainable development, particularly as outlined in the United Nations Sustainable Development Goals. The impact of remittances on poverty reduction suggests that financial flows supporting households can be an effective means of achieving long-term social and economic stability. Overall, the research underscores the complexity of the relationships between economic indicators and poverty, suggesting that targeted and multifaceted strategies are necessary for effective poverty alleviation in African countries. Additionally, the study underscores the necessity of a development-oriented approach to international trade, where economic policies not only foster growth but also contribute to sustainability and equitable wealth distribution. Future research should explore the structural aspects of exports and the regional specifics of the impacts of FDI inflows and exports to gain a deeper understanding of this dynamic. Also, research should further examine how international trade strategies can be integrated with sustainability frameworks to ensure inclusive development that benefits all segments of the population.

Acknowledgment

References

Akobeng, E. (2016). Out of inequality and poverty: Evidence for the effectiveness of remittances in Sub-Saharan Africa. *The Quarterly Review of Economics and Finance, 60*, 207-223. https://doi.org/10.1016/j.qref.2015.10.008

Arogundade, S., Mduduzi, B., & Eita, H. (2022). Foreign direct investment and poverty in sub-Saharan African countries: The role of host absorptive capacity. *Cogent Economics & Finance*, *10*(1). https://doi.org/10.1080/23322039.2022.2078459

Balat, J., Brambilla, I., & Porto, G. (2009). Realizing the gains from trade: Export crops, marketing costs, and poverty. *Journal of International Economics*, *78*(1), 21-31. https://doi.org/10.1016/j.jinteco.2009.01.016

Baltagi, B. H., & Baltagi, B. H. (2021). Test of hypotheses with panel data. Econometric Analysis of Panel Data, 75-108. https://doi.org/10.1007/978-3-030-53953-5_4

Best, H., & Wolf, C. (2015). Logistic regression. The SAGE handbook of regression analysis and causal inference. Los Angeles: Sage, 153-171.

Brugger, B. (2021). A guide to panel data regression: theoretics and implementation with python. Towards data science, 6.

Gallo, A. (2015). A refresher on regression analysis. *Harvard Business Review*, *4*.

Gohou, G., & Soumaré, I. (2012). Does Foreign Direct Investment Reduce Poverty in Africa and are There Regional Differences? *World Development, 40*(1), 75-95. https://doi.org/10.1016/j.worlddev.2011.05.014

Gunst, R. F., & Mason, R. L. (2018). *Regression analysis and its application: a data-oriented approach*. CRC Press. https://doi.org/10.1201/9780203741054

Isik, H. B., Nihat, I. Ş. I. K., & Kilinc, E. C. (2016). The Relationship between Entrepreneurship and Innovation: A Dynamic Panel Data Analysis. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *11*(3), 7-20.

Lukáčiková, A., Lukáčik, M., & Szomolányi, K. (2018). Úvod do ekonometrie s programom Gretl. Bratislava: Letra Edu, 345.

Magombeyi, M. T., & Odhiambo, N. M. (2018). Dynamic impact of FDI inflows on poverty reduction: Empirical evidence from South Africa. *Sustainable Cities and Society*, *39*, 519-526. https://doi.org/10.1016/j.scs.2018.03.020

OECD.Stat. (2024). Africa's Development Dynamics - Statistical Annex. https://stats.oecd.org/Index.aspx?ThemeTreeId=9.

Rahman, A., Muda, I., Caroline, C., Panjaitan, P. D., & Situmorang, R. Y. (2022). The panel data regression: relationship of the exports, imports and intake of oil reserves son oil production levels in southwest asian countries to contribute to state revenue (The implement of International Trade Theory). *International Journal of Professional Business Review, 7*(3), e0593. https://doi.org/10.26668/businessreview/2022.v7i3.0593

Sarstedt, M., & Mooi, E. (2019). Regression Analysis. *Springer Texts in Business and Economics*, 209-256. https://doi.org/10.1007/978-3-662-56707-4_7

Skae, F. O., & Barclay, B. (2007). Managing the linkage between export development and poverty reduction: an effective framework. *Management Decision*, *45*(8), 1208-1223. https://doi.org/10.1108/00251740710819005

Sul, D. (2019). Panel data econometrics: Common factor analysis for empirical researchers. Routledge. https://doi.org/10.4324/9780429423765

Suparman, S. (2022). Relationship Between Economic Growth, Income Inequality and Poverty by Provinces in Indonesia: Panel Data Regression Approach. *International Journal of Environmental, Sustainability, and Social Science*, *3*(1), 103-108. https://doi.org/10.38142/ijesss.v3i1.167

Umar, Y. H., Muhammad, B., & Omoren, U. (2020). Panel Data Analysis of International Trade in West African Sub Region. *American Journal of Theoretical and Applied Statistics*, *9*(4), 106-120. https://doi.org/10.11648/j.ajtas.20200904.14

United Nations. (2024). Department of Economic and Social Affairs. The 17 goals. https://sdgs.un.org/goals

William, H. (1997). Greene. Econometric Analysis.

Xinyan, M., Jinmin, L., Han, W., Yuan, T., & YuXin, Z. (2023). Assessing the environmental impact of export trade on the Bejing-Tianjin-Hebei urban agglomeration. An analysis using the spatial panel stirpat model. *Environmental Engineering & Management Journal (EEMJ)*, *22*(8), 1399-1411. https://doi.org/10.30638/eemj.2023.117

Zulfikar, R., & STp, MM. (2018). Estimation model and selection method of panel data regression: An overview of common effect, fixed effect, and random effect model. *JEMA: Jurnal Ilmiah Bidang Akuntansi*, *9*(2), 1-10. https://doi.org/10.31227/osf.io/9qe2b

Analyzing the Snowball Effect on Public Debt Dynamics and Its Determinants: The Case of North Macedonia

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Abstract: *Maintaining healthy public finances is essential for financial stability and economic growth. This study examines Macedonian public debt dynamics from 2002 to 2023, focusing on the primary budget balance, the interest-growth differential (snowball effect), and stock-flow adjustments. The snowball effect, where the debt ratio changes based on whether GDP growth surpasses or lags behind interest rates, is emphasized. Recent challenges include sluggish economic growth due to declining external demand and rising food and energy prices, coupled with increasing interest rates, exacerbating the snowball effect. Using the Ordinary Least Squares (OLS) method, the study analyzes how macroeconomic variables like foreign direct investment, trade openness, and unemployment, alongside institutional factors such as government effectiveness and corruption, influence debt dynamics. Policy recommendations stress the need for enhanced fiscal discipline, measures to stimulate economic growth, and improved institutional frameworks to mitigate the adverse effects of the snowball effect on public debt.*

1. INTRODUCTION

Public debt sustainability has gained significant attention in recent years, particularly during and after the 2008 global financial crisis, the COVID-19 pandemic, and the ongoing conflict in Ukraine. The continually growing levels of public debt have become a primary concern, as Debt-to-GDP ratios have surged globally as governments capitalized on historically low interest rates and adopted expansionary fiscal policies during times of crisis. Globally, the Debt-to-GDP ratio has seen significant changes from 2007 to 2023. In 2007, the global average Debt-to-GDP ratio was around 57%. This ratio increased to 97% by 2021 due to various fiscal policies and economic challenges, including the financial crisis and the COVID-19 pandemic (IMF, 2021a). By the end of 2022, the global Debt-to-GDP ratio had reached 238%, indicating a continued upward trend despite efforts to manage debt levels post-pandemic (IMF, 2022). However, in 2023, the global debt stock reached a staggering $307 trillion, with the global Debt-to-GDP ratio stabilizing just below 335% (IFF, 2023). In Europe, the Debt-to-GDP ratio also experienced significant fluctuations. In 2007, the average Debt-to-GDP ratio in the European Union (EU) was 62%. This ratio increased to 90% by 2021 due to various fiscal policies and economic challenges (European Commission, 2021). As of the end of 2022, the Debt-to-GDP ratio in the EU was recorded at 83.4%, showing a slight decrease from the previous year (European Commission, 2022). These statistics underscore the significant fiscal pressures faced by countries worldwide.

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In line with this, Macedonia's government debt has followed an intriguing trajectory over the last two decades. In 2008, the government debt was at its historical lowest level, standing at only 20,6% of GDP. Then, over the subsequent 8 years, the debt has doubled, reaching 40,4% of GDP in 2016. Later, the crisis caused by the Covid-19 virus in 2020 had a very profound effect on Macedonia's debt. In just one year, the debt increased by more than 1 billion euros, equal to an increase of over 20 percentage points, reaching 50,8% of GDP in 2020. Finally, the energy crisis intensified by the war in Ukraine in 2022, brought the government debt to its historical highest level of 54,6% of GDP in 2023.

However, the concept of fiscal sustainability indicates that debt-to-GDP ratios cannot grow indefinitely, as this would require continuous tax increases and reductions in government spending on public goods and services. Fiscal sustainability and public debt sustainability are closely related, both referring to a government's ability to meet its debt obligations over the long term (Cottarelli & Moghadan, 2011). According to the International Monetary Fund (IMF), maintaining fiscal sustainability involves ensuring that a government's debt remains on a stable path over time without large adjustments in revenues or expenditures (IMF, 2021b). The World Bank also emphasizes that high and rising public debt can constrain a government's ability to respond to economic shocks and invest in growth-promoting initiatives, ultimately impacting long-term economic stability (World Bank, 2022). Furthermore, Reinhart and Rogoff (2010) argue that when debt levels exceed certain thresholds, economic growth tends to slow down, highlighting the importance of sustainable debt levels for economic health. These perspectives underscore the need for balanced fiscal policies that support economic growth while maintaining debt at manageable levels.

Economic theory identifies three main drivers of public debt accumulation: the primary balance, the snowball effect (interest-rate-growth differential), and deficit-debt adjustments (Boussard et al., 2013; Georgescu, 2014; Heylen et al., 2013). The primary balance reflects the difference between government revenues and expenditures, excluding interest payments. The snowball effect involves the interaction between interest rates and GDP growth, influencing debt dynamics. Deficit-debt adjustments account for factors such as exchange rate fluctuations and stock-flow adjustments.

The "snowball effect" in public debt dynamics refers to the process where the interest rate on debt and the growth rate of the economy interact to influence the overall debt level. When the interest rate on public debt exceeds the economic growth rate, the debt grows exponentially, compounding the burden on the government. Conversely, if the economic growth rate surpasses the interest rate, it helps in stabilizing or even reducing the debt-to-GDP ratio over time (Blanchard, 1990).

In this study, we examine the snowball effect by analyzing the components such as interest rates, GDP growth, and inflation. This involves decomposing the debt dynamics into contributions from the primary balance, interest rate-growth differential (snowball effect), and other factors like deficit-debt adjustments. The period analyzed spans from 2002 to 2023, providing insights into how these components have influenced Macedonia's public debt as well as the main determinants of the snowball effect.

The structure of the paper is organized as follows: Section 2 provides a comprehensive review of the empirical literature on the topic. Section 3 presents an overview of fiscal variables and the economic growth trends in North Macedonia over the past two decades. Section 4 details the data collection process, outlines the methodology employed in the research and presents the results. Finally, Section 5 offers a discussion of the findings, along with concluding remarks and implications for policy and future research.

2. EMPIRICAL LITERATURE REVIEW

Fiscal sustainability refers to a government's ability to maintain sound public finances over the long term without requiring excessive fiscal adjustments. This concept is multi-dimensional, encompassing various academic, policy, and pragmatic approaches. Academically, fiscal sustainability involves inter-temporal solvency, where the initial debt plus the discounted value of future primary expenditures equals the discounted value of future incomes (Blanchard, 1990). The IMF categorizes these definitions into academic, policy, and pragmatic approaches. Policy-wise, debt sustainability implies that a country or its government does not need to default, renegotiate, or restructure its debt, nor make drastic policy adjustments in the future (IMF, 2021b). Pragmatically, public debt is considered sustainable if projected debt ratios are stable or declining and are low enough to avoid default. The European Central Bank defines fiscal sustainability as a government's capacity to service its long-term obligations, which requires solvency, i.e., the ability to repay future debts (ECB, 2012).

Historical perspectives from Buiter (1985), Hamilton and Flavin (1986), and Blanchard (1990) contribute significantly to our understanding of public finance sustainability. Buiter (1985) asserts that fiscal policy is sustainable if the government's net value, in terms of GDP, is maintained. Hamilton and Flavin (1986) empirically test the inter-temporal budget constraint rule, while Blanchard (1990) suggests that sustainable fiscal policy ensures the debt-to-GDP ratio returns to its initial level.

Numerous studies have examined the determinants and implications of public debt. Eichengreen and Portes (1986) find a negative correlation between public debt and economic growth. Sinha et al. (2011) highlight economic growth as a critical determinant of public debt, showing a negative correlation. Hall and Sargent (2011) indicate that economic growth significantly reduced the debt-to-GDP ratio in the United States, with inflation contributing to debt reduction. Aizenman and Marion (2011) demonstrate that moderate inflation can significantly decrease the debt-to-GDP ratio. Bittencourt (2015) emphasizes the importance of economic activity in reducing public debt, showing that a 1% increase in economic growth leads to a 0.7% reduction in public debt. Kudła (2019) investigates the determinants of public indebtedness in European Union countries, emphasizing the role of the snowball effect and specifically analyzing the determinants of the interest-rate-growth differential and changes in government assets.

Additionally, several recent studies have provided further insights into the determinants of the snowball effect on public debt dynamics. Checcherita-Westphal (2019) discussed the critical role of the interest-rate-growth differential in government debt dynamics, finding that the differential has turned negative in many advanced economies, which could imply the potential for higher debt sustainability even with primary deficits. Nguyen and Luong (2021) investigated the impact of fiscal policy and institutional quality on public debt in transition countries, demonstrating that improving governance can significantly reduce public debt accumulation. Al Yahya (2019) examined how governance affects public debt accumulation in the Arabian Gulf countries, finding that good governance can reduce borrowing costs and manage financial risk, thereby lowering public debt levels.

These studies collectively provide valuable insights into the factors influencing public debt dynamics and the critical role of the interest-rate-growth differential. They emphasize the importance of understanding these determinants to formulate effective fiscal policies that ensure debt sustainability.

3. GOVERNMENT DEBT INDICATORS – STYLIZED FACTS

The following section briefly analyzes the key fiscal variables and the economic growth in the Republic of North Macedonia over the last two decades. As graph 1. shows, the fiscal variables since 2002 have shown in general adverse trends, particularly during 2008-2016 and from 2020 onward. In particular, the Macedonian government debt has followed a very intriguing trajectory. In the period before the financial crisis, the government debt was decreasing and in 2008 it reached a historically low level of 20.6% of GDP. However, from 2008, within just 8 years, the debt has doubled and exceeded 40% of GDP in 2016. Later, following a brief phase of fiscal consolidation between 2016 and 2020, the COVID-19 pandemic crisis sharply escalated the debt within a year, from 40,4% in 2019 to 50,8% in 2020. Hence, while Macedonia's government debt level (around 54% of GDP in 2024) may not be very high, the rapid acceleration of debt accumulation in recent years is cause for concern.
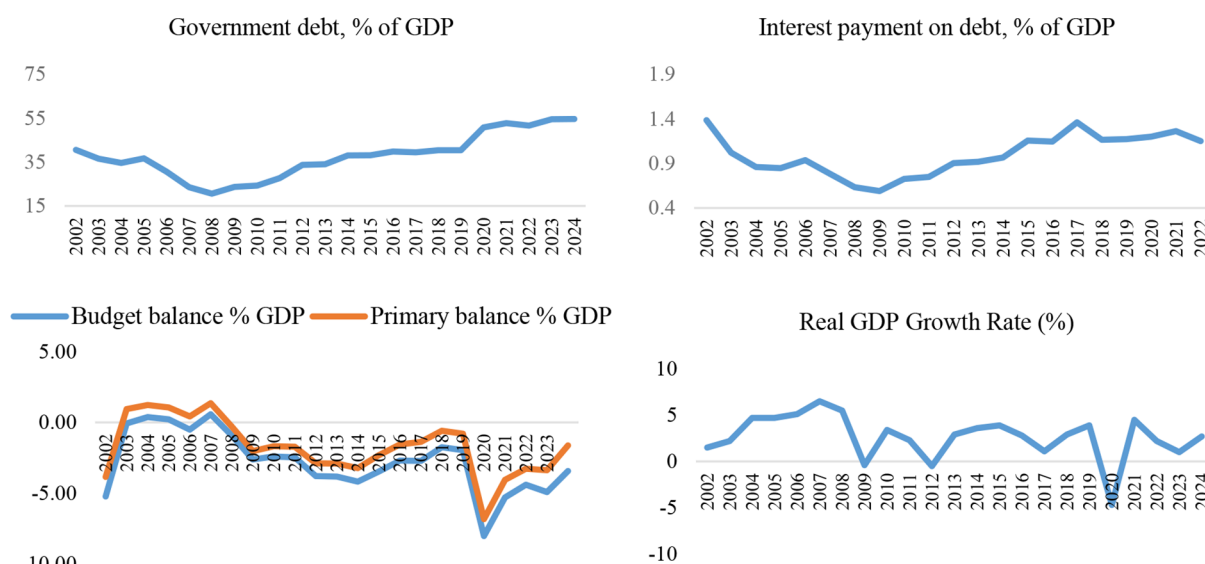
Graph 1. Fiscal variables and Real GDP growth rate
in the Republic of North Macedonia, 2002-2024
Source: Ministry of Finance of the Republic of North Macedonia (n.d.)

The large debt increase naturally led to higher interest payment costs in the analyzed period (the interest cost related to GDP increased from 0,58% in 2009 to 1,36% in 2017), spreading the gap between the primary and overall budget balance, as shown on graph 1.

The primary budget balance, which excludes interest payments, is a key factor in debt accumulation. The primary balance more accurately reflects the present fiscal policy stance by not including interest expenses related to fiscal policy decisions in the previous period. As can be observed from the previously shown debt dynamics, primary surpluses were recorded in the period before the fiscal crisis (peaking at 1.4% of GDP in 2007). However, from 2008 onward, the primary budget balance was consistently in deficit, averaging -2,4 % of GDP.

Economic growth, on the other hand, is a key macroeconomic variable with the most significant impact on the country's public debt sustainability. Higher GDP growth rates, other things being equal, lead to a reduction in the debt-to-GDP ratio and vice versa. In the analyzed period from 2002 to 2023, the economic growth in the Republic of N. Macedonia remained relatively modest, with the real GDP growth rate averaging around 2.7%. Moreover, the second crisis within the

analyzed timeframe, COVID-19 crisis had a more detrimental effect on economic growth, than the financial crisis in 2008 (causing the highest negative real growth rate of -4,5% in 2020). Therefore, we can anticipate that public debt servicing will pose an even greater challenge in the near future.

4.   DATA, METHODOLOGY AND RESEARCH RESULTS

4.1. "Snow-Ball" Effect on Public Debt and Its Components

To determine the driving factors of government debt in the Republic of North Macedonia, we performed a conventional dynamic analysis of government debt sustainability. This analysis is based on data from the central government budget and general government debt provided by the Ministry of Finance, GDP and inflation data from the National Bank of the Republic of North Macedonia and the State Statistical Office, covering the period from 2004 to 2023.

Our analysis incorporates the concept of the primary budget balance, calculated as the difference between the actual budget balance and the interest payments on government debt. The annual interest rate on government debt is computed as the ratio of annual interest paid to the government debt outstanding. The GDP deflator is used as an indicator of inflation.
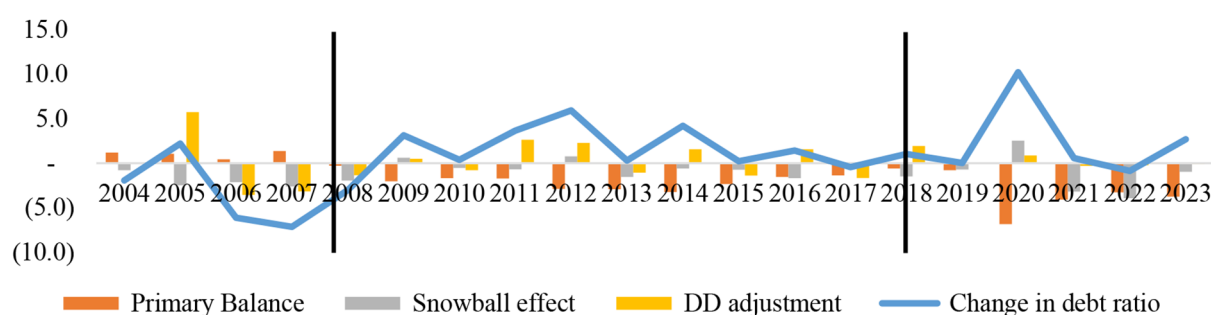
Graph 2. Dynamics of driving factors on public debt

Source: Own calculations based on National Bank of the Republic of North Macedonia (n.d.), State Statistical Office of the Republic of North Macedonia (n.d.), Ministry of Finance of the Republic of North Macedonia (n.d.)

The dynamic analysis of government debt in the Republic of North Macedonia from 2004 to 2023 reveals significant trends and underlying factors influencing debt sustainability, as shown in Graph 2. The graph illustrates persistent primary deficits throughout the period, with notable deficits during the global financial crisis of 2008/09 and the COVID-19 pandemic in 2020. These deficits reflect the government's fiscal policies aimed at stimulating the economy during downturns but have significantly contributed to the overall debt increase. The snowball effect represents the impact of nominal GDP growth and inflation relative to the interest rate on debt. Positive snowball effects (negative values in the graph) indicate periods where economic growth and inflation out-paced interest rates, thereby reducing debt pressures. This effect is particularly noticeable during economic recovery periods such as post-2008 and post-2020, indicating effective debt allevia-tion during these times. The Debt Dynamics (DD) adjustments show sporadic spikes, indicating sudden fiscal adjustments or policy changes, often reflecting extraordinary fiscal measures or corrections in accounting that impact the overall debt ratio. The overall change in the debt ratio captures the cumulative impact of the primary balance, snowball effect, and DD adjustments. The graph highlights sharp increases in the debt ratio during the 2008/09 financial crisis and the 2020 pandemic, reflecting periods of significant fiscal stress. Despite these challenges, the debt

ratio shows periods of stabilization, particularly in the mid-2010s, and improvement post-2021, suggesting a trend toward economic recovery and enhanced fiscal discipline.

Furthermore, we conduct an in-depth analysis of the components of the "snowball effect". The following graph 3 illustrates how the interest rate effect consistently contributes to the snowball effect, with peaks during economic crises. The growth effect varies, showing significant contributions during economic expansions and negative impacts during downturns. The inflation effect generally provides a stabilizing influence, mitigating some of the interest rate burdens. The snowball effect fluctuates, with spikes during crises, highlighting periods of increased debt burden, while negative values indicate periods where economic growth and inflation help reduce the overall debt burden.
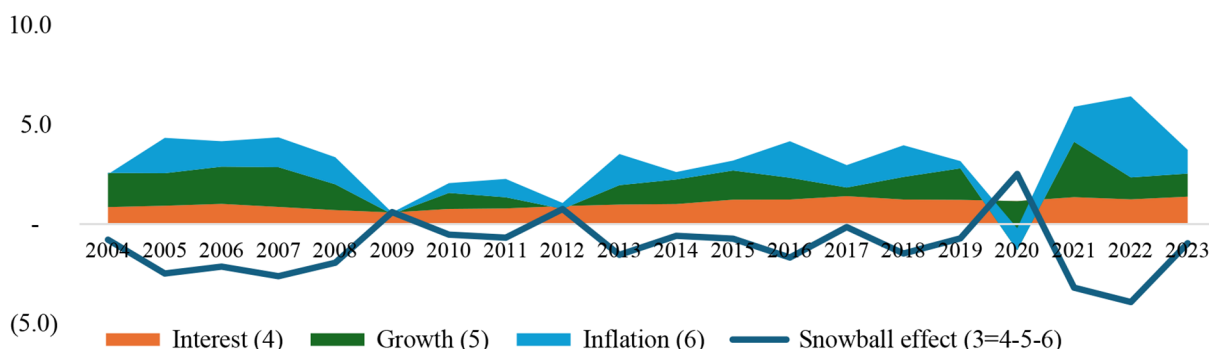

Graph 3. Dynamics of driving factors on "snowball" effect

Source: Own calculations based on National Bank of the Republic of North Macedonia (n.d.), State Statistical Office of the Republic of North Macedonia (n.d.), Ministry of Finance of the Republic of North Macedonia (n.d.)

4.2. Determinants of "Snow-Ball" Effect

To further understand public debt dynamics in North Macedonia, we investigate the determinants of the snowball effect. Our analysis highlights that the snowball effect, characterized by the interest rate-growth differential, is a pivotal factor in shaping public debt sustainability. By systematically examining key macroeconomic and institutional variables, we aim to identify the underlying factors that influence this differential (snow-ball effect).

There is no single answer in the literature to the question of which methodological approach to apply. For example, in a review of the empirical literature we have seen that different studies use different types of statistical techniques, from the simplest least squares method to more complex techniques (separating short-term from long-term dynamics). Hence, the general regression equation for estimating the determinants of the snowball effect can be written as follows:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_n x_{ni} + \varepsilon_i \tag{1}$$

where, y_i is the dependent variable, which is snowball effect, $x_{1i}, x_{2i}, \ldots x_{ni}$ are explanatory variables: macroeconomics (FDI, trade openness, unemployment) and institutional (government effectiveness and corruption); $\beta_0, \beta_1, \beta_2, \ldots \beta_n$ are the parameters to be calculated, and ε_i is the error term that contains other factors that affect the dependent variable and are not included in the independent variables. According to the null conditional mean assumption (Wooldridge, 2006, p. 27), the error term has an expected value of zero if the covariance between it and the independent variables is zero (there is no relationship between the error term and the independent variables).

Table 1. OLS estimation, Results

Dependent Variable: SNOWBALL_EFFECTS			
Independent Variable	Coefficient	Coefficient	Coefficient
	(1)	(2)	(3)
C	17.680*	15.273**	12.908
FDI_GDP	0.091		
TRADE_OPENNES	-0.084*	-0.071**	-0.066*
UNEMPLOYMENT_RATE	-0.340**	-0.299**	-0.258**
GOVERNMENT_EFFECTIVNESS	-7.120*	-7.154*	-6.201
CONTROL_OF_CORRUPTIONS	3.230	2.849	
R-squared	39.92%	38.99%	29.91%

Notes: *, ** and ** indicate rejection of the null hypothesis that the coefficient is not statistically different from zero at 10%, 5%, and 1% significance levels.

Source: Own calculations

The more appropriate method for solving the above equation is the Ordinary Least Squares (OLS) method. This method estimates the coefficients by minimizing the sum of the square deviations between the calculated and the actual values (Gujarati, 2003, p.58). The results are shown in table 1. We employ multiple regressions to get more robust results.

The results of the OLS estimation provide significant insights into the determinants of the interest rate-growth differential effect, commonly referred to as the "snowball" effect. The primary factors under consideration are trade openness, unemployment rate, and government effectiveness. These variables play crucial roles in shaping public debt sustainability by influencing the differential between interest rates on public debt and economic growth rates (snow-ball effect).

Trade openness is found to have a statistically significant negative coefficient across all models, indicating its critical role in mitigating the snowball effect. This relationship suggests that higher levels of trade openness enhance a country's economic growth and external competitiveness. By integrating more fully into the global economy, countries benefit from increased export opportunities, technological spillovers, and greater efficiencies in resource allocation. These benefits collectively contribute to higher growth rates which, in turn, reduce the relative burden of interest rates on public debt. This aligns with existing literature that emphasizes the positive growth effects of trade liberalization and its role in improving fiscal health (Frankel & Romer, 1999). Government effectiveness is another critical determinant, evidenced by its significantly negative coefficient in models (1) and (2). Enhanced government effectiveness reflects better-quality governance, characterized by sound fiscal policies, effective public administration, and minimal corruption. These attributes contribute to an efficient allocation of resources and improved economic management, which are vital for sustaining economic growth and controlling public debt levels. Effective governance ensures that fiscal policies are conducive to growth, thereby reducing the interest rate-growth differential. This relationship is well-documented in the literature, where effective governance is often correlated with favorable economic outcomes and sustainable debt trajectories (Al Yahya, 2019). The unemployment rate exhibits a significantly negative coefficient in all regressions, suggesting an inverse relationship with the snowball effect. Specifically, an increase in the unemployment rate is associated with a reduction in the snowball effect. This means that surprisingly, higher unemployment leads to a smaller differential between interest rates and economic growth rates, which has a positive impact on public debt dynamics. Higher unemployment might lead to lower inflation and interest rates, as central banks may adopt more accommodative monetary policies to stimulate the economy (Blanchard & Summers, 1986). Lower interest rates reduce the cost of servicing public debt, thereby mitigating the snowball effect. Furthermore, lower

economic activity might reduce the need for new borrowing, stabilizing debt levels. In summary, an increase in the unemployment rate, while generally negative for the economy, appears to reduce the snowball effect due to lower interest rates and reduced borrowing needs, leading to a more favorable impact on public debt dynamics. This finding highlights the complex interactions between labor market conditions, monetary policy, and public debt sustainability.

5. CONCLUSION

This study investigated the dynamics of public debt and the determinants of the snowball effect in North Macedonia from 2002 to 2023, providing critical insights into the country's fiscal sustainability. The analysis revealed a significant increase in the debt-to-GDP ratio, which doubled from 20.6% in 2008 to over 50% by 2023, driven by external shocks and domestic fiscal policies. The primary budget balance, excluding interest payments, consistently showed deficits, particularly during economic downturns, significantly contributing to debt accumulation.

The snowball effect, characterized by the interplay between interest rates and GDP growth rates, emerged as a crucial factor in debt dynamics. Positive economic growth and inflation often outpaced interest rates, mitigating some of the debt burden. However, periods of high interest rates and low growth exacerbated debt levels. Key macroeconomic variables, such as trade openness and unemployment rates, significantly influenced the snowball effect. Increased trade openness and unemployment rates positively impacted growth rates, thereby reducing the debt burden relative to GDP. Institutional factors, such as government effectiveness, also played a critical role in shaping debt sustainability. Effective governance contributes to better fiscal management, which in turn leads to lower debt ratios.

The findings underscore the necessity for policies that foster economic growth, enhance trade openness, and improve institutional quality. Strengthening fiscal discipline, controlling primary deficits, and ensuring efficient resource allocation are essential for maintaining public debt sustainability. Additionally, improving trade openness and government effectiveness can significantly impact debt dynamics, ensuring that economic growth translates into sustainable debt levels.

In conclusion, North Macedonia's experience highlights the complex interplay between fiscal policies, economic growth, and institutional quality in managing public debt. By focusing on these areas, policymakers can better navigate the challenges of public debt sustainability, ensuring long-term economic stability and growth. This comprehensive approach is vital for creating a resilient economic environment that can withstand future shocks and maintain fiscal health.

References

Aizenman, J., & Marion, N. (2011). Inflation and debt dynamics. *Journal of Applied Finance & Banking, 1*(1), 51-69.

Al Yahya, B. B. A. (2019). The effect of governance on public debt: an empirical investigation for the Arabian Gulf countries. *Journal of Economic Studies, 46*(4), 812-841. https://doi.org/10.1108/JES-07-2017-0168

Bittencourt, M. (2015). Determinants of public debt in middle-income countries: The role of financial crises. *Emerging Markets Finance and Trade, 51*(4), 841-853. https://doi.org/10.1080/1540496X.2015.1056002

Blanchard, O. (1990). Suggestions for a new set of fiscal indicators. *OECD Economics Department Working Papers, No. 79.* OECD Publishing. https://doi.org/10.1787/5kmlbz5jpc4t-en

Blanchard, O. J., & Summers, L. H. (1986). Hysteresis and the European unemployment problem. *NBER Macroeconomics Annual, 1*, 15-78. https://doi.org/10.1086/654013

Boussard, J., de Castro, F., & Salto, M. (2013). Fiscal multipliers and public debt dynamics in consolidations. *European Economy - Economic Papers*, 460. https://doi.org/10.2765/40381

Buiter, W. H. (1985). A guide to public sector debt and deficits. *Economic Policy, 1*(1), 13-61. https://doi.org/10.2307/1344612

Checherita-Westphal, C. (2019). Interest rate-growth differential and government debt dynamics. *European Central Bank Economic Bulletin, 2*, 1-18.

Cottarelli, C., & Moghadan, P. R. (2011). Fiscal adjustment: Theoretical aspects and some country experiences (IMF Working Paper WP/11/142). International Monetary Fund. https://doi.org/10.5089/9781455260433.001

ECB. (2012). Ensuring fiscal sustainability in the euro area. https://www.ecb.europa.eu/pub/pdf/other/art1_mb201104en_pp61-77en.pdf?7e60e35118a9713b28501fa1819b9880

Eichengreen, B., & Portes, R. (1986). Debt and default in the 1930s: Causes and consequences. *European Economic Review, 30*(3), 599-640. https://doi.org/10.1016/0014-2921(86)90072-1

European Commission. (2021). *European Economic Forecast: Spring 2021.* Brussels.

European Commission. (2022). *European Economic Forecast: Winter 2022.* Brussels.

Frankel, J. A., & Romer, D. (1999). Does trade cause growth? *American Economic Review, 89*(3), 379-399. https://doi.org/10.1257/aer.89.3.379

Georgescu, G. (2014). Fiscal sustainability in emerging Europe: Lessons from the global crisis. *International Economics and Economic Policy, 11*, 411-423. https://doi.org/10.1007/s10368-014-0283-7

Gujarati, D. N. (2003). *Basic Econometrics* (4th ed.). New York: McGraw-Hill.

Hall, G. J., & Sargent, T. J. (2011). Interest rate risk and other determinants of post-WWII U.S. government debt/GDP dynamics. *American Economic Journal: Macroeconomics, 3*(3), 192-214. https://doi.org/10.1257/mac.3.3.192

Hamilton, J. D., & Flavin, M. A. (1986). On the limitations of government borrowing: A framework for empirical testing. *The American Economic Review, 76*(4), 808-819.

Heylen, F., Hoebeeck, A., & Buyse, T. (2013). Government efficiency, institutions, and the long-run impact of fiscal policy on economic activity. *European Economic Review, 58*, 54-79. https://doi.org/10.1016/j.euroecorev.2012.11.001

IFF. (2023). *Global Debt Monitor.* Washington, DC.

IMF. (2021a). *World Economic Outlook: Recovery During a Pandemic.* Washington, DC.

IMF. (2021b). *Fiscal Monitor: A Fair Shot.* Washington, DC.

IMF. (2022). *World Economic Outlook: Managing Divergent Recoveries.* Washington, DC.

Kudła, J. (2019). Determinants of public indebtedness in European Union countries. *Economic Research-Ekonomska Istraživanja, 32*(1), 1-16. https://doi.org/10.1080/1331677X.2019.1638291

Ministry of Finance of the Republic of North Macedonia. (n.d.). https://finance.gov.mk

National Bank of the Republic of North Macedonia. (n.d.). https://www.nbrm.mk

Nguyen, T. A. N., & Luong, T. T. H. (2021). Fiscal policy, institutional quality, and public debt: Evidence from transition countries. *Sustainability, 13*(19), 10706. https://doi.org/10.3390/su131910706

Reinhart, C. M., & Rogoff, K. S. (2010). Growth in a time of debt. *American Economic Review, 100*(2), 573-578. https://doi.org/10.1257/aer.100.2.573

Sinha, T., Arora, V., & Bansal, R. (2011). Economic growth and debt dynamics. *Journal of Applied Finance & Banking, 1*(1), 51-69.

State Statistical Office of the Republic of North Macedonia. (n.d.). https://www.stat.gov.mk

Wooldridge, J. M. (2006). *Introductory Econometrics: A Modern Approach* (3rd ed.). Mason, OH: Thomson South-Western.

World Bank. (2022). *Global Economic Prospects.* Washington, DC. https://doi.org/10.1596/978-1-4648-1742-1

Drivers and Barriers to the Competitiveness of Rural Areas in Bulgaria

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Abstract: *Rural areas are diverse and they offer specific sets of economic, social, and environmental functions crucial for sustainable development of countries. Based on that, they compete for investments, tourists, and population, leading to regional imbalances. This study is about the multifaceted dynamics of rural competitiveness in Bulgaria, aiming to reveal its complex nature, the key drivers and the barriers to growth. The main goal is to examine the factors influencing the competitiveness of rural areas in Bulgaria in various dimensions. The mixed-methods approach for analysis is applied, and results present comprehensive knowledge for policymakers, stakeholders, and researchers interested in sustainable rural development. The study provides insights into the most and least competitive rural areas in Bulgaria, based on the constructed index of competitiveness, and suggests practical recommendations for informed policy implementation and governance.*

1. INTRODUCTION

The rural areas across different regions show significant diversity, playing a crucial role in providing a wide range of economic, social, and environmental functions. To ensure that rural areas can continue to fulfil these vital functions, the European Commission has developed an extensive plan for the European Union's (EU) rural areas until 2040 (European Commission, 2021). It focuses on strategies to enhance the strength, connectivity, resilience, and overall prosperity of rural regions and communities. The EU Rural Action Plan, in combination with a Rural Pact, encompasses specific flagship initiatives and innovative instruments aimed at effectively achieving territorial cohesion, new opportunities for innovative businesses, access to quality jobs and promoting new and improved skills, better infrastructure and services, accelerating the role of sustainable agriculture and diversified economic activities (European Commission, 2024). This territorial development approach also introduces new forms of coordination and cooperation, including top-down and bottom-up initiatives. Moreover, it emphasizes the need to identify and valorize resources and identities specific to the respective territory. Namely, the way in which it differs from the others ensures a basis for the competitive advantage of the territory in terms of natural and climatic conditions, geographic features, historical heritage and cultural traditions, demographic and societal changes, human capital and knowledge capacity for innovations and sustainability, national and regional specifics, and economic prosperity (European Commission, 2021). Thus, the EU Rural Action Plan focuses on key elements of territorial competitiveness, encouraging activities and processes to address specific challenges of rural areas in Europe. The

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successful implementation of this plan requires the integration of policies and funds through coordinated investments in infrastructure, human capital, and innovation, perceived as vital for enhancing the competitiveness of rural areas.

Achieving territorial competitiveness is a complex process comprising the production of competitive local products and social, cultural, and natural sustainability based on interregional cooperation. It covers the multifaceted nature of sustainable rural development and the various factors contributing to a rural area's ability to thrive in a modern, globalized knowledge-based economy. Therefore, this study thoroughly explores the complex dynamics of rural competitiveness in Bulgaria, seeking to identify the key drivers of growth and the barriers that hinder prosperity. Understanding these factors is crucial for the design of effective policies to support rural development and exploit regional economic advantages in rural planning for positive impacts. Through a review of existing literature and comprehensive empirical analysis, this paper offers valuable insights for policymakers, stakeholders, and researchers interested in the sustainable advancement of rural communities. The primary objective is to examine the factors influencing the competitiveness of rural areas in Bulgaria in various dimensions.

In this opening section, we introduce the research topic, providing background information and the rationale for the study. The next two sections briefly explore the concept of territorial competitiveness and provide an overview of rural areas in Bulgaria. The methodology is presented in the fourth section, while the fifth one focuses on the results and a discussion of their significance. Finally, the last section concludes the study and offers recommendations.

2.   THE CONCEPT OF TERRITORIAL COMPETITIVENESS

The concept of "competitiveness" and the lack of a single definition for it has given rise to many discussions. In the broadest sense, competitiveness refers to the propensity and capacity to compete to build and maintain market positions and increase market share and profitability (Filo, 2007). Nevertheless, even before 1990, Porter had paid attention to regions and competing nations, not just companies. The cross-sectoral concept of clusters is developed, considering firms and organizations whose activities are not only linked financially and technologically but are also close in location and thus coincide on many levels. Porter (1990) also examines the role of geographic concentration of related activities in the overall innovation activity of a national economy, focusing mainly on the learning processes that underlie innovation. Standard accounts of agglomeration suggest that the geographic concentration of activities enables and facilitates knowledge spillovers and the associated positive externalities (Porter, 1990).

According to others, like Siebert (2000), the competitiveness of firms is simply a separate concept from that of geographic areas. He states that competitiveness exists on at least three levels: firms, geographies, and workers. Regions and countries compete with each other for mobile factors of production in factor markets, while firms compete for market shares. (Siebert, 2000)

Territorial competitiveness is also affected by the regionalization of public policy due to the relocation of the decision-making process and coordination of activities at the regional level. Within government circles, there is growing interest in the regional foundations of national competitiveness and the development of new regional policy interventions to help improve the competitiveness of each region and major city and, hence, of the national economy as a whole. Integrating sustainability principles to balance economic growth with environmental preservation and social

equity ensures that competitiveness is achieved while enhancing long-term ecological and social prosperity across these diverse regions.

Territorial competitiveness rankings at a regional level are produced by organizations such as the World Economic Forum, the Organization for Economic Co-operation and Development (OECD), the European Commission and the World Bank. Each one of them applied its own approach based on a certain understanding of the essence of regional competitiveness and the factors affecting it. For this paper, we adopt the European Commission's definition of regional competitiveness, which takes into account the perspectives of both businesses and residents, thereby integrating their viewpoints. The definition applied by the European Commission in the editions of the Regional Competitiveness Index states that regional competitiveness is "the ability of the region to offer an attractive and sustainable environment for companies and local residents to live and work" (Dijkstra et al., 2011, p. 4).

3.   RURAL AREAS IN BULGARIA

Rural areas in Bulgaria occupy a significant share of the country's territory. Depending on the applied method, they account for approximately 75%-81% and house between 37%-42% of the population (Mishev et al., 2020). However, their importance in socio-economic development at the national level is declining (Miteva & Doitchinova, 2022), and they face many challenges shaped by demographic, economic, and policy factors (Mishev et al., 2020). Among them, significant demographic challenges include depopulation and aging. Internal migrations have exacerbated these issues, reducing the working-age population and deteriorating the age structure of rural communities (Petrov, 2021; Sarov, 2023). The process is driven by youth migration for better education and employment, which limits human capital capacity, impedes innovation integration, and weakens rural development. The state of infrastructure is the next critical factor affecting the socio-economic development of rural areas. The aging of the population worsens the educational and healthcare systems. Poor infrastructure (mainly for connectivity, digitalization, and knowledge) limits regional integration and economic opportunities, hindering local development (Doitchinova et al., 2018; Popov & Marinov, 2023; Yarkova & Mutafov, 2017). The European and national policies (with emphasis on agricultural and rural policies) play a crucial role in addressing these challenges through measures and instruments shaping the agricultural landscape and influencing the socio-economic dynamics of these areas (Atanasov et al., 2023). The effectiveness of financial management and the utilization of these financial resources are pivotal in overcoming the challenges (Beluhova-Uzunova & Hristov, 2020; Mishev et al., 2020) and strengthening the sustainable development of the rural areas in Bulgaria.

4.   METHODOLOGY

4.1. Research Approach

Assessing competitiveness, as well as understanding and defining it, is a complicated process as stated above. Regional competitiveness, as a theoretical framework and practical assessment, is developed and refined within several social sciences. However, there is still a lack of a unified approach to be applied in practice. In the scientific literature, there are suggestions and solutions for implementing competitiveness assessment, and their application is most often limited to several regions and/or countries. Similarly, usually, aggregated macroeconomic indicators applied to the regional level are used for evaluation (Bąk et al., 2022; Chrobocińska, 2021; Möbius & Althammer, 2020; Roszko-Wójtowicz & Grzelak, 2020; Scaccabarozzi et al., 2024). Other authors' approach

implies a comprehensive literature and qualitative analysis aimed at identifying the key factors for competitive regional development (Celli et al., 2024; Doitchinova & Stanimirova, 2022; Grassia et al., 2024; Rodríguez-Pose & Ketterer, 2020). The main factors and indicators for competitiveness measurement that are applied are productivity, innovations, and economic growth including the increase of wages and living standards. At the European level, the developed index used to assess and compare the competitiveness of EU regions has both advantages and disadvantages, as discussed by Annoni and Dijkstra (2013).

Looking at competitiveness, a group of Finnish scientists Huovari et al. (2002) developed an Index for measuring regional variation and competitiveness, which contains available statistical indicators. The constructed index is formed based on four sub-indices, each with the same weight in the final one. After researching on a regional basis in Finland, the authors found a strong relationship between the index and long-term indicators of economic well-being, such as GDP per capita and income, and a comparatively weaker one with short-term outcomes, such as changes in production, employment and population. The calculation of rural competitiveness in this paper follows this research approach.

In Bulgaria, a few studies explored territorial competitiveness and the most recent (and the only one known to us) was conducted by Doitchinova and Stanimirova (2022). The authors utilized the FAO methodology to assess the competitiveness of specific rural areas in Bulgaria. This involved conducting a field survey to examine economic competitiveness, labor market, local governance, infrastructure, etc., among rural stakeholders. Therefore, the current paper further extends the understanding of rural competitiveness, encompassing evaluation of all rural areas in Bulgaria and considering quantitative assessment based on statistical data.

4.2. Data Collection

The selection of indicators (variables) for measuring rural competitiveness is based on the state and perspectives for sustainable development of rural areas in Bulgaria and the elements of the existing models for assessing regional competitiveness, which measure various aspects of it. The variables are grouped into four main categories and presented in Table 1.

Table 1. List of variables included in the assessment of the rural competitiveness in Bulgaria

Categories (Variables)	
Human resources (HR)	Population: Population density (X_1), Population between 0-24 years (X_2), Population with higher education (X_3)
	Labour market: Total labour force (X_4), Unemployment (X_5), Persons not in the labour force (X_6)
Agriculture (Ag)	Macroeconomic: GVA in agriculture (X_7), Average wages in agriculture (X_8)
	Specialization of rural economy: Index of localization for agriculture (X_9)
Industry and services (I&S)	Macroeconomic: GVA in industry (X_{10}), GVA in services (X_{11}), Average wages in industry (X_{12}), Average wages in services (X_{13})
	Specialization of rural economy: Index of localization for industry (X_{14}), Index of localization for services (X_{15})
Innovations (Inn)	Macroeconomic: Expenditure on acquisition of tangible fixed assets (X_{16})
	Education and research: Expenditure on research and development (X_{17}), Academic and teaching staff (X_{18}), Enrolments in all types of schools (X_{19})
	Digitalization: Relative share of households with Internet access (X_{20}),Relative share of individuals aged 16-74, regularly using internet (X_{21})

Source: Authors' elaboration adapted from Huovari et al. (2002)

This input-output-results measurement approach is also consistent with the definition of regional competitiveness adopted by the European Commission, allowing both a comprehensive assessment and linking the main competitiveness factors and business interests with the well-being of the population in the respective rural area. The study encompasses data up to the year 2021 due to the data availability as the main source of information is the database of the National Statistical Institute of Bulgaria.

The methodology frame for this research is based on the typology of the rural regions developed by the OECD. It involves two main steps: first, defining rurality at the LAU 2 level, and next, based on the population share in rural LAU 2 units, classifying the regions at the NUTS 3 level. The main reason to choose this approach is the availability of data, keeping in mind the extended discussion about criteria and the relevance of the different classifications and their relevance for international comparisons and evaluation. The OECD method classifies LAU 2 units (in Bulgaria, they refer to administrative unit municipality) with a population density below 150 inhabitants per square kilometre as rural. After that, the NUTS 3 regions (in Bulgaria, they refer to administrative unit districts) are classified as predominantly rural, intermediate or predominantly urban based on the percentage of the population living in local rural units. The result of this approach can be seen on the map in Figure 1. It shows that 21 out of the total 28 districts in the country are defined as predominantly rural (light green colour). Six of the districts are classified as intermediate, and only one is primarily urban (it encompasses the capital city of Sofia); both groups are presented in dark green in Figure 1.
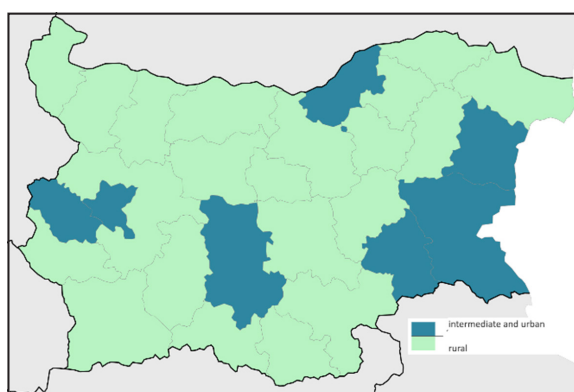
Figure 1. Map of urban-rural typology for Bulgarian NUTS 3 regions (districts) according to OECD method, 2021

Source: Authors' calculations, based on the data provided by the National Statistical Institute (2021) and for visualization applying Eurostat IMAGE Interactive map generator (Eurostat, 2023)

4.3. Analysis technique

To evaluate the index of competitiveness of rural areas in Bulgaria, an index developed and applied for Finland (Huovari et al., 2002) was adapted following the available statistical data for the country and the relevance of the variables. The formula used to calculate the indices for each of the variables, defined in Table 1 as important for the competitiveness of Bulgarian rural areas, and included as an element of the overall model for its assessment, is:

$$C_{xi} = 100 * (x_i/X) / (p_i/P), \text{ where}$$

C_{xi} – index for the variable involved in the model and its estimation for the i rural area
x_i – the empirical value of the variable selected to be included in the model for the respective rural area

X – the empirical value of the variable selected to be included in the model at the country level

pi – number of inhabitants in the respective rural area

P – number of inhabitants in the country.

After calculating the individual indices by variables of each category included in the competitiveness assessment model, an average value is determined for each category, assuming that each indicator is equally significant, i.e., none of the metrics inside the category is prioritised. Ultimately, the final evaluation of the competitiveness model of rural areas in Bulgaria at the district level is formed as an arithmetic mean value of the categories. The index values themselves are not meaningful, but the rank order and the distances that districts defined as rural are from one another provide useful information, revealing each district's competitive strength relative to others. The calculation of an index of rural competitiveness is not definitive and may change based on the availability of data, the goal and the advancement of socio-economic research.

5.   RESULTS AND DISCUSSION

The findings in Figures 2 and 3 show the outcomes of geographical distribution of assessing rural competitiveness at the district level, with primarily urban and intermediate districts being omitted from the analysis, in line with the previously explained methodology. The scores are divided into three classes to enable meaningful comparisons. The maps show that highly competitive districts, represented with the lilac colour in the maps, are identified only by one category, as the concentration is visibly higher in the Northern part of the country, while for the rest of the categories, low-competitive districts are located throughout the whole country.

By observing the final evaluation of the index, we came to the conclusion that rural areas in Bulgaria, in general, demonstrate lower level of competitiveness.

The three districts – Razgrad, Dobrich and Stara Zagora – in yellow in Figure 2 are the most competitive districts among the rural areas in Bulgaria. This can be interpreted in a way that the three districts need less changes to adapt and reach the competitiveness close to the one of the country.

By observing the individual indices results (Figure 3) by categories, namely HR, Ag, I&S and Inn, the differences in the elements supporting and hindering rural competitiveness by categories and within the single district are considered.
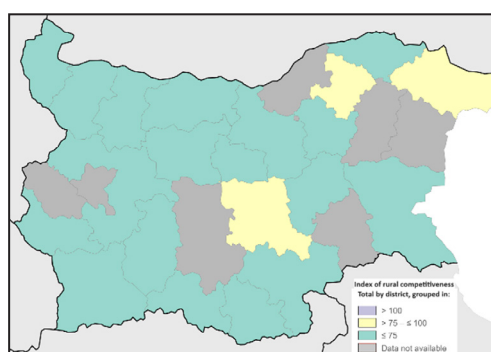
Figure 2. Map of index of rural competitiveness in Bulgaria, 2021

Source: Authors' calculations, based on the data provided by the National Statistical Institute (2021) and for visualisation applying Eurostat IMAGE Interactive map generator (Eurostat, 2023)
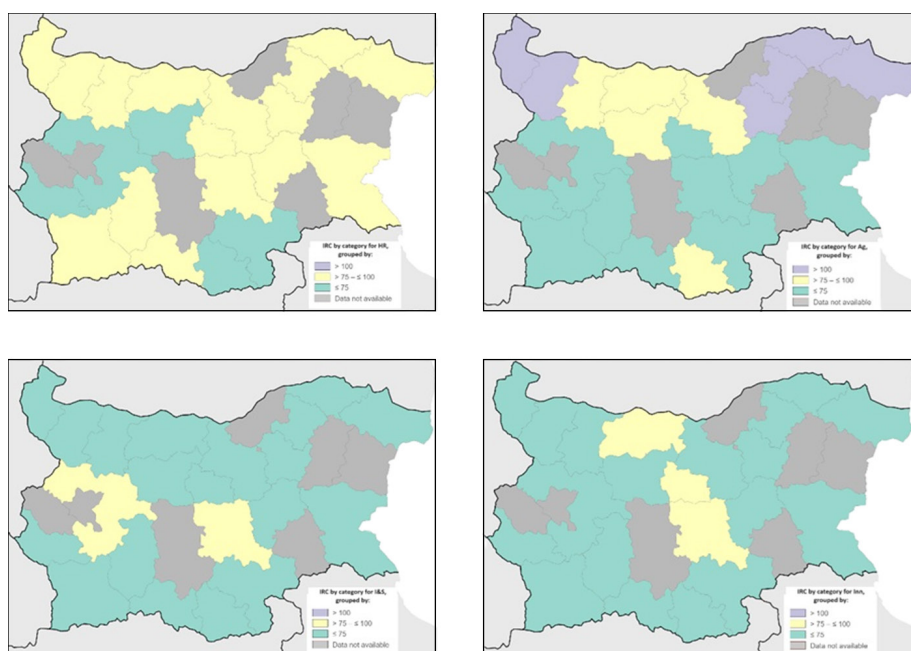
Figure 3. Map of indices by categories of rural competitiveness in Bulgaria, 2021

Source: Authors' calculations, based on the data provided by the National Statistical Institute (2021) and for visualisation applying Eurostat IMAGE Interactive map generator (Eurostat, 2023)

The most significant differences identified in the regions are those closely linked to the dependency on economic sectors, particularly agriculture, in the Northeast region. Next is the proximity of large urban centres with higher populations that plays a crucial role in driving higher competitiveness, as these areas tend to have better infrastructure, access to innovations and well-developed service sectors, including public services. The latter are crucial concerning the resident's quality of life and are considered essential in competing with other regions through better access to schools, medical and social services, etc. (Doitchinova & Stanimirova, 2022). This is particularly evident in the districts neighbouring the capital city as well as in the South Central region, which is not surprising because regions with large cities seem to perform better than other regions (Möbius & Althammer, 2020). The same pattern follows the variables from the Inn category, amplifying territorial inequalities in rural competitiveness between districts (Bąk et al., 2022). It should be mentioned that in long-term perspective without investments in this group of factors (variables), low competitive rural areas are at risk of marginalization hindering their sustainable development. Knowledge, technologies and digitalization are nowadays key drivers of growth and prosperity.

Next, non-favourable developments in the human resources category serve as major barriers to competitiveness across all regions, as depicted in Figure 3. Addressing these challenges in the human resources sector is essential for fostering overall competitiveness and sustainable development in the regions. Švagždienė and Perkumienė (2017) consider the need for continuous interpretation of rural communities' needs and bridging the gap between program services and demands.

6. CONCLUSION

The overall diversity within the districts' competitive performance is evidence that locally tailored responses and appropriate policy measures to address the specific needs and possibilities of each area are needed. Moreover, using the proposed research approach, it was possible to identify which rural regions are the most and least competitive. The most competitive regions can offer

good practices for the less competitive ones, both from the south and north parts of the country. In practice, the paper offers a clear understanding of which factors are crucial to the regions, exploring them as drivers for competitiveness improvements.

The research, however, has some limitations that open areas for further research. The analysis of competitiveness covered only one year. To generalize the conclusions, it would be necessary to assess it over the time series of several years. Furthermore, the study may be extended by adjustments in the socio-economic categories and adding ecological variables to represent all the dimensions of sustainability.

Acknowledgment

References

Annoni, P., & Dijkstra, L. (2013). EU regional competitiveness index RCI 2013.

Atanasov, D., Ivanova, B., Beluhova-Uzunova, R., Shishkova, M., Hristov, K., Sharipov, S., & Khasanov, I. (2023). Regional transformations in Bulgaria and challenges for sustainable development. *E3S Web of Conferences, 386*, 05002. https://doi.org/10.1051/e3sconf/202338605002

Bąk, I., Wawrzyniak, K., & Oesterreich, M. (2022). Competitiveness of the Regions of the European Union in a Sustainable Knowledge-Based Economy. *Sustainability, 14*(7), 3788. https://doi.org/10.3390/su14073788

Beluhova-Uzunova, R., & Hristov, K. (2020). Models for Balanced Development of Bulgarian Rural Regions in the Context of CAP post-2020. *Trakia Journal of Sciences, 18*(Suppl.1), 491-497. https://doi.org/10.15547/tjs.2020.s.01.080

Celli, V., Cerqua, A., & Pellegrini, G. (2024). Does R&D Expenditure Boost Economic Growth in Lagging Regions? *Social Indicators Research, 173*(1), 249-268. https://doi.org/10.1007/s11205-021-02786-5

Chrobocińska, K. (2021). Comparative Analysis of Regional Competitiveness in Poland from 2010-2019 in the Context of the Concept of Sustainable Development. *Sustainability, 13*(6), 3202. https://doi.org/10.3390/su13063202

Dijkstra, L., Annoni, P., & Kozovska, K. (2011). A new regional competitiveness index: Theory, methods and findings. In Working papers: A series of short papers on regional research and indicators.

Doitchinova, J., Kanchev, I., Terziyska, R., & Todorowa, K. (2018). Socio-economic and environmental parameters and results of rural development under the CAP: the case of Bulgaria. The Common Agricultural Policy of the European Union - the present and the future EU Member States point of view, 247-259. https://doi.org/10.30858/pw/9788376587431.19

Doitchinova, J., & Stanimirova, M. (2022, February). Competitiveness assessment of rural areas: The example of Bulgaria. In Proceedings of 24th RSEP International Conference on Economics, Finance & Business (pp. 24-25).

European Commission. (2021). A Long-Term Vision for the EU's Rural Areas—Towards Stronger, Connected, Resilient and Prosperous Rural Areas by 2040. Communication from the Commission

to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions.

European Commission. (2024). The EU Rural Action Plan. https://rural-vision.europa.eu/action-plan_en

Eurostat. (2023, August 23). Create your maps with IMAGE, our map generator tool. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/wdn-20230823-1

Filo, C. (2007, October). Territorial Competitiveness and the Human Factors. In International Conference of Territorial Intelligence, Huelva 2007.

Grassia, M. G., Marino, M., Mazza, R., Misuraca, M., Zavarrone, E., & Friel, M. (2024). Regional Competitiveness: A Structural-Based Topic Analysis on Recent Literature. *Social Indicators Research, 173*(1), 83-108. https://doi.org/10.1007/s11205-022-02951-4

Huovari, J., Kangasharju, A., & Alanen, A. (2002). Constructing an Index for Regional Competitiveness. *Advances in Spatial Science*, 121-138. https://doi.org/10.1007/978-3-540-24823-1_7

Mishev, P., Alexandrova, S., Stoyanova, Z., Harizanova, H., Kazakova, J., Kabadjova, M., & Dimitrova, A. (2020). Social - Economic Analysis of the Development of Rural Areas. Sofia. Ministry of Agriculture and Food, Sofia.

Miteva, A., & Doitchinova, J. (2022). Agriculture in the Southwestern region of Bulgaria and its impact on rural development. *Ekonomika poljoprivrede, 69*(4), 1003-1016. https://doi.org/10.5937/ekopolj2204003m

Möbius, P., & Althammer, W. (2020). Sustainable competitiveness: a spatial econometric analysis of European regions. *Journal of Environmental Planning and Management, 63*(3), 453-480. https://doi.org/10.1080/09640568.2019.1593005

National Statistical Institute. (2021). Statistical Yearbook 2021. https://www.nsi.bg/en/content/19555/публикация/statistical-yearbook-2021

Petrov, K. (2021). The Regional Development of the Rural Areas in Bulgaria and the Support of the European Union. *European Countryside, 13*(1), 208-221. https://doi.org/10.2478/euco-2021-0012

Popov, R., & Marinov, P. (2023). Development of Bulgarian agriculture within the CAP in the EU 2007-2020 in the context of the green deal, farms and employed people, relative to location index for rural areas of the South Central Region. *SHS Web of Conferences*, 176, 03001. https://doi.org/10.1051/shsconf/202317603001

Porter, M. (1990). Competitive Advantage of Nations. *Competitive Intelligence Review, 1*(1), 14-14. https://doi.org/10.1002/cir.3880010112

Rodríguez-Pose, A., & Ketterer, T. (2020). Institutional change and the development of lagging regions in Europe. *Regional Studies, 54*(7), 974-986. https://doi.org/10.1080/00343404.2019.1608356

Roszko-Wójtowicz, E., & Grzelak, M. M. (2020). Macroeconomic stability and the level of competitiveness in EU member states: a comparative dynamic approach. *Oeconomia Copernicana, 11*(4), 657-688. https://doi.org/10.24136/oc.2020.027

Sarov, A. (2023). Scenarios for the Demographic Development of Rural Areas in Bulgaria – 2027. *Economic and social alternatives, 29*(3), 94-105 (in Bulgarian).

Scaccabarozzi, A., Mazziotta, M., & Bianchi, A. (2024). Measuring Competitiveness: A Composite Indicator for Italian Municipalities. *Social Indicators Research, 173*(1), 53-82. https://doi.org/10.1007/s11205-022-02990-x

Siebert, H. (2000). The paradigm of locational competition (No. 367). Kieler Diskussionsbeitraege.

Švagždienė, B., & Perkumienė, D. (2017). Evaluation of competitiveness factors of rural communities. *Proceedings of International Scientific Conference "RURAL DEVELOPMENT 2017"*. https://doi.org/10.15544/rd.2017.211

Yarkova, Y., & Mutafov, E. (2017). Rural Areas in Bulgaria - Investigation on some Factors for Development. *Eastern European Countryside, 23*(1), 51-70. https://doi.org/10.1515/eec-2017-0003

Beyond Sustainability. The Girolomoni Agricultural Cooperative: A Case Study

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Abstract: *The environmental issue has become a major subject of debate also in the field of social sciences. Sociological studies have shown how an anthropocentric approach is often adopted in political and scientific contexts, with knowledge acquiring a technical value aimed at changing both individual and collective behavior. This paper explores the management of an agricultural cooperative that goes beyond the conventional criteria of sustainability. One of the first organic farming businesses in Italy, the company in question has developed a management model in which scientific, technological, and economic knowledge helps to understand the relationship between nature and human beings, in a process of information sharing that involves business partners, stakeholders, and consumers.*

1. INTRODUCTION

The ecological issue has become the most important sociopolitical problem debated in Europe. Sociological research has been conducted to explore the development of models of thought and intervention based on the concepts of environment and sustainability (Hannigan, 2006; Mulberg, 2003), with specific studies showing the impact that different interpretations of such concepts may have on society and the planet (Dunlap & Brulle, 2015; Dunlap & Michelson, 2002). Since the environmental issue started to be investigated sociologically (Catton & Dunlap, 1978), theoretical and empirical analyses have been carried out mainly on politico-economic, cultural, and technological aspects. Politico-economic studies have critically explored organizational and production models, as well as measures aimed at adjusting human systems to different environments. Within the cultural dimension, educational models promoting sustainability have been examined (Morin, 2014), together with the concepts of human being and environment, their political, scientific, and social interpretations and their impact on social behavior (Dunlap & York, 2008). Over the past twenty years, sociological analysis has also dealt with the consequences and benefits of technological development, as the digitalization and robotization of production processes may lead to an increase in environmentally-friendly production models and behaviors.

Therefore, even when it comes to environmental issues, sociology helps society to reflect on the problems it has to face. The importance of such a process can be grasped when considering that self-awareness is rarely taken into account in the environmental debate. Indeed, the concept of "knowledge-based sustainable development" mainly refers to technical aspects aimed at the development of sustainable production methods and educational models, such as recycling and mindful consumption. This has led some scholars (Beretta, 2016; Giuliodori & Malavasi, 2016) to point out how an anthropocentric and sectoral perspective is still adopted, as the individual is considered a subject of rights and the environment is seen as a passive subject. On the other hand, in multidisciplinary studies, an ecocentric approach is mainly taken, with the environment and

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human system being described as having equal rights and equally contributing to determining the future of the planet. Yet, despite focusing on the relationship with nature, the ecocentric model still sees the human being as the main agent in the fate of the planet, whereas less importance is placed on the individual's identity and role in the environment (Capra & Luisi, 2014; Morin, 2007).

Even the European Union has dealt with the environmental issue by adopting an anthropocentric approach, as its action has been aimed at monitoring and standardizing. The focus on environmental protection has increased as a result of studies carried out in the field of legal sciences, which have attempted to demonstrate that human beings and nature have equal rights (Cullinan, 2011). Consequently, educational and production models have been developed that may regulate the behavior of the human system, in order for it to respect environmental and climate systems. Directive No. 2022/2464 – the Corporate Sustainability Reporting Directive (European Union, 2022) – requires that an increasing number of companies draft an environmental, social, and governance sustainability report, while annually monitoring, measuring, and outlining the impact of their organizational and production model on the environment, workers, and community. Directives, measures, and research papers have encouraged companies to draft sustainability reports to increase their visibility at a social, economic, and financial level, in an attempt to attract the attention of consumers and institutions, become more appealing to stakeholders, and obtain bank credit. However, the quality and quantity of reports produced, the difficulty in drafting one, or the refusal to do so have led to identifying greenwashing, while showing how reporting is often merely seen as a way to receive financial benefits (Higgins et al., 2012; Rahim & Idowu, 2016; Said et al., 2016; Stubbs & Higgins, 2012; Yusoff et al., 2018). Such an – unsurprising – attitude has been shaped by both top-down guidelines on environmental matters and an emergency narrative based on feelings of risk and fear.

Nevertheless, some virtuous approaches may be identified by which scientific and technical knowledge combines with environmental and social awareness to create best practices. Examples of that may be found in the industrial agriculture sector. More specifically, a virtuous company that produces organic durum wheat flour is currently being helped to draft a sustainability report, a process that needs to be based on self-knowledge. Not only does this entail having a deep knowledge of production processes, technological aspects, management strategies, and the impact that the business has on the local area, but it also involves becoming aware – through benchmarking – of the best practices adopted by other companies working in the same field.

Benchmarking has led to identifying a business whose management goes beyond traditional Italian and European criteria of sustainability. This paper aims to describe some of the achievements of such a company, whose relationship with the natural and social environment relies on self- and hetero-knowledge. Its management model combines politico-economic, cultural, and technological aspects in the "spiritual and religious" dimension of the interrelation between nature and the human being.

2. METHODOLOGICAL APPROACH

Thanks to the funding provided by the European Social Fund Plus and the Recovery Assistance for Cohesion and the Territories of Europe program, the University of Foggia is conducting intervention research in order to analyze and improve the management of a company based in northern Apulia. Despite having no legal obligation to improve its standards, such a company aims to do so, by going through a process of self-knowledge that will result in a sustainability report being drafted.

A tool for business improvement (Stapenhurst, 2009), benchmarking allows one to identify the best practices adopted by sustainable companies. In this research, benchmarking was used to analyze the performance of some Italian businesses sharing the same regulatory, financial, economic and cultural framework. As a result of such an analysis, the management of three companies was explored through fieldwork. Findings showed that one of these – the Girolomoni Agricultural Cooperative – is not managed according to traditional politico-institutional criteria of sustainability, with even the reasons leading such a business to achieve sustainability being far from conventional ones.

Empirical analysis was carried out by adopting a case study approach, a strategy that allows one to explore in detail the behavior of a single individual, a group, or an organization, besides being useful to investigate how they evolved. When taking a case study approach, different methods and techniques may be used, including observation, interviews, and (digital) data gathering. The choice of this approach and of the case to study is determined by the unconventional and unique nature of the phenomenon to examine, whose analysis may lead to theoretical and empirical developments (Sena, 2023).

As Gino Girolomoni and his wife Tullia, the founders of the Girolomoni Agricultural Cooperative, are no longer alive, the analysis of its management was carried out with the help of the board members of the Cooperative itself – the founders' heirs and the managing director. Gino and Tullia's son has been appointed as the president of the Cooperative. Their daughter is responsible for internal and external communication, being in charge of both establishing coordination mechanisms and building relationships between the Cooperative and the local, national, and international community. Commercial and administrative aspects were investigated by involving the managing director. Being privileged witnesses, the board members were interviewed using a semi-structured interview approach, since having a conversation with people who have a good understanding of the context to explore allows one to investigate both its general and specific aspects. Not only may this help to identify the structural features of a company, but it might also reveal the cultural, rational, and emotional factors characterizing its identity, professional sphere, and organizational and management framework. When using this method of research, data collection occurs through a set of loosely structured questions about the crucial issues that need to be explored. However, as interviewees need to be allowed to express themselves freely, they may even end up describing aspects considered of little or no importance when designing the research project (Denzin et al., 2024).

Observation was conducted for three days, a process that was made easier by the accommodation facilities and restaurants available on site. Ethnographic observation (Gobo, 2008) was combined with detached observation and shadowing (Czarniawska, 2007; McDonald & Simpson, 2014). Observation has been useful in identifying – even through photographic and video graphic evidence – the various components of the business analyzed: the production area with the workers at work, the accommodation facilities and inn, the internal and external spaces, including offices, a museum, a chapel, a dining hall, and a kitchen. The analysis of such components has been instrumental in assessing the consistency of the purpose and vision of the company.

The paper and digital documents drafted by the Cooperative were examined. This has led to understanding how the group has committed to changing both the local and national mindset.

3.   RESULTS

A combination of survival strategies, economic development, and cultural progress, the Girolomoni Agricultural Cooperative has become a unique example in the agricultural sector. Its management

model may be described using an Italian term coined by anthropologist Vito Teti (2022) – *restanza*. Meaning "resisting so as to stay", the word "*restanza*" refers to an individual's willingness and right to remain in their hometown, in spite of it all, promoting their local area while having the opportunity to strengthen the relationship between their being and the local environment.

In the early 1970s, Gino and Tullia Girolomoni challenged the economic and demographic trend of the hilly area in the north of the Marche region. While the population in the area was migrating to other places, they let themselves be inspired by two local historical figures and embarked on a regeneration project. With a view to making it their headquarters, they renovated the medieval monastery where Blessed Pietro Gambacorta established the order of the Poor Hermits of Saint Jerome. In 1970, Gino decided to run for mayor of his town, taking Federico da Montefeltro as his role model, since the man, a patron and the lord of Urbino, had managed to regenerate an area that had always been seen as peripheral. Both living in the late medieval period, Pietro Gambacorta and Federico da Montefeltro became the religious and political symbols of the Girolomoni approach, which is rooted in *historical knowledge*. The Cooperative has always tried to boost the local economy, to highlight the social relevance of the area through the creation of meaning.

In 1977, the Girolomonis founded their first agricultural cooperative, which they called *Alce Nero*, so as to express their religious faith and further define their project. "Alce Nero" is the Italian for Black Elk, the spiritual guide of the Lakota Sioux who converted to Catholicism, leading a life that the Vatican considered an example to believers. Gino Girolomoni embraced the principle underlying Black Elk's economic and political action: the essential interrelationship between all living beings, which may also be described as *ecological knowledge*.

The complex nature of the Girolomoni Agricultural Cooperative makes it difficult to divide its activities into well-defined categories. Acquiring a practical dimension in self-knowledge and the relationship with the environment, spirituality is the principle that connects all the aspects of the Cooperative. Therefore, in order to analyze the interrelationships between the material, economic, political, and cultural factors contributing to the development of the Cooperative, reference will be made to the environmental, social, and governance (ESG) criteria set out by the European Union.

Intrinsic to their spirituality, the Girolomonis' relationship with the environment (E) is outlined in a monograph that was published to celebrate the fiftieth anniversary of their business. The book includes the story and vision of the Cooperative, as well as the views of those who collaborated with the group. Titled *Dignità alla Terra*, literally meaning "dignity to the land", it explains that natural resources should not be used by applying a mere logic of profit. Gino Girolomoni even disapproved of seed patents, which he described as a "Promethean delusion of modern technological society". However, Girolomonis' idea to restore the dignity of the environment goes beyond protecting natural resources. Their Cooperative aims at celebrating the generosity coming from the land through an economic model that may increase the value of what nature has to offer and enhance the ways in which it does so while highlighting how human beings are dependent on biodiversity and soil fertility. In the Girolomoni approach, the anthropological concept of "roots" takes on not only a geographical and cultural meaning but also carries a medical connotation. One's psychophysical health is rooted in what one experiences through the five senses when enjoying what the environment has to offer, even at an aesthetic level. Besides being explored in various articles published in the company journal, this approach has been clarified by the president of the Cooperative. He has even explained that during a seminar organized by the Cooperative, a medical researcher presented the findings of a study demonstrating the relationship between male

infertility and pollution. By disseminating information, the Girolomonis once more confirmed their interest in taking care of the environment and the human being.

In 1974, the Girolomonis started to spread knowledge of organic farming and production methods, an initiative that was ahead of its time, as the first European Union regulation on the matter was adopted in 1987. From 1978 to 1990, Gino Girolomoni was prosecuted several times for failing to comply with Italian regulations, with the goods found at the Cooperative being seized. The Girolomonis' legal trouble was mainly due to the production of whole-wheat pasta, as no laws on the matter had been passed in Italy at the time. Despite that, Gino Girolomoni carried out his project by showing great *technical knowledge*. He grew cereals, chickpeas, tic beans, lentils, sunflowers, and forage by implementing crop rotation and avoiding using chemicals. He followed the rhythms of nature, improving soil organic matter and organic soil fertility.

The Girolomonis established a transparent short supply chain, with all their business partners sharing and adopting an organic approach. This led to the creation of an ad-hoc organization, the Montebello Cooperative, which provides services for farmers and takes care of the shared management of products. Seventy percent of raw materials are produced in the region, which helps to reduce transport pollution. The small roller mills used on the Girolomoni farm show how tradition may be preserved despite technological innovation. Roller mills prevent thermal stress during grinding and reduce the waste of resources while providing farmers with special types of flour that can be used to make different types and shapes of pasta. The Cooperative only produces durum wheat, including the high-quality Senatore Cappelli variety, and ancient grains, such as Khorasan wheat. Such varieties are rich in protein, carotenoids, and fibers with detoxifying and filling properties. The pasta produced by the Cooperative is perfect for people who suffer from heart disease, as it contains no cholesterol and has a lower glycemic index than that made with soft wheat. Furthermore, during grinding, another precious resource is used: the water coming from the hills in the Marche region.

The Cooperative set up a pasta factory and also started producing tomatoes, legumes, and olive oil. An inn and a bed and breakfast were opened and managed in line with organic standards. Through experiential travel, guests have the opportunity to grasp the relationship between human beings and the environment, understanding how the autonomy of farmers and small business owners may result in social growth and psychophysical well-being.

In order to reduce its carbon footprint, the Cooperative is no longer relying on non-renewable sources of energy. About 810 square meters of solar panels have been installed, and certified green energy is purchased from an external supplier. A biomass boiler burning local wood is used during the pasta drying process. Over the past few months, the Cooperative has been working on increasing its production capacity. It has met architectural criteria that may contribute to reducing energy consumption, improving the quality of the materials used, and enhancing the aesthetic appeal of the headquarters building, in order for it to blend into the surrounding hilly landscape, with a decrease in visual pollution.

The social dimension (S) of the Girolomoni project can be seen in the economic and cultural regeneration of the local area, which is occurring through the acquisition and spread of technical and scientific knowledge of the relationship between the environment and human beings. Knowledge is shared through poetry, philosophy, books, journals, conferences, educational farm experiences, and even packaging. A further example of *shared and spread knowledge*, the monastery has

become a cultural and inter-religious center. The Girolomonis mainly aims at building a cultural and interdisciplinary approach that, differing from the neoliberal perspective, may result in an increase in individual and collective practices based on the principles of equity and solidarity between human beings and the land. This idea of *knowledge as education* has always led the Girolomonis to believe that an appropriate cultural environment proves essential for businesses like theirs to thrive. In this context, a fundamental role is played by the agricultural past (Namer, 2000), which strengthens the actions taken in the present, projecting them to the future. Therefore, a museum of folk art was opened in the monastery, an example of *knowledge as historical rooting.*

Right from the beginning, the approach adopted by the Girolomonis and their business partners has had an impact at a local, regional, and national level. In 1978, Gino Girolomoni, then mayor of his town, organized the first course on organic farming, held by national and international experts. A decade later, he created the *Associazione Marchigiana Agricoltura Biologica*, an association for organic farming operating in the Marche region. Public and private meetings were organized with internationally renowned thinkers, poets, and scientists. In 1996, knowledge of the organic approach started to be spread more systematically, as the Girolomonis founded the *Mediterraneo Dossier* journal and established the *Fondazione culturale Girolomoni*, a cultural foundation. Being responsible for internal and external communication, Gino Girolomoni's daughter has been entrusted with the most difficult and necessary task to facilitate the relationship between the Cooperative and institutions such as schools, universities, and local bodies, in order to raise awareness of the principles underlying an organic lifestyle – equity, transparency, and respect. Such principles characterize even packaging, which is environmentally-friendly, due to its being exclusively made of paper. An example of *transparent knowledge* provides information about the producers, their philosophy, the geographical origins and production location of products, product certification, and nutrition facts.

The Girolomoni Agricultural Cooperative is no longer part of the original Alce Nero group, as Gino Girolomoni left it due to management issues. As the interviewees have explained, Gino Girolomoni was such a charismatic man that his cooperative, which exports to about thirty countries, started to be referred to simply after the name of its founder. Indeed, since Gino Girolomoni died in 2012, packaging has featured a picture of the founder, as requested by Japanese stakeholders, among the best customers of the Cooperative.

Underlying also the governance model (G) of the Cooperative, the principles of equity, transparency, and respect may help to reach the political objective of achieving autonomy. Initially aiming at giving new life to their local area and restoring its dignity, the Girolomonis were willing to re-establish the key economic role that farming used to have, helping small and medium-sized farming businesses to thrive. Prioritizing the land and the farmers' needs meant supporting the development of about 500 small businesses, 300 of which were based in the Marche region. To win the loyalty of stakeholders, the Girolomonis started purchasing their products at a higher price than the standard one, making them earn 3,000 euros a year more than they used to. Furthermore, by following a logic of transparency, the Girolomonis soon involved their workers and business partners in a process of knowledge sharing. Such *knowledge as participation* has resulted not only in details being provided about raw materials, production processes, control strategies, quality assessments, and financial statements, but also in farming services being offered, including continuous financial, biochemical, and technological training.

The board of the Cooperative decides on the quality of raw materials. As the president and managing director have stated, organic farming becomes pointless when high-quality organic seeds

are not used. Agronomists verify that the farming process meets the required standards. Crop yield is assessed, the state of the fields is analyzed, and samples of spikes are tested for pesticides. Crop rotation is monitored, as it is essential to protect biodiversity and increase the fertility of the soil. High standards are maintained also in the warehouses where the various items are stored. In other words, each stage of the production chain is carefully controlled, since any component may influence the well-being of the environment and the health of end consumers. While in the past such a process was carried out through sample checking, by randomly visiting suppliers, digitalization has made everything smoother and more effective, providing an example of what may be described as *knowledge as network sharing.*

The Girolomoni model even takes into account an aspect that is often disregarded when conducting organizational analysis – the migration issue, which Gino Girolomoni tried to address by collaborating with thinkers, academics, sociologists, anthropologists, and poets. He realized that the phenomenon was mainly caused by a misconception about the role of farmers in modern industrial society. As the managing director of the Cooperative has pointed out, people preferred to be employed as workers and be paid a lower salary if that meant having a higher social status determined by their being perceived as city rather than country people. However, technological and scientific developments have gradually resulted in a significant change in the way in which farmers are perceived.

The Girolomonis' approach to knowledge sharing became even more evident when the president of the Cooperative joined the *Unione Cristiana degli Imprenditori Dirigenti*, an association of Catholic entrepreneurs that promotes innovative organizational strategies and production methods. Besides aiding entrepreneurs to face competition in global markets, the *Unione Cristiana* association helps them to deal with national measures that do not facilitate organic farming, being rather aimed at supporting the use of technology and chemicals to produce non-renewable raw materials, including seeds.

Further proof that the Girolomoni model revolves around organic farming is the fact that their Cooperative has become the first Italian agricultural cooperative to join the World Fair Trade Organization, which promotes self-sufficiency and economic fairness while supporting small and medium-sized businesses that contribute to the development of local economies.

4.   FUTURE RESEARCH DIRECTIONS

The Girolomoni case study has shown that three main aspects need to be explored in more detail. Firstly, the Girolomoni ecosystem should be further analyzed. Given the prominent role the Girolomonis have in the agricultural sector and the importance that trust has in their governance model, it would be interesting to investigate the cultural and motivational factors contributing to the growth of their partner businesses, whose management goes beyond traditional political and economic criteria. Such an analysis may lead to understanding what variables influence the relationship of trust between the Girolomonis and their business partners, and how the symbolic trust in the charismatic leadership (Weber, 1946) of the Girolomonis (Luhmann, 1988) may combine with the systemic trust (Luhmann, 1979) in those who are responsible for the governance of the Cooperative.

Secondly, studies should be conducted on the cultural, scientific, and political debate on seeds. The Girolomonis use part of their budget to support research on the organic production and growth of

seeds, an underdeveloped area of research even at a public level. Therefore, it would be useful to further explore such a field, involving politicians, academics, and even food producers, who do not seem to consider it to be profitable enough.

Finally, industrial districts should be investigated, as they are seen as a typically Italian phenomenon (Ricciardi, 2013). It would be important to understand what factors have caused a considerable reduction in the impact of Italian small and medium-sized businesses on the national economy. Once a pillar of political and economic democracy, over the past thirty years, such businesses have become less able to join forces to foster autonomy and technological innovation. When exploring this process, it should be considered that the globalization of the markets has resulted in local areas becoming fundamental in preserving these production models and enhancing the competitiveness of small and medium-sized businesses. Yet, as the Girolomoni case study has shown, although social capital and entrepreneurial, financial, technical, and scientific know-how are necessary to succeed (Intesa San Paolo, 2023), cultural and philosophical knowledge is essential, while charisma is key.

5. CONCLUSION

It would not be inappropriate to title this final section "Fostering Empowerment to Reduce Dependence". The most important Italian organic farming businesses are based in the Marche region, which is going to become the largest organic district in Europe. Nevertheless, due to its particular characteristics, the Girolomoni model may be difficult to export if the current legislation is not amended. As interviewees and workers have pointed out, despite being structured as a cooperative, the Girolomoni ecosystem has been built on the sacrifice and resilience of a single family. This makes it a business reality that is solidly based on the trust that business partners have in the Girolomonis, who still manage to work in the same way they have in their first twenty years of business operations. The Girolomonis have never acted to make a profit, but always to create well-being. By adopting an unconventional approach, they have never aimed at being competitive, always focusing on creating shared wealth.

An expert in financial management, the managing director of the Cooperative has highlighted how such a "family" approach to management initially led to misunderstandings and disagreements. When he was hired the Cooperative was suffering a fall in turnover and was in debt, he thought he had been entrusted with the task of making a profit. However, he soon became aware of the vision of the Cooperative, which does not prioritize the economic dimension in terms of management and production. The Girolomonis have always promoted culture, in order to make citizens, stakeholders, and consumers understand what organic farming is and the beneficial impact it may have on economic, social, and individual well-being. In the Girolomoni model, the creation of wealth transforms into a shared creation of meaning, between self- and hetero-knowledge.

References

Beretta, I. (2016). Politiche per un'ecologia umana. In Ecologia integrale. Laudato sì'. Ricerca, formazione, conversione (pp. 91-98). Vita e Pensiero, Milano.

Capra, F., & Luisi, P. L. (2014). *The Systems View of Life: A Unifying Vision,* Cambridge (Ca): Cambridge University Press. https://doi.org/10.1017/cbo9780511895555

Catton, W. R. Jr., & Dunlap, R. E. (1978). Environmental Sociology: A New Paradigm. *The American Sociologist*, *13*(1), 41-49.

Cullinan, C. (2011). *Wild Law: A Manifesto for Earth Justice (2nd ed.)*, Cambridge (UK): UIT Cambridge Ltd.

Czarniawska, B. (2007). *Shadowing: And Other Techniques for Doing Fieldwork in Modern Societies*, Copenhagen: Copenhagen Business School Press.

Denzin, N. K., Lincoln, Y. S., Giardina, M. D., & Cannella, G. S. (Eds.). (2024). *The Sage Handbook of Qualitative Research (6th ed.)*, Los Angeles: Sage.

Dunlap, R. E., & Brulle, R. J. (2015). *Climate Change and Society. Sociological Perspectives*, Oxford: Oxford University Press.

Dunlap, R. E., & Michelson, W. (Eds.). (2002). *Handbook of Environmental Sociology*, Westport (Connecticut): Greenwood Press.

Dunlap, R. E., & York, R. (2008). The Globalization of Environmental Concern and The Limits of The Postmaterialist Values Explanation: Evidence from Four Multinational Surveys. *The Sociological Quarterly*, *49*(3), 529-563. https://doi.org/10.1111/j.1533-8525.2008.00127.x

European Union. (2022). Directive (Eu) 2022/2464 of the European Parliament and of the Council, *Official Journal of the European Union*, 322: 15-80. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022L2464

Giuliodori, C., & Malavasi, P. (Eds.). (2016). *Ecologia integrale. Laudato sì. Ricerca, formazione, conversione*, Milano: Franco Angeli.

Gobo, G. (2008). *Doing Ethnography*, London: Sage. https://doi.org/10.4135/9780857028976

Hannigan, J. (2006). *Environmental Sociology (2nd ed.)*, London-New York: Routledge. https://doi.org/10.4324/9780203001806

Higgins, C., Stubbs, W., & Markus, M. (2012). *Sustainability Reporting and Non-Reporters: Understanding why Companies do not Produce Sustainability Reports – Report*, Melbourne: CPA Australia.

Intesa San Paolo. (2023). *Economia e finanza dei distretti industriali – Rapporto n. 15*, Torino: Direzione Studi e Ricerche.

Luhmann, N. (1979). *Trust and Power*, Hoboken, NJ: John Wiley & Sons.

Luhmann, N. (1988). Familiarity, Confidence, Trust: Problems and Alternatives. In D. Gambetta (Eds.). *Trust. Making and breaking cooperative relations*. Oxford: Oxford University Press. http://www.sociology.ox.ac.uk/papers/luhmann94-107.pdf

McDonald, S., & Simpson, B. (2014). Shadowing research in organizations: the methodological debates. *Qualitative Research in Organizations and Management: An International Journal*, *IX*(1): 3-20. https://doi.org/10.1108/QROM-02-2014-1204

Morin, E. (2007). *L'anno I dell'era ecologica. La terra dipende dall'uomo che dipende dalla terra*, Roma: Armando Editore.

Morin, E. (2014). *Enseigner à vivre. Manifeste pour changer l'éducation*, Arles-Paris: Actes Sud-Play Bac.

Mulberg, J. (2003). Environment and Sociology: The State of the Debate. *Global Environmental Politics*, *3*(1), 125-142. https://doi.org/10.1162/152638003763336428

Namer, G. (2000). *Halbwachs et la memoire sociale*. Paris: L'Harmattan. https://doi.org/10.4000/books.psorbonne.409

Rahim, M. M., & Idowu, S. O. (Ed.). (2016). *Social Audit Regulation. Development, Challenges and Opportunities*, Berlino: Springer.

Ricciardi, A. (2013). I distretti industriali italiani: recenti tendenze evolutive. *Sinergie, rivista di studi e ricerche*, *91*: 21-58. https://doi.org/10.7433/s91.2013.03

Said, R. M., Kim, L. L., Senik, R., & Yusri, Y. (2016). Quantity and Quality of Environmental Disclosure by Environmental Sensitive Companies in Malaysia. International Business Management, *10*(18): 4342-4350.

Sena, B. (2023). *The Case Study in Social Research. History, Methods and Applications*, London-New York: Routledge. https://doi.org/10.4324/9781003318255

Stapenhurst, T. (2009). *The Benchmarking Book: A How-To Guide to Best Practice for Managers and Practitioners*, Amsterdam: Elsevier/Butterworth-Heinemann. https://doi.org/10.4324/9780080943329

Stubbs, W., & Higgins, C. (2012). *Sustainability and Integrated Reporting: A Study of the Inhibitors and Enablers of Integrated Reporting*, Sydney: The Institute of Chartered Accountants in Australia.

Teti, V. (2022). *La restanza*, Torino: Einaudi.

Weber, M. (1946). *The Sociology of Charismatic Authority*. In Mills H. H. & C. Mills W. *From Max Weber: Essays in Sociology*, Oxford: Oxford University Press.

Yusoff, H., Nurhazwani, S., & Ghani, E. K. (2018). Environmental Reporting Practices of Top Public Listed Companies: Analyzing Pre-Post Corporate Social Responsibility Framework. *Indonesian Journal of Sustainability Accounting and Management*, *2*(1): 50-64. https://doi.org/10.28992/ijsam.v2i1.48

The Contribution of BFs to the SDGs:
A Global-Local Comparative Strategic Study

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Abstract: *Sustainable Development (SD) has been progressively gaining importance in the strategic actions of businesses for more than a decade. The purpose of this paper is to analyze the strategic contribution of BFs (BFs) to the SD. The methodology followed consists of the analysis of the strategic orientations of major global BFs and the identification of the specific role of (local) BFs in the Abruzzo Region (Italy). The main result of the study is the observation of the areas of sustainability where BFs make their greatest contribution and the ways through which they act.*

1. INTRODUCTION

The biotechnology industry plays a key role in global Sustainable Development (SD) since it presents high levels of growth and works as a boosters for other strategically related sectors (e.g., healthcare, chemical, pharmaceutical, ICT) (Etit et al., 2024). The BFs, the subject of this paper, through the object of their activities and the way they manage their businesses, make a significant contribution to the achievement of the Sustainable Development Goals (SDGs) (Lokko et al., 2018). The 17 SDGs adopted by the United Nations as part of the 2030 Agenda for SD, indicate the interconnected work needed to address global social, economic, environmental and ethical challenges. BFs have distinctive anatomy, that can meet the needs of both science and business. BFs are knowledge-based since they use knowledge and innovation as their main sources of competitive advantage (Bloem & Salimi, 2023). The innovation capabilities of BFs lie in three key processes: i) prospecting and sensing new knowledge; ii) mobilizing and melding knowledge from multiple differentiates and dispersed sources; and iii) deploying, leveraging, and scaling up the innovation (Doz, 2023). BFs are also characterized by the presence of strategic intra-sectoral and inter-sectoral interdependencies (Lin & Lekhawipat, 2023), which support the evolution of the biotech and related sectors through knowledge transfer, which is also prodromal to the pursuit of the SDGs (González-Ramos et al., 2023).

This paper aims to analyze the strategic contribution to sustainability of BFs that, given the characteristics of their activities, are determinants of positive impact on the SDGs (Baumgartner,

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2014). Indeed, BFs operate in different sub-sectors of activities that can be distinguished using the color criterion (Iseppi & Rosa, 2022): red (health, medicine, diagnostics), green (agriculture, environmental biotechnology-biofuels, biofertilizers, bioremediation, geo microbiology), white (gene-based bioindustries), and blue (aquaculture, coastal and marine biotechnology). The positive impacts that BFs' innovations generate in terms of the SDGs have been summarized in Table 1, based on information recently made available by the International Council of Biotechnology Association (ICBA, 2024). The ICBA is a coalition of non-profit, national biotech trade associations and represents the biotech industry in international fora for promoting innovation in the human health, agriculture, and industrial and environmental sectors.

The contribution of BFs is mainly evident under SDG #9 and SDG #3. Biotechnology is a key enabling technology that uses living organisms such as bacteria, yeast, plant and animal cells or parts thereof to develop products and processes, which explains the substantial contribution to SDG #9; in addition, the largest share of BFs operates in the red sub-sector (SDG #3). Moreover, BFs, through their distinctive competencies in creating and managing intra-sectoral and inter-sectoral strategic partnerships (SDG #17), foster the pursuit of the other SDGs. The comparative global-local strategic analysis allowed us to highlight the contribution of BFs to SD. At this aim, the paper is structured as follows: i) definition of the conceptual framework deriving from the analysis of the main theoretical contributions of strategic Corporate Social Responsibility (CSR) (Vishwanathan et al., 2020); ii) analysis of the strategic behavior of firms at global and local levels in the pursuit of the SDGs; and finally, iii) comparison of the approaches adopted (global vs local).

2. CONCEPTUAL FRAMEWORK

SD is a global meta-goal, with respect to which firms play a strategic role (Caroli, 2021). Firms are portrayed as both the reason for the global crisis and the solution to it and should be conceived as vehicles of change (Matten & Moon, 2020) in which strategic management must be increasingly oriented toward generating positive sustainability impacts. Sustainability management in BFs fits into the broader framework of strategic CSR, in which innovation plays a key role (Verdecho et al., 2021). Given the strategic peculiarities of BFs, the strategic CSR framework fosters a better understanding of the phenomenon under analysis, although many approaches exist in the literature to support firms in managing sustainability (Velte, 2022). The relationship between strategic management and CSR has been explored and extensively studied in the literature (Kantabutra & Ketprapakorn, 2020) and is a dynamic process in which CSR is not a precondition, but rather one of the relevant dimensions of corporate strategies. Recent literature (Latapí Agudelo et al., 2019) has emphasized the temporal transformation of the concept by highlighting that the main strategic orientation of firms should be the creation of sustainable shared value. The contribution to SD of BFs comes not only from the final outputs of their corporate activities (see Table 1), but also from the way they manage their businesses and the activities involved in value creation (Porter & Kramer, 2018). Although the outputs of BFs' innovation processes contribute to SD, these are not the subject of this paper, which highlights, instead, that the way BFs manage their businesses generates positive sustainability impacts (Mio et al., 2020). For BFs, sustainably managing innovation processes triggers virtuous circles of value creation that lead firms to consolidate their positions of competitive advantage (Achard & Bellini, 2023). In fact, in recent years, BFs have globally adopted innovative and sustainable ways in the areas of drug testing, research and development (Burik, 2024). The analysis of the main dimensions of strategic CSR is dealt with in the top 10 global BFs (which operate in the red sub-sector) by market capitalization (year 2023), shown in Table 2.

Table 1. Biotech's contribution to SDGs

SDG vs biotech contribution	
SDG#1 -Biotech helps farmers increase income and reduce their vulnerability to climate change.	SDG#9 -Biotech R&D is empowering scientists to develop solutions to the most pressing global challenges.
SDG#2 -Agricultural biotech is critical in helping to feed a growing world population.	SDG#12 -Industrial biotech applies tools to traditional processes to more sustainable products and materials.
SDG#3 -Biotech plays a critical role in saving lives and improving the quality of life for all.	SDG#13 -Biotech's agricultural and industrial applications are critical in combating the effects of climate change.
SDG#6 -Biotech helps ensure availability and sustainable management of water and sanitation.	SDG#14 -Biotech can contribute to efforts to conserve and sustainably use ocean resources.
SDG#7 -Biofuels derived from a range of renewable sources reduce CO_2 in transportation fuels.	SDG#15 -Agricultural biotech innovation contributes to the protection of terrestrial ecosystems and biodiversity.
SDG#8 - Biotech innovations present opportunities for economic growth.	SDG#17 -BFs, NGOs, research and multilateral institutions and governments are creating global partnerships.

Source: Own elaboration based on International Council of Biotechnology Association (2024)

Table 2. Top global biotech companies based on market capitalization (2023)

Firm	Market cap *	Firm	Market cap *
Novo Nordisk (Denmark)	302	Gilead Sciences (U.S.)	91.3
AbbVie (U.S.)	260.2	Vertex Pharm. (U.S.)	89.1
Roche (Switzerland)	219.2	Regeneron (U.S.)	87.8
Amgen (U.S.)	139.6	CSL (Australia)	75.7
Bristol Myers Squibb (U.S.)	119.5	Moderna (U.S.)	39.2

*values in Billion dollars (U.S.)

Source: Own elaboration based on data available on Statista (2024)

Table 3. Purpose of global BFs selected

BF	Purpose
Novo Nordisk (Denmark)	*"We turn ideas into better treatments for people living with serious chronic diseases".*
AbbVie (U.S.)	*"AbbVie discovers and delivers innovative medicines and solutions that enhance people's lives".*
Roche (Switzerland)	*"Doing now what patient needs next".*
Amgen (U.S.)	*"In everything we do, we aim to fulfill our mission to serve patients. And every step of the way, we are guided by the values that define us".*
Bristol Myers Squibb (U.S.)	*"We are ... the latest science and technology to help improve lives through the research and development of new medicines for serious diseases".*
Gilead Sciences (U.S.)	*"Helping to Create New Possibilities for People with Primary Biliary Cholangitis".*
Vertex Pharm. (U.S.)	*"We invest in scientific innovation to create transformative medicines for people with serious disease".*
Regeneron (U.S.)	*"Push the bounds of science, make life change medicines".*
CSL (Australia)	*"CSL's offerings are more diverse than ever to help ensure patients and people everywhere get the treatments they need. We're always improving so life can, too".*
Moderna (U.S.)	*"We embarked on this journey with the goal of making drugs developed from mRNA a new reality that can change the world".*

Source: Own elaboration based on the information available on corporate websites

Strategic CSR is an opportunity for firms to reconfigure the competitive landscape and develop distinctive and dynamic resources and capabilities. The concept of strategic CSR can be traced back to the integration of sustainability dimensions into corporate strategic directions, how strategic goals are pursued, and how competitive advantage is achieved (Marakova et al., 2021). In the context of strategic CSR, the value created is declined in the economic, social, environmental and ethical dimensions. The creation of shared value (Menghwar & Daood, 2021) is focused on identifying, developing and enhancing the interdependencies among the identified areas of sustainability. Indeed, the value creation of BFs is appreciated in the economic, social, environmental and ethical spheres. The economic sphere was taken as the initial reference (see Table 2), while the others are explored in more detail in the following discussion. More recent studies highlight that strategic CSR is geared toward the creation of shared value, but from a sustainable perspective (Chandler, 2022). This aspect can be found in all the global BFs included in the analysis, for which community benefits and SDGs are an integral part of corporate purpose (George et al., 2023) as shown in Table 3. This characteristic is in line with the strategic factors that characterize the biotech industry, among which the management of innovation and knowledge through strategic interactions of a collaborative nature assume greater importance.

Global BFs contribute to SD through the sustainable strategic management of their innovation processes (Voegtlin & Scherer, 2017), which are based on: i) management and engagement of key stakeholders; ii) integration of strategic goals with economic, social, environmental, and ethical sustainability objectives; iii) reconfiguration of value-creating activities from a socially and environmentally sustainable perspective; and, finally, iv) design of organizational mechanisms that foster the integration of sustainable practices into the organizational structure. The interconnected management of human resource management, internal communication and innovation activities is one way to appreciate the integration of sustainability into strategic business action (Stahl et al., 2020), of which AbbVie is an example. AbbVie is a global BF, established in 2013 in the United States as a spin-off of Abbott Laboratories. To date, it has doubled the number of human resources to more than 50,000 with a widespread presence in more than 70 countries globally. Just under 60% of the staff are women, 52% of whom hold managerial positions. About 20% of the human resources are directly involved in Research & Development (R&D), the firm's core business, in which it has invested more than $55 billion since the beginning and has nearly 2,000 scientific publications. These strategic goals have also been achieved through the use of multidisciplinarity and multiculturalism in research teams with the aim of enhancing their innovative capabilities arising from diversity (SDG #4). This management is in line with another strategic factor that connotes the entire industry and that concerns collaboration strategies. As of 2022, some 250 agreements with strategic partners are active (SDGs #17), including competitors, universities, non-profit firms, and government organizations. Attributing strategic relevance to CSR for firms means moving to corporate governance that: i) rethinks the concept of stakeholders (Freeman, 2023); ii) adopts stakeholder management strategies differentiated according to the degree of involvement in decision-making processes (Colvin et al., 2020); and iii) emphasizes the role of collaborative strategies based on enhancing the interdependencies among actors/businesses belonging to the public, private and social sectors (Achard, 2019). From a strategic perspective, stakeholders can also play a role as drivers of the evolution toward sustainable corporate management. Exemplary in this regard is CSL, a global BF founded in 1916 in Melbourne, Australia, owned by the Australian federal government and privatized in 1994. The firm operates in the businesses of research, development, production and commercialization of biotechnology products, predominantly, plasma derivatives (SDG #3). Stakeholder engagement (Stocker et al., 2020) (SDGs #4; #17) is a strategic activity carried out through periodic assessment processes based on sharing material issues to update and inform the

sustainability strategy pursued. CSL's stakeholders articulate, according to the interdependence that exists between the issues associated with them, into: internal (employees), external (research partners, shareholders investors, business partners, potential employees, healthcare professionals, customers), primary (patient groups, research partners and plasma donors), secondary (media, public health consumers) and institutional (regulators, governments, debt providers). By way of illustration, the primary stakeholders, given their relevance to CSL's businesses, are patients, who are involved in R&D processes with marketing strategies and with whom are primarily discussed the issues related to: i) access to therapies; and ii) improving participation in R&D processes, innovation, safety, and product quality. In addition, the evolution towards a CSR-based management approach is confirmed by the establishment within the organizational structure of the Executive Committee for Sustainability, which reports directly to the CEO, coordinated by the Chief Corporate & External Affairs and the Heads of strategic support functions: finance, sustainability, legal, human resources management, R&D and external relations management (investors). In the area of internal stakeholder management, the case of Novo Nordisk is interesting because of its emphasis on the link between CSR activities and corporate performance evaluation (the connection between strategic and organizational control) (Awa et al., 2024). Novo Nordisk is a global BF established in 1989 in Denmark from the merging of two firms, Novo and Nordisk, both engaged in insulin production. Novo Nordisk has adopted a value-based management system supported by specific strategies and policies in key business areas, including finance, environment, and social. The staff performance evaluation process is based on shared local and corporate (Executive Board and Board of Directors) responsibilities. For example, in 2023, 42 organizational units were evaluated and about 2,300 employees (about 8% of the total) were interviewed individually. In terms of social value creation, Novo Nordisk involved primary stakeholders (about 550) in the assessment process (SDG #4). The rationale for value creation was based on the link between the strategic goals and the internal goals of the organizational units involved. In the broader perspective of shared value creation that best fits the purposes of this paper, pursuing SDGs implies that the strategic action of firms goes through the ability to rethink services and redesign value chain and value system activities. Firms can compete by adopting a strategic approach that leads them to create shared value, in terms of societal benefits, while improving firm competitiveness (Mai et al., 2021). Amgen Inc., recognizing the strategic relevance of ethics to its businesses and to consolidate its competitive position, has outlined a strategy for managing its suppliers based primarily on sustainability dimensions (SDGs #3; #4; #12). Amgen Inc. is a global BF founded in California (USA) in 1980. Ethical business practices, labor and human rights, health and safety, environment, management system and supply transparency are the requirements on which the supplier selection and evaluation processes are based, throughout the business agreement. Adherence to Amgen's ethical principles is not formal, but substantial, i.e., suppliers are required to make it formally explicit that they meet and integrate compliance with the Supplier Code of Conduct into their business actions, which is an integral part of the agreement. In this way, suppliers support Amgen Inc. in its processes of creating shared value with patients, local communities and other supply chain actors (e.g., distributors) by supporting the firm to generate positive social and environmental impacts (López-Concepción et al., 2022). Along the same lines Amgen, but from an intern stakeholder management perspective (Bhattacharya et al., 2023), stands Regeneron. This firm was founded in 1988 in New York and is active in R&D, manufacturing and commercialization of innovative drugs. Regeneron has a Code of Conduct and Ethics based on a collaborative strategic approach grounded on shared responsibility and commitment among human resources. Ethics is a key dimension of innovation processes (SDGs #3; #4; #5; #12; #17) through: i) clinical trial data and information sharing (transparency); ii) animal welfare; iii) good operating principles in operations, manufacturing and distribution; iv) monitoring safety and quality of processes and products.

The integration of CSR is a challenging and progressive process over time and involves the inclusion of economic, social, environmental and ethical sustainability factors in firms (Nguyen & Kanbach, 2024), in which a relevant aspect is the ability to manage the strategic interdependencies among the factors mentioned. The strategic choices of Vertex and Bristol Meyer Squibb better clarify the role of environmental choices in the firm-society relationship (Risi et al., 2023). Vertex is a BF founded in 1989 in Boston, now engaged in R&D in therapeutic areas for the treatment of serious diseases without a cure. Vertex recognizes the strategic interdependence between the firm's value-creating activities and the well-being of the Communities (Carroll, 2021) of the geographical areas in which it operates. In this regard, it has adopted environmental strategies (SDGs #6; #12; #13), at the global scale, to contribute to climate protection and the promotion of a healthy and sustainable outlook through: i) reduction of greenhouse gas; ii) conservation of water; iii) minimization of waste; iv) adoption of green chemistry practices; and v) promotion of workplace safety. To this end, Vertex, to facilitate the integration of corporatelevel environmental strategies into the organizational structure of the firm, has designed horizontal structures (cross-functional teams and cross-functional Sustainability Committee) that serve the purposes of coordinating, supervising, and implementing sustainability goals in the strategies of individual business units. Bristol Meyer Squibb, on the other hand, has extended its environmental strategies to other key activities. Bristol Meyer Squibb is a global BF, formed in 1989 in New York City following a merger between Bristol-Myers Company and the Squibb Corporation. Its environmental value creation (SDGs #6; #7; #12) is achieved through: i) reduction of pharmaceuticals in the environment; ii) inclusion of sustainability criteria in the selection of strategic partners; iii) green and sustainable science (sustainability in science and drug development); iv) sustainable packaging; and v) sustainable transportation. All these aspects directly affect the effective management of the most impactful supply chain stages in drug lifecycle management.

Finally, it has to be mentioned Roche as an example of the integration of different dimensions of sustainability elevated to a driver of business governance. Roche was founded in 1986 in Switzerland and, today, Roche Holding AG wholly controls BF Genentech (USA) and is the majority shareholder (62%) of BF Chugai Pharmaceuticals (Japan). Roche has developed an integrated governance approach to pursue several SDGs (SDGs #3; #4; #5; #6; #7; #8; #9; #12; #13; #16; #17). The governance model of Roche has also evolved significantly through the establishment of organizational units to oversee sustainability: (i) the Corporate Governance and Sustainability Committee of the Board of Directors (BoD), which serves as an internal advisor to sustainability strategies and is accountable to the BoD; (ii) the Corporate Executive Committee (CEC), that is responsible for planning corporate strategies and delegates, coordinates and manages the Corporate Sustainability Steering Committee; (iii) the Corporate Sustainability Steering Committee, which defines the sustainability strategy; (iv) the Corporate Sustainability Operations Committee, responsible for sustainability programs, their implementation in the corporate organizational structure, reporting and verification of the pursuit of objectives in all global organizational units. Finally, the Global Sustainability Network created by Roche supports the alignment of all foreign subsidiaries to act with a view to the internal and external creation of shared value.

3. METHODOLOGY

The methodology followed in this paper is qualitative and comparative, and given the strategic peculiarities of BFs, it was included in the conceptual framework of strategic CSR. The analysis of BFs' contribution to SD was divided into three parts:1) Identification of the top 10 leading global BFs, selected based on the market cap criterion (see Table 2) (Statista, 2024). Next, their strategic

orientations to economic, social, environmental and ethical sustainability were studied. The results of this first part were used as a benchmark for comparison with what emerged from the analysis of local BFs. 2) Definition of the panel of local BFs operating in the Abruzzo region (Italy), based on the convenience sampling method, and detection of the economic, social, environmental and ethical sustainability strategies pursued. 3) Overview of strategic evidence from the global vs. local biotech comparison. To study the BFs that constitute the described setting, it was deemed appropriate to analyze the following strategic documents: strategic plans, sustainability plans, and annual reports (Tsalis et al., 2020). The choice of these three types of documents stems from three interrelated aspects: i) checking their accessibility (transparency); ii) accessing information relevant to this analysis; and iii) appreciating the degree of coherence and interconnectedness among the various documents, since it is, in part, an expression of the level of integration of sustainability issues into corporate strategies. The documents were accessed through consultation with the corporate website. The choice of in-depth study of individual issues of strategic CSR in the firms was made on the basis of relevance, relative to the purpose of the paper, and the representativeness they have for each firm studied. In section 4, we report on the analysis of local BFs with the aim of studying a narrower set of firms in the context of an Italian region where the industry is still in a growth phase and verifying whether the sustainability and SDGs orientation of local BFs is aligned with the strategic choices pursued by global BFs.

4. RESULTS

More than 1,200 BFs operate in the Italian biotech industry, in which about 14,000 human resources are employed. The red sub-sector is the most significant in terms of turnover, determining 74% of the Italian biotech industry's turnover, and R&D investment (85% of the total). Abruzzo is located in an area where BFs are growing and developing. In Abruzzo, 35 BFs are active (3% of the total) and operate about 70% in the red sub-sector while the remainder in the yellow (about 15%) and green (about 15%) sub-sectors. The contribution of local BFs to SD is appreciable, albeit to varying degrees, in three areas: social, environmental and ethical. Local BFs actively promote social sustainability through corporate welfare policies and by investing in the welfare of local communities. Some firms have also undertaken social responsibility initiatives that include volunteer programs and collaborations with local non-profit organizations. Environmental strategies adopted by local BFs include measures to reduce the environmental impact of business activities through the adoption of clean technologies and waste management practices. Previous research indicates that many firms have implemented certified environmental management systems (e.g., ISO 14001) and that some of them regularly monitor their CO_2 emissions. Although the regional average is around this type of choice regarding environmental sustainability, there is no shortage of cases of more advanced firms. For example, a local BF active in the red sub-sector and engaged in research and production of plant extracellular vesicles has developed a business model based on the circular economy. Local BFs, given the nature of their businesses (R&D; manufacturing), adopt strict ethical standards, ensuring transparency and integrity of their activities. Most firms have formal codes of ethics and offer ongoing training programs on ethical responsibility to the staff. Attention to these dimensions can be also explained as a specific response to the legal-institutional factors (Wæraas, 2020) that characterize the macroenvironment and is also aimed at attracting investors, especially international ones.

Through the pursuit of sustainability strategies, local BFs contribute to the achievement of the SDGs, with a focus on SDGs #3, #9, #7, and #17. Local BFs have started the process of integrating the SDGs into their corporate strategies and some of them have promoted specific projects

to contribute to SD through rethinking the way they conduct relevant activities in innovation processes (e.g., green supply chain; circular economy). The strategies pursued by local BFs in strategic CSR are comparable and partially aligned with those adopted by global BFs, especially in the environmental and ethical dimensions. Regarding the social sphere, on the other hand, differences and less implementation are appreciated in local firms compared to global ones, and this can be explained, in part, by the dimensional differences (number of active human resources, number of geographic areas in which they operate, low degree of cultural differentiation of human resources) that characterize the two groups of firms. Also, regarding communication choices of the sustainability strategies pursued, transparency (e.g., accessibility to strategic planning documents Strategic Plan, Sustainability Plan and Annual Report), completeness and updates of corporate websites, local firms still have fair room for improvement. Finally, in local BFs, unlike global ones, sustainability has not yet found its place at the organizational level (e.g., committees, specific inter-divisional and inter-functional groups). The comparative analysis, therefore, highlights that the sustainability orientation of local BFs is at an early stage compared to global BFs. The latter, in fact, are committed to their legitimacy with respect to the requirements set forth (in the social, environmental, and ethical spheres) by the directives, regulations, and laws that characterize their macroenvironment of reference. Global BFs, on the other hand, are undertaking initiatives to innovate their business models and governance arrangements so that strategies to achieve competitive advantage are also effective in contributing to SD and vice versa.

5. FUTURE RESEARCH DIRECTIONS

Considering the findings from the comparative study and the stimuli from the strategic actions of global BFs, possible future research trajectories are identified. The latter may concern the study of a positive correlation between the innovative capabilities of BFs and their degree of development with respect to the adoption of a governance approach marked by the dimensions of strategic CSR. Given that BFs pursue collaborative strategies to foster knowledge sharing to support innovation processes by activating virtuous circles of value creation, it might be challenging to investigate whether these firms integrate sustainability criteria to select strategic collaborations. Finally, from a strategic point of view, it is interesting to conduct a double-time measurement to appreciate the further evolution.

6. CONCLUSION

BFs, being knowledge-based firms, contribute to the pursuit of the SDGs both through the performance of their businesses and in the way they manage the key activities involved in the processes of innovation. BFs generate and distribute value, including environmental, social and ethical value, to all their stakeholders through the adoption of sustainable innovation strategies that enable them to: i) reconfigure the activities of the value chain and system, ii) redefine the pool of resources and competencies placed at the basis of their competitive advantage; and iii) redesign corporate governance through the definition of organizational positions that have primary responsibility for sustainability. The comparative strategic study of global and local BFs revealed that the two observed groups pursue similar strategies in the areas of environmental sustainability and ethics. They differ, however, in their choices of social sustainability and transparency. Local BFs show a lower degree of integration of strategic objectives with those of a sustainable nature than global BFs, placing themselves at an early stage (legitimation phase) of evolution towards sustainability. This is confirmed by both the low degree of stakeholder engagement in strategic planning processes and the absence of organizational changes in this direction. Despite this, the

influence of the strategic orientations pursued by global BFs and the strategic contribution of the global biotech industry to SD promote the spread of an innovative corporate culture that connects patients, suppliers, customers, distributors, competitors, investors, governmental organizations, local communities and research partners with each other. All this at the local level translates into positive impacts that create value in terms of growth of the business structure, development and enhancement of the welfare of local communities.

References

Achard, P. O. (2019). Strategic Management of Public–Private Partnerships: Actors, Aims, and Capabilities. In R. M. Clark and S. Hakim (Eds.), *Public Private Partnerships: Construction, Protection, and Rehabilitation of Critical Infrastructure*, pp. 261-280. Springer, Cham. https://doi.org/10.1007/978-3-030-24600-6_13

Achard, P. O., & Bellini, C. (2023). Value creation processes in the European Biotech Industry: the role of collaboration strategies. Selected Papers from the ERAZ Conference (pp. 63-72). Association of Economists and Managers of the Balkans. https://doi.org/10.31410/ERAZ.S.P.2023.63

Awa, H. O., Etim, W., & Ogbonda, E. (2024). Stakeholders, stakeholder theory and Corporate Social Responsibility (CSR). *International Journal of Corporate Social Responsibility*, *9*(1), 11. https://doi.org/10.1186/s40991-024-00094-y

Baumgartner, R. J. (2014). Managing corporate sustainability and CSR: A conceptual framework combining values, strategies and instruments contributing to sustainable development. *Corporate Social Responsibility and Environmental Management*, *21*(5), 258-271. https://doi.org/10.1002/csr.1336

Bhattacharya, C. B., Sen, S., Edinger-Schons, L. M., & Neureiter, M. (2023). Corporate purpose and employee sustainability behaviors. *Journal of Business Ethics*, *183*(4), 963-981. https://doi.org/10.1007/s10551-022-05090-5

Bloem, V., & Salimi, N. (2023). Role of knowledge management processes within different stages of technological innovation: evidence from biotechnology SMEs. *Knowledge Management Research & Practice*, *21*(4), 822-836. https://doi.org/10.1080/14778238.2022.2064352

Burik, A. (2024, March 18). *More sustainable drug development and lab sustainability*. Labiotech. https://www.labiotech.eu/partner/sustainable-drug-discovery-and-development/

Caroli, M. (2021). *Economics and Sustainable Business Management*, Milano: McGraw Hill.

Carroll, A. B. (2021). Corporate social responsibility: Perspectives on the CSR construct's development and future. *Business & Society*, *60*(6), 1258-1278. https://doi.org/10.1177/00076503211001765

Chandler, D. (2022). *Strategic corporate social responsibility: Sustainable value creation*. Sage Publications.

Colvin, R. M., Witt, G. B., & Lacey, J. (2020). Power, perspective, and privilege: the challenge of translating stakeholder theory from business management to environmental and natural resource management. *Journal of Environmental Management*, *271*, 110974. https://doi.org/10.1016/j.jenvman.2020.110974

Doz, Y. L. (2023). In Search of Metanationals. INSEAD Working Paper, 2023/14/STR. https://dx.doi.org/10.2139/ssrn.4417190

Etit, D., Meramo, S., Ögmundarson, Ó., Jensen, M. K., & Sukumara, S. (2024). Can biotechnology lead the way toward a sustainable pharmaceutical industry?. *Current Opinion in Biotechnology*, *87*, 103100. https://doi.org/10.1016/j.copbio.2024.103100

Freeman, R. E. (2023). Managing for Stakeholders: Trade-Offs or Value Creation. Issues in Business Ethics, 295-299. https://doi.org/10.1007/978-3-031-04564-6_15

George, G., Haas, M. R., McGahan, A. M., Schillebeeckx, S. J., & Tracey, P. (2023). Purpose in the for-profit *firm*: A review and framework for management research. *Journal of Management*, *49*(6), 1841-1869. https://doi.org/10.1177/01492063211006450

González-Ramos, M. I., Guadamillas, F., & Donate, M. J. (2023). The relationship between knowledge management strategies and corporate social responsibility: Effects on innovation capabilities. *Technological Forecasting and Social Change*, *188*, 122287. https://doi.org/10.1016/j.techfore.2022.122287

International Council of Biotechnology Association (ICBA). (2024, August 29). *Biotechnology is Driving Solutions for Sustainable Development.* ICBA. https://internationalbiotech.org/biotechnology/biotech-sdgs/

Iseppi, L., & Rosa, F. (2022). *Economics and business of biotechnology from rDNA to NGS*. Padova University Press: Italy.

Kantabutra, S., & Ketprapakorn, N. (2020). Toward a theory of corporate sustainability: A theoretical integration and exploration. *Journal of Cleaner Production*, *270*, 122292. https://doi.org/10.1016/j.jclepro.2020.122292

Latapí Agudelo, M. A., Jóhannsdóttir, L., & Davídsdóttir, B. (2019). A literature review of the history and evolution of corporate social responsibility. *International journal of corporate social responsibility*, *4*(1), 1-23. https://doi.org/10.1186/s40991-018-0039-y

Lin, M., & Lekhawipat, W. (2023). Key influencing factors for the success of external innovation strategies in the biotechnology industry. *Journal of Business & Industrial Marketing*, *38(12*), 2745-2759. https://doi.org/10.1108/JBIM-07-2022-0307

Lokko, Y., Heijde, M., Schebesta, K., Scholtès, P., Van Montagu, M., & Giacca, M. (2018). Biotechnology and the bioeconomy—Towards inclusive and sustainable industrial development. *New biotechnology*, *40*, 5-10. https://doi.org/10.1016/j.nbt.2017.06.005

López-Concepción, A., Gil-Lacruz, A. I., & Saz-Gil, I. (2022). Stakeholder engagement, CSR development and SDGs compliance: A systematic review from 2015 to 2021. *Corporate Social Responsibility and Environmental Management*, *29*(1), 19-31. https://doi.org/10.1002/csr.2170

Mai, N. K., Nguyen, A. K. T., & Nguyen, T. T. (2021). Implementation of corporate social responsibility strategy to enhance firm reputation and competitive advantage. *Journal of Competitiveness*, *13*(4), 96-114. https://doi.org/10.7441/joc.2021.04.06

Marakova, V., Wolak-Tuzimek, A., & Tučková, Z. (2021). Corporate social responsibility as a source of competitive advantage in large enterprises. *Journal of Competitiveness*, *13*(1), 113-128. https://doi.org/10.7441/joc.2021.01.07

Matten, D., & Moon, J. (2020). Reflections on the 2018 decade award: The meaning and dynamics of corporate social responsibility. *Academy of Management Review*, *45*(1), 7-28. https://doi.org/10.5465/amr.2019.0348

Menghwar, P. S., & Daood, A. (2021). Creating shared value: A systematic review, synthesis and integrative perspective. *International Journal of Management Reviews*, *23*(4), 466-485. https://doi.org/10.1111/ijmr.12252

Mio, C., Panfilo, S., & Blundo, B. (2020). Sustainable development goals and the strategic role of business: A systematic literature review. *Business strategy and the environment*, *29*(8), 3220-3245. https://doi.org/10.1002/bse.2568

Nguyen, H. L., & Kanbach, D. K. (2024). Toward a view of integrating corporate sustainability into strategy: A systematic literature review. *Corporate Social Responsibility and Environmental Management*, *31*(2), 962-976. https://doi.org/10.1002/csr.2611

Porter, M. E., & Kramer, M. R. (2018). Creating shared value: How to reinvent capitalism—And unleash a wave of innovation and growth. In: Lenssen, G. G., Smith, N. C. (Eds.) Managing Sustainable Business (pp. 323-346). Springer, Dordrecht. https://doi.org/10.1007/978-94-024-1144-7_16

Risi, D., Vigneau, L., Bohn, S., & Wickert, C. (2023). Institutional theory-based research on corporate social responsibility: Bringing values back in. *International Journal of Management Reviews*, *25*(1), 3-23. https://doi.org/10.1111/ijmr.12299

Stahl, G. K., Brewster, C. J., Collings, D. G., & Hajro, A. (2020). Enhancing the role of human resource management in corporate sustainability and social responsibility: A multi-stakeholder, multidimensional approach to HRM. *Human resource management review*, *30*(3), 100708. https://doi.org/10.1016/j.hrmr.2019.100708

Statista. (2024, August 29). *Select top global biotechnology companies based on market capitalization as of 2023*. Statista. https://www.statista.com/statistics/262708/top-biotech-companies-based-on-revenue/

Stocker, F., de Arruda, M. P., de Mascena, K. M., & Boaventura, J. M. (2020). Stakeholder engagement in sustainability reporting: A classification model. *Corporate Social Responsibility and Environmental Management*, *27*(5), 2071-2080. https://doi.org/10.1002/csr.1947

Tsalis, T. A., Malamateniou, K. E., Koulouriotis, D., & Nikolaou, I. E. (2020). New challenges for corporate sustainability reporting: United Nations' 2030 Agenda for sustainable development and the sustainable development goals. Corporate Social Responsibility and Environmental Management, 27(4), 1617-1629. https://doi.org/10.1002/csr.1910

Velte, P. (2022). Meta-analyses on corporate social responsibility (CSR): a literature review. *Management Review Quarterly*, *72*(3), 627-675. https://doi.org/10.1007/s11301-021-00211-2

Verdecho, M. J., Alarcón-Valero, F., Pérez-Perales, D., Alfaro-Saiz, J. J., & Rodríguez-Rodríguez, R. (2021). A methodology to select suppliers to increase sustainability within supply chains. *Central European Journal of Operations Research*, *29*, 1231-1251. https://doi.org/10.1007/s10100-019-00668-3

Vishwanathan, P., van Oosterhout, H., Heugens, P. P., Duran, P., & Van Essen, M. (2020). Strategic CSR: A concept building meta-analysis. *Journal of Management Studies*, *57*(2), 314-350. https://doi.org/10.1111/joms.12514

Voegtlin, C., & Scherer, A. G. (2017). Responsible innovation and the innovation of responsibility: Governing sustainable development in a globalized world. *Journal of Business Ethics*, *143*, 227-243. https://doi.org/10.1007/s10551-015-2769-z

Wæraas, A. (2020). Organizational Identity and Corporate Social Responsibility (CSR) Legitimation. In: Rendtorff, J. D. (Eds.) Handbook of Business Legitimacy (pp. 1059-1078). Springer, Cham. https://doi.org/10.1007/978-3-030-14622-1_78

The Determinants of Sustainability Reporting: Evidence for Portuguese Listed Corporations

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Abstract: *This paper aims to analyze the sustainability reporting of Portuguese listed corporations between 2019 and 2022, as well as to identify its determinant factors. The study utilizes content analysis to construct four sustainability reporting indices (economic, environmental, social, and global). Panel regression is employed to explore the determinant factors of each index. Findings indicate a growth in sustainability reporting, with corporations predominantly disclosing environmental information. Panel regression results suggest that larger companies are more inclined to disclose sustainability information, particularly of an economic nature. The quality of the auditor and notoriety and visibility achieved by being included in PSI only seem to affect the environmental reporting. The study is constrained by a small sample size and a focus solely on Portuguese listed corporations, limiting result generalization. Additionally, the period of analysis includes the years of the COVID-19 pandemic, which may influence not only sustainability reports but also financial results.*

1. INTRODUCTION

Sustainability has gained increasing attention in recent years, with governmental entities and international organizations promoting more sustainable and responsible practices. Corporations have not remained oblivious to this reality. In fact, there is an increasing number of companies adopting sustainable practices and publishing sustainability reports. Sustainability reporting is becoming increasingly important for companies and is increasingly being used as a tool for communicating and managing sustainability practices.

In this context, the following research questions arise: Is the tendency for increasing sustainability reporting also observable in Portugal? What are the most reported aspects (social, economic, environmental) in the sustainability report? What drives corporate sustainability reporting?

This paper addresses these questions by focusing on the sustainability reports of a sample of publicly traded companies in Portugal from 2019 to 2021. The structure of the paper is as follows: section 2 presents the literature review; section 3 presents the methodology, namely the objectives and research hypotheses, the sample and variables; in section 4 the authors discuss the results. Finally, section 5 concludes, summarizing the main conclusions, as well as the main limitations and suggestions for future research.

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2.   LITERATURE REVIEW

According to the World Commission on Environment and Development (1987), sustainable development encompasses meeting the present needs of the population without compromising the needs of future generations. It entails the conservation of natural resources, fostering fair and equitable development, and considering the long-term consequences of current decisions and actions on the environment, society, and the economy (Ruggerio, 2021).

The concept of corporate social responsibility (CSR) is closely tied to sustainable development. CSR incites corporations to consider the social and environmental impact of their daily activities, products, and services, to meet the expectations of stakeholders (Carroll & Shabana, 2010). Although CSR is commonly associated with the private sector, it is increasingly adopted by both the public sector and non-profit organizations (Carroll & Shabana, 2010).

Introducing sustainability in business promotes a mindset known as ecological efficiency or eco-efficiency (Jassem et al., 2018). This concept harmonizes resource efficiency with environmental responsibility, enabling organizations to achieve superior economic performance while minimizing their negative environmental impact. Companies further contribute to sustainable development through partnerships, investments in social and environmental projects, and organize volunteer activities (Ordonez-Ponce et al., 2021). These initiatives not only benefit communities and the environment, but also enhance a company's reputation, and community relations, and stimulate innovation (Carroll & Shabana, 2010). Thus, corporations ensure long-term economic development without harming the environment and society (AlQershi et al., 2022).

In this context, the number of companies embracing sustainable practices and disclosing sustainability reports has increased substantially in recent years. The sustainability report is a comprehensive document showcasing a company's efforts and objectives in economic, social, and environmental aspects (BCSD, 2021). As outlined by Martínez et al. (2023), sustainability reporting is a vital communication tool for companies to share their sustainable activities and performance with stakeholders.

Internationally recognized entities provide guiding principles for sustainability reporting. The International Integrated Reporting Council (IIRC) offers a guide for integrated reporting, presenting both financial and non-financial information to stakeholders in a straightforward manner (Hamad et al., 2020). The Global Reporting Initiative (GRI), established in 1997, is a key international entity for sustainability reporting, promoting transparency and corporate responsibility (GRI, 2023). GRI develops guidelines and principles, which are regularly updated to be aligned with the changes in the business environment and stakeholder expectations and to meet the needs for comprehensive sustainable information disclosure (GRI, 2023). GRI standards include disclosure principles, topics, and indicators for companies to measure and report their performance in different sustainability areas (environmental, social, and governance).

The principles guide the sustainability reporting process, emphasizing transparency, integrity, accuracy, relevance, and comparability (GRI, 2023). Topics include key sustainability issues like management, environment, employee relations, human rights, and supplier relations. Indicators provide measures for reporting sustainability performance, categorized into Economic, Environmental, and Social Performance Indicators (GRI 200, GRI 300 and GRI 400 indicators, respectively). These performance indicators allow corporations to identify and monitor key areas, such as reducing greenhouse gas emissions or enhancing employee satisfaction (Isaksson & Steimle, 2009). The GRI standards are

widely recognized and globally used by investors, governments, consumers, and other stakeholders, to assess companies' economic, social and environmental responsibility (GRI, 2023).

Some papers on systematic literature review have been developed to understand the multi-theoretical framework used in relation to sustainability reporting studies, as well as the main determinants of sustainability reporting (Dienes et al., 2016; Farisyi et al., 2022). The growing importance of sustainability reporting can be explained in the light of three main theories: the legitimacy theory, the agency theory and the stakeholders' theory. The Legitimacy Theory explores how organizations establish and sustain legitimacy in society. Legitimacy is defined by the perceived appropriateness and desirability of an organization's actions in a social context (Silva, 2021) and comprises (Haack & Rasche, 2021):

• Cognitive Legitimacy: organizations gain legitimacy by aligning with societal norms, values, and beliefs, and adhering to accepted standards.
• Pragmatic Legitimacy: organizations secure legitimacy by contributing with goods and services valued by society and, thus, enhancing individual and societal well-being.
• Moral Legitimacy: organizations gain legitimacy by aligning actions with moral standards and societal expectations, beyond legal requirements.

Agency Theory outlines the dynamic between shareholders (principals) and managers (agents), acknowledging potential conflicts of interest (Dura et al., 2021). This principal-agent relationship can lead to an agency problem, where the manager's objectives may differ from those of the shareholder (Hamad et al., 2020). In the context of sustainability reporting, the report acts as a communication tool to mitigate the agency problem by providing shareholders with pertinent information and reducing information gaps. This transparency aids shareholders in assessing sustainability performance and making informed investment decisions while motivating agents to prioritize sustainability (Hamad et al., 2020). Additionally, sustainability reporting fosters alignment with other stakeholders, building trust through a commitment to social responsibility.

Stakeholder theory emphasizes that companies owe responsibilities not solely to shareholders but also to employees, customers, suppliers, communities, and the environment. It advocates for decision-making that considers the interests of all stakeholders, prioritizing value creation (Hamad et al., 2020). According to Freudenreich et al. (2020), stakeholders engage with a company if they receive value in return. Non-financial reports fulfill stakeholders' need for information on social and environmental performance (Hamad et al., 2020). Transparent sustainability reporting enables informed decisions, ensuring accountability for environmental, social, and governance performance (Hörisch et al., 2020), making it a tool to manage stakeholder expectations and interests.

Several studies have been conducted to investigate sustainability reporting and its determinants. These studies tend to focus on large publicly traded corporations, as they are widely scrutinized by the market. Researchers commonly perform content analysis of annual financial reports and sustainability disclosures to evaluate corporate sustainability practices. One prevalent method among researchers is the development of sustainability reporting indices. These tools help determine the extent to which companies address sustainability compared to established accounting standards or guidelines for sustainability reporting. Regarding the determinants of sustainability disclosures, empirical studies tend to consider both internal and external factors, such as corporate size and financial performance, industry sector, ownership structure, corporate governance the presence of a social responsibility committee or environmental certifications (Dienes et al., 2016; Farisyi et al., 2022; Kumar et al., 2021).

Empirical evidence indicates that there is a trend for growing sustainability disclosures, particularly concerning environmental and social issues and that companies are using standardized frameworks to enhance transparency and the credibility of their sustainability disclosures. There is also evidence that larger companies tend to disclose more about their sustainability efforts (e.g. Kumar et al., 2021; Nguyen, 2020). Additionally, companies operating in industries with potentially significant environmental footprints are inclined to share more about their environmental endeavors (Mihai & Aleca, 2023). However, the relationship between a company's profitability and its sustainability reporting remains ambiguous.

3. METHODOLOGY

3.1. Objectives and Research Hypotheses

The objective of this paper is twofold: first, to analyze the sustainability reporting of Portuguese-listed corporations between 2019 and 2022; and second, to investigate determinants of sustainability reporting. Based on the literature review, were defined the following research hypotheses:

H1: Sustainability reporting is positively affected by financial performance.

From a theoretical point of view, more profitable companies can allocate greater resources to social and environmental responsibility practices. Therefore, they are interested in making these practices known to stakeholders to achieve legitimacy. In this perspective, a positive relationship between the profitability of companies and the level of sustainability disclosure is expected. However, empirical evidence is inconclusive. Some studies suggest that profitability does not significantly influence sustainability reporting practices (e.g. Diantimala, 2018), whereas others find a significant positive (e.g., Garcia et al., 2022; Carvajal & Nadeem, 2022) or even negative (e.g., Buallay, 2019; Ece & Sari, 2020) relationship between these variables.

In our study, we consider it reasonable to expect that companies with better financial performance disclose more sustainability information, due to the need to align with investor expectations, communicate social and environmental benefits, as well as comply with government regulations.

H2: Sustainability reporting is positively affected by corporate size.

The positive association between corporate size and sustainability reporting is justified in the light of the Legitimacy Theory. Larger companies, due to their higher visibility and pressure from various stakeholders, tend to disclose their social and environmental responsibility practices to legitimize their actions in society and for stakeholders (Monteiro & Guzmán, 2010). The association between sustainability information disclosure and company size has been supported by various empirical studies (e.g. Garcia et al., 2022; Kaya & Akbulut, 2019; Kumar et al., 2021). However, other authors (e.g., Barros & Monteiro, 2012) found no association between these two variables.

H3: Sustainability reporting is positively affected by the sector of activity of the corporation.

The sustainability reporting, particularly regarding environmental matters, may be related to the company's industry sector. According to the literature, the greater the impact of its activities on the environment, the higher the likelihood that the organization will demonstrate greater environmental responsibility practices and, consequently, higher levels of disclosed information. Several

authors (e.g. Garcia et al., 2022) argue that this association is due to the fact that more sensitive and polluting sectors are subject to greater pressures and compliance with certain regulations, compelling them to communicate their environmental performance (Monteiro & Guzmán, 2010). Many studies have considered this variable as a determining factor in sustainability disclosure practices (e.g. Posadas et al., 2022; Tudor et al., 2019), concluding that the level of environmental information disclosure is higher in companies from more polluting sectors.

H4: Sustainability reporting is positively affected by the quality of the external auditor.

Since social and environmental issues are increasingly relevant, several empirical studies consider the quality of the auditor as a possible explanatory factor for the level of sustainability reporting (Dienes et al., 2016). According to Ruiz-Barbadillo and Martínez-Ferrero (2020), large audit firms belonging to the Big 4 group (KPMG, PWC, Deloitte, and Ernst&Young) tend not to associate with clients with low levels of disclosure, imposing high standards on reporting. In this sense, we expected the level of sustainability reporting to be higher in companies audited by a Big 4 firm. Nevertheless, García and Ayala (2010) did not find a statistically significant connection between the quality of the auditor and their environmental disclosure index.

H5: Sustainability reporting is positively affected by the notoriety of the firm.

Considering the legitimacy theory, companies more 'visible' to the public eye tend to present more information to enhance their reputation and, thus, ensure legitimacy with stakeholders. Some studies consider the inclusion of a company in a stock index as a proxy for visibility/notoriety (Carvalho, 2012). Thus, we expect sustainability reporting to be higher for companies with greater visibility. The Portuguese Stock Index 20 (PSI-20) is the main benchmark index of the Portuguese stock market, which brings together the largest companies also listed on Euronext Lisbon. Typically, this index is composed of companies with the highest market capitalization.

3.2. Sample

The sample consists of Portuguese non-financial listed corporations that disclose sustainability information according to the GRI standards from 2019 to 2022. Sustainability reporting can be done in the financial statements, in a specific section dedicated to non-financial reporting, usually known as integrated reporting, or by the disclosure of an independent report dedicated to non-financial reporting, the sustainability report. Considering these criteria, the sample comprises 9 non-financial listed corporations: Altri, SGPS, SA; Corticeira Amorim, SGPS, SA; EDP – Energias de Portugal, SA; Mota-Engil, SGPS, SA; NOS, SGPS, SA; SEMAPA – Sociedade de Investimento e Gestão, SGPS, SA; SONAE, SGPS, SA; Teixeira Duarte, SA; and The Navigator Company, SA. Since each company in the sample is observed 4 years (from 2019 to 2022), we are left with 36 observations.

3.3. Variables

Based on content analysis of financial statements and/or sustainability reports, we construct a sustainability reporting index for each category outlined in the GRI 2021 standards series: Economic Performance (GRI 200), Environmental Performance (GRI 300), and Social Performance (GRI 400). The value of the index in each category (Economic, Environmental and Social) is the ratio of the number of topics in each category disclosed by each corporation in each year to the total

of topics in each category (17, 32, and 40, respectively). Based on these 3 indices, we construct a global sustainability reporting index, which is the ratio of the number of topics in the 3 categories disclosed by each corporation in each year to the total of topics in the 3 categories (89 topics).

We use panel data regression, to investigate the determinants of sustainability reporting. As a dependent variable, we consider each of the sustainability reporting indexes: Economic Reporting Index, Environmental Reporting Index, Social Reporting Index and Global Sustainability Reporting Index. As independent variables, we use financial performance, as measured by the return of assets (ROA), and size, as measured by the natural logarithm of total assets, in year t. Data is from SABI dataset. We also consider 3 dummy variables: (1) a dummy variable to proxy for activity sector, taking the value 1 if the company belongs to the industry sector; 0 otherwise; (2) a dummy variable to proxy for the quality of the auditors of financial statements, taking the value 1 if the auditors belong to Big4; 0 otherwise; and (3) a dummy variable that proxies for notoriety, taking the value 1 if the company belongs to Portuguese Stock Index (PSI); 0 otherwise. Table 1 summarizes the variables.

Table 1. Variables

Variable	Measure
Sustainability Reporting Index	Economic Reporting Index
	Environmental Reporting Index
	Social Reporting Index
	Global Sustainability Reporting Index
Financial Performance	ROA
Size	Natural Logarithm of Total Assets
Sector	Dummy variable, that takes the value 1 if the company belongs to the industry sector; 0 otherwise
Audit	Dummy variable, that takes the value 1 if the auditors belong to Big4; 0 otherwise.
PSI	Dummy variable, that takes the value 1 if the company belongs to PSI 20; 0 otherwise

Source: Own elaboration

4.   RESULTS AND DISCUSSION

Table 2 presents the value of the 4 sustainability reporting indices in each year of analysis. This table allows us to assess which categories of information (social, economic, environmental) are most reported by corporations in the sample and to analyze the evolution of sustainability reporting over time.

Table 2. Sustainability Reporting Indices

Year	Economic Index	Environmental Index	Social Index	Global Index
2019	0,33	0,41	0,37	0,38
2020	0,44	0,59	0,58	0,56
2021	0,54	0,68	0,63	0,63
2022	0,63	0,70	0,67	0,67
Average 2019-2022	0,48	0,60	0,56	0,56

Source: Own elaboration

As we can observe, on average, Portuguese listed corporations disclose more environmental information (60% of the topics defined in GRI 300 standards are disclosed by Portuguese corporations in the sample), followed by social information (56% of the topics defined in GRI 400 standards

are disclosed), and economic information (48% of the topics defined in GRI 200 standards are disclosed). It also stands out a significant growth in the value of all indices over the four years between 2019 and 2022. Notably, there was a substantial increase in the disclosure of non-financial information from 2019 to 2020 (the percentage of disclosed criteria rose from 38% to 56%). From 2021 to 2022, there is also an increase in disclosure, though less considerable (from 63% to 67%).

Table 3 summarizes the results of the panel regressions, allowing us to check the determinants of sustainability reporting.

Table 3. Determinants of Sustainability Reporting

Variable	Economic Index		Environmental Index		Social Index		Global Index	
Constant	-1,916	**	-.186		-0,810		-0,716	
ROA	0,846		0,593		0,363		0,584	
Size	0,169	***	0,064	**	0,096	**	0,092	**
Sector	0,037		-0,065		-0,067		-0, 0295	
AUD	-0,313		-0,369	***	-0,937		-0,219	
PSI	0,155		0,351	***	0,453		0,156	*
N	36		36		36		36	
Wald Chi^2	16,53 ***		59,36 ***		7,69		15,36 ***	
R^2 Within	0,1097		0,0137		0,0252		0,1164	
R^2 Between	0,8046		0,9593		0,6805		0,6467	
R^2 Overall	0,5843		0,6643		0,3484		0,4444	
Sigma_u	0,1523		0		0,1071		0,1001	
Sigma_e	0,1783		0,1781		0,1699		0,1396	
rho	0,4221		0		0,2845		0,3399	

Source: Own elaboration

The results suggest a positive but statistically insignificant relationship between financial performance and Sustainability Reporting, regardless of the index considered. Size shows significant positive effects on sustainability reporting: larger corporations tend to disclose more sustainability information. The coefficient of the regression is stronger when we consider the Economic index. Regarding the dummy variables, the quality of the auditor only seems to affect the environmental reporting (with firms audited by big4 disclosing less environmental information), whereas the notoriety and visibility achieved by being included in PSI affects positively the environmental index (and also the global index, at a confidence level of 10%).

Our results were not able to support the first research hypothesis. Although there is a positive relationship between financial performance and sustainability disclosure, this relationship was not statistically significant for any of the sustainability reporting indices considered (economic, environmental, social and global). This result is similar to those of Diantimala (2018), who found that financial performance does not have a significant impact on corporate sustainability reporting practices.

The results corroborate the second research hypothesis: a positive and significant relationship between the size of the company and sustainability disclosures, which is in line with the results of previous studies (e.g. Kaya & Akbulut, 2019; Kumar et al., 2021; Nguyen, 2020).

Regarding the third research hypothesis, our results go against the extensive empirical literature that identifies the sector as an explanatory variable of sustainability disclosures (Posadas et al., 2022; Tudor et al., 2019).

The fourth research hypothesis cannot be validated. In fact, we find a negative relationship between the quality of the auditor and sustainability reporting, which is statistically significant for environmental disclosures. Thus, our results are contrary to those of García and Ayala (2010).

Finally, our results support the fifth research hypothesis, i.e., a positive relationship between visibility/notoriety and sustainability reporting, namely environmental reporting. Thus, our results are contrary to the results of Carvalho (2012) who found a non-statistically significance between visibility/notoriety, as measured by the inclusion in PSI20, and environmental disclosures.

5. CONCLUSION

Business sustainability ensures the alignment of economic, social, and environmental aspects of corporate activity. Guided by GRI principles, sustainability reporting provides valuable information to investors and stakeholders, contributing to organizational transparency.

This study investigates the determinants of the sustainability reporting of Portuguese non-financial listed corporations. The results show a significant increase in the level of sustainability reporting from 2019 to 2022. Overall, corporations in the sample tend to disclose more topics related to the environmental category (60%), followed by the social category (56%), and finally, the economic category (48%). Thus, environmental disclosures exhibit the highest compliance with GRI standards.

Regarding the determinants of sustainability reporting, we find that there is a positive and significant relationship between the size of the company and sustainability disclosures, which corroborates the results of previous empirical studies. We also find a positive relationship between visibility/notoriety and sustainability reporting, namely environmental reporting. The sector of activity and profitability does not seem to influence sustainability reporting. The quality of the auditor only seems to affect negatively and significantly environmental disclosures.

This study acknowledges some limitations, namely the small sample size and the focus on only Portuguese listed corporations, which limits the generalization of results. Additionally, the period of analysis includes the years of the COVID-19 pandemic, which may influence not only the sustainability report but also financial results. Considering these limitations, we suggest future research to investigate the determinants of sustainability reporting considering listed and non-listed corporations of different countries, as well as to investigate the impact of sustainability reporting on corporate financial performance and market value.

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References

AlQershi, N. A., Saufi, R. B. A., Mokhtar, S. S. M., Muhammad, N. M. N., & Yusoff, M. N. H. B. (2022). Is strategic orientation always beneficial? A meta-analysis of the relationship between innovation and business sustainability: A dynamic capabilities perspective from Malaysian insurance companies. *Sustainable Futures, 4,* 100075. https://doi.org/10.1016/j.sftr.2022.100075

Barros, C., & Monteiro, S. (2012). Determinant Factors of Mandatory Environmental Reporting: The Casa of Portuguese Primary Metal and Steel Industry. *Studies in Fuzziness and Soft Computing, 286,* 123–147

BCSD. (2021). *Diretrizes de Sustentabilidade - Reporting*. BCSD Portugal: https://bcsdportugal.org/diretrizes-da-sustentabilidade-reporting/

Buallay, A. (2019). Between cost and value: Investigating the effects of sustainability reporting on a firm's performance. *Journal of Applied Accounting Research, 20*(4), 481-496. https://doi.org/10.1108/jaar-12-2017-0137

Carroll, A. B., & Shabana, K. M. (2010). The Business Case for Corporate Social Responsibility: A Review of Concepts, Research and Practice. *International Journal of Management Reviews, 12*(1), 85-105. https://doi.org/10.1111/j.1468-2370.2009.00275.x

Carvajal, M., & Nadeem, M. (2022). Financially material sustainability reporting and firm performance in New Zealand. *Meditari Accountancy Research, 31*(4), 938-969. https://doi.org/10.1108/medar-06-2021-1346

Carvalho, V. (2012). A Divulgação da Responsabilidade Ambiental: O Caso das Empresas Cotadas em Portugal. Mestrado em Contabilidade e Finanças, IPCA

Diantimala, Y. (2018). The Mediating Effect of Sustainability Disclosure on the Relationship between Financial Performance and Firm Value. *Journal of Accounting, Finance and Auditing Studies, 4*(2), 32-48.

Dienes, D., Sassen, R., & Fischer, J. (2016). What are the drivers of sustainability reporting? A systematic review. Sustainability Accounting, *Management and Policy Journal, 7*(2), 154-189. https://doi.org/10.1108/sampj-08-2014-0050

Dura, J., Chandrarin, G., & Subiyantoro, E. (2021). The Effect Of Disclosure Of Economic, Social, Environmental Performance Sustainability On Financial Performance And Its Implications On Company Value With The Triple Bottom Line Approach. *Natural Volatiles & Essential Oils,* 8(6), 3642-3658.

Ece, O., & Sari, S. (2020). *Relationship between corporate sustainability reporting and firm efficiency, productivity, and profitability and firm value: Evidence from Turkey.* 32.

Farisyi, S., Musadieq, M. A., Utami, H. N., & Damayanti, C. R. (2022). A Systematic Literature Review: Determinants of Sustainability Reporting in Developing Countries. *Sustainability, 14*(16), 10222. https://doi.org/10.3390/su141610222

Freudenreich, B., Lüdeke-Freund, F., & Schaltegger, S. (2020). A Stakeholder Theory Perspective on Business Models: Value Creation for Sustainability. *Journal of Business Ethics, 166*(1), 3-18. https://doi.org/10.1007/s10551-019-04112-z

García, J., & Ayala, F. (2010). La Divulgación de Información Medioambiental en España y México: Un estudio aplicado a las empresas de la bolsa de Madrid y de la bolsa Mexicana de valores. Cuadernos de Trabajo. Facultad De Economía. Universidad Autónoma De San Luis Potosí. México.

García, M., Bollas, H., & Sierra, L. (2022). Non-financial reporting in Spain. The effects of the adoption of the 2014 EU Directive. *Spanish Accounting Review. 25*(1), 3-1

GRI (Global Reporting Initiative). (2023). https://www.globalreporting.org/

Haack, P., & Rasche, A. (2021). The Legitimacy of Sustainability Standards: A Paradox Perspective. *Organization Theory, 2*(4). https://doi.org/10.1177/26317877211049493

Hamad, S., Draz, M. U., & Lai, F.-W. (2020). The Impact of Corporate Governance and Sustainability Reporting on Integrated Reporting: A Conceptual Framework. *Sage Open, 10*(2). https://doi.org/10.1177/2158244020927431

Hörisch, J., Schaltegger, S., & Freeman, R. (2020). Accounting for sustainability and stakeholders: Field experiments and behavioral lab-experiments. *Journal of Cleaner Production, 275,*124097.

Isaksson, R., & Steimle, U. (2009). What does GRI-reporting tell us about corporate sustainability? *The TQM Journal, 21*(2), 168-181. https://doi.org/10.1108/17542730910938155

Jassem, S., Azmi, A., & Zakaria, Z. (2018). Impact of Sustainability Balanced Scorecard Types on Environmental Investment Decision-Making. *Sustainability, 10*(2), 541. https://doi.org/10.3390/su10020541

Kaya, I., & Akbulut, D. H. (2019). Sustainability reporting and firm performance. *Pressacademia, 9*(9), 81-84. https://doi.org/10.17261/pressacademia.2019.1071

Kumar, K., Kumari, R., & Kumar, R. (2021). The state of corporate sustainability reporting in India: Evidence from environmentally sensitive industries. *Business and Society Review, 126*(4), 513-538. https://doi.org/10.1111/basr.12247

Martínez, E. O., Hernández, S. M., & Jaén, J. S. (2023). Sustainability, corporate social responsibility, non-financial reporting and company performance: Relationships and mediating effects in Spanish small and medium sized enterprises. *Sustainable Production and Consumption, 35*, 349-364. https://doi.org/10.1016/j.spc.2022.11.015

Mihai, F., & Aleca, O. E. (2023). Sustainability Reporting Based on GRI Standards within Organizations in Romania. *Electronics, 12*(3), 690. https://doi.org/10.3390/electronics12030690

Monteiro, S., & Guzmán, B. (2010). Determinants of environmental disclosure in the annual reports of large companies operating in Portugal. *Corporate Social Responsibility and Environmental Management, 17*(4), 185-204.

Nguyen, T. (2020). An Empirical Study on the Impact of Sustainability Reporting on Firm Value. *Journal of Competitiveness, 12*(3), 119-135. https://doi.org/10.7441/joc.2020.03.07

Ordonez-Ponce, E., Clarke, A., & MacDonald, A. (2021). Business contributions to the sustainable development goals through community sustainability partnerships. *Sustainability Accounting, Management and Policy Journal*. https://doi.org/10.1108/sampj-03-2020-0068

Posadas, S., Ruiz-Blanco, S., Fernandez-Feijoo, B., & Tarquinio, L. (2022). Institutional isomorphism under the test of Non-financial Reporting Directive. Evidence from Italy and Spain. *Meditari Accountancy Research, 31*(7), 26–48. https://doi.org/10.1108/medar-02-2022-1606

Ruggerio, C. A. (2021). Sustainability and sustainable development: A review of principles and definitions. *Science of The Total Environment, 786*, 147481. https://doi.org/10.1016/j.scitotenv.2021.147481

Ruiz-Barbadillo, E., & Martínez-Ferrero, J. (2020). Empirical analysis of the effect of the joint provision of audit and sustainability assurance services on assurance quality. *Journal of Cleaner Production, 266,* 121943. https://doi.org/10.1016/j.jclepro.2020.121943

Silva, S. (2021). Corporate contributions to the Sustainable Development Goals: An empirical analysis informed by legitimacy theory. *Journal of Cleaner Production, 292,* 125962. https://doi.org/10.1016/j.jclepro.2021.125962

Tudor, A., Silvia, N., Ştefănescu, C., & Zanellato, G. (2019). Encompassing Non-Financial Reporting in a Coercive Framework for Enhancing Social Responsibility: Romanian Listed Companies Case. *Amfiteatru economic*, 21(52), 590-606. https://doi.org/10.24818/ea/2019/52/590

World Commission on Environment and Development. (1987). *Our Common Future: From One Earth to One World*. Retrieved from http://www.un-documents.net/ocf-ov.htm#1.2

Disclosure Practices of the Sustainable Development Goals in the Healthcare Sector: The Case of Portuguese Hospital Sector

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Abstract: *This paper aims to analyze the disclosure practices of the Sustainable Development Goals (SDGs) on the websites of Portuguese hospitals. A content analysis was conducted on the websites of 84 Portuguese hospitals, searching for the keywords 'SDGs,' 'sustainable development goals,' '2030 agenda,' and 'sustainability.' For the generated results, the general and specific mention of the SDGs, the location of the information on the website, and the existence of sustainability reports and their alignment with the SDGs were investigated. The results revealed that SDGs/2030 Agenda /Sustainability is mentioned on only 9 of the websites of Portuguese hospitals. Among these, only 5 disclose the SDGs, either in a general or specific manner. The majority belongs to the private sector. Regarding information location, it is more likely to find information in non-financial reports published on websites than in thematic sections specifically dedicated to the 2030 Agenda/SDGs. These findings represent a significant gap in the promotion and dissemination of sustainable development practices in the healthcare sector. The results are limited to the availability of information based on keyword searches, considering the existence of at least one mention of the concept of SDGs, 2030 Agenda, or Sustainability, without assessing the quantity or quality of the disclosed information.*

1. INTRODUCTION

The Sustainable Development Goals (SDGs) are a global agenda adopted during the United Nations summit in September 2015, consisting of 17 goals and 169 targets to be achieved by 2030. The objectives assumed by the countries have an appeal to "Leave no one behind" and present goals that are based on the 5P's: Planet, People, Prosperity, Peace and Partnerships (Tremblay et al., 2020).

In 2017, Portugal strengthened its commitment to the SDGs by preparing a "National Report on the implementation of the 2030 Agenda for Sustainable Development", which lists SDGs 4, 5, 9, 10, 13 and 14 as strategic priorities in the implementation of the 2030 Agenda in the country (Government of Portugal, 2017)

Social aspects such as sustainability are growing in the business scenario, being an important factor for the survival of organizations in a market that increasingly observes the social role of companies, especially in the areas of health (Lopes et al., 2015). While the primary mission healthcare sector is to protect health, it is paradoxically a major contributor to environmental pollution that negatively impacts health (Consolandi et al., 2020). The study by Banerjee (2024) highlights the lack of awareness in implementing corporate SDG plans in the healthcare sector and emphasises the need for a strategic action plan to improve budget planning and allocation for healthcare development projects. Additionally, we realize the importance of disclosing sustainable practices, mainly through websites, since we are in a digital age, where information reaches the population in a practical and

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fast way. However, the literature on sustainability disclosure in hospital networks remains omitted (Andrades Peña et al., 2020; Garzoni et al., 2024). Manes-Rossi et al. (2020) conclude, from a structured literature review in the public sector, that most existing studies have focused on sustainability reporting in higher education institutions, local governments and state-owned enterprises, while the healthcare sector remains silent. In this sense, due to the lack of empirical research on the disclosure of sustainable practices, SDGs and the 2030 Agenda in the hospital sector, more research is needed to understand the subject, making it a priority to analyze whether the Hospitals are communicating the SDGs on the websites and what are their disclosure practices.

However, hospitals still need to evolve a lot in the adoption, application and disclosure of sustainable practices (Andrades Peña et al., 2020), resulting in an interesting study context. Given the above, the specific objectives of this article are: 1) to ascertain the existence of a mention of sustainability, the 2030 agenda, or the SDGs, in general and specific terms; 2) to identify the location of information, whether it has been separated on the website or mentioned in reports; and 3) carry out a withdrawal of the characteristics of the sustainability reports available on the website, including their alignment with the SDGs. This data will be collected from the institutional websites of the Portuguese Hospitals.

In addition to this introduction, the article is structured in 3 parts: we started with a literature review on the contribution of hospitals to the SDGs, as well as the importance of reporting the SDGs and the use of websites as channels of disclosure. The second part presents the methodology followed, with the characterization of the sample and methods of data collection and analysis. The third part is dedicated to the analysis and discussion of the results according to the two specific objectives previously stated. Finally, the conclusions of the work are presented, including the main contributions, limitations and suggestions for future investigations.

2. LITERATURE REVIEW

The practice of sustainability is more widespread in the private sector than in the public (Goswami & Lodhia, 2014), which is surprising for having the purpose of meeting social and environmental needs and being a significant sector to the development of the national economy. According to Traxler and Greiling (2019), public organizations should be leading companies in the practice and disclosure of sustainability. Applying and disclosing practices related to sustainable development goals increases awareness of the importance of social and environmental action practices in the hospital sector (Andrades Peña et al., 2020).

The objective of the hospital sector is to provide medical services of maximum quality to the population, being a responsibility to society (Andrades Peña et al., 2020). The practice of sustainability disclosure is not imposed, but if adopted reinforces the trust of the society before the responsibility of the services. However, hospitals could disclose sustainability information to meet stakeholders' expectations by generating economic and financial benefits to the sector (Bonollo, 2015).

In this context, Aleixo et al. (2016, 2020) characterized sustainable development in Portugal at an early stage, with little progress, and the lack of policies and financial resources are the main obstacles. Therefore, this study analyzes how is the level of disclosure of sustainability information (ODS, 2030 Agenda), in Portuguese hospitals.

Nowadays the internet is the most effective means of communication, compared to other media, so companies' online presence is essential. The sites function as a space for international disclosure of

sustainable development practices, helping to communicate with stakeholders in a more updated, timely and interactive way, in addition to having a lower cost (Aleixo et al., 2016; Di Tullio & La Torre, 2022).

Internet channels are important tools used for the communication of sustainability to the public, work as a tool for image construction and organizational self-representation (Katiliute & Daunoriene, 2015).

In this sense, it is important to analyze how hospitals are exploring the potential of sites as a means to communicate their performance in sustainability and the dissemination of the SDGs. Websites allow users to access sustainability reports, as well as other non-financial reporting documents that have information on the SDGs, which can be highlighted in a specific section related to the theme (Izzo et al., 2020).

As far as hospitals are concerned, the empirical literature on reports disclosing the SDGs is still at an embryonic stage. However, as far as we know, no previous study explored the online dissemination of SDGs in Portuguese hospitals. Table 1 summarizes the main studies.

Therefore, we intend to analyze how the SDGs are being disclosed on the websites of Portuguese hospitals, in specific locations and directed to the theme, such as: sections and specific non-financial reporting documents.

Table 1. Studies on sustainability disclosure in the health sector

Author	Objectives	Sample	Methodology	Results
Asmara and Rahmawati (2024)	Analyzes the disclosure practices of environmental, social and governance (ESG) dimensions from 2021 to 2022. It assesses the quantity and quality of ESG disclosures based on the Global Reporting Initiative (GRI) standards.	28 healthcare sector companies listed on the Indonesia Stock Exchange (IDX) during 2021-22	Content analysis of annual reports and sustainability reports from company websites and the IDX websites, evaluating ESG disclosure in quantity and quality	ESG disclosure is low (below 50%), with governance having the highest disclosure, followed by social and environmental aspects.
Garzoni et al. (2024)	Investigates the determinants of online sustainability disclosure, using a legitimacy theory perspective	175 international hospitals selected from *The World's Best Hospitals 2022*	Web-content analysis of hospital websites between April and May 2023. Sustainability disclosure was measured using a 60-item Sustainability Disclosure Index (SDI)	International hospitals disclose only limited sustainability information. Hospital size, public status and teaching status positively influence disclosure, while internet visibility has no significant impact. Gender diversity of the board increases disclosure, while hospital complexity decreases it.
Siregar et al. (2022)	Examines the sustainability reporting in the healthcare sector, specifically among pharmaceutical companies	Pharmaceutical companies listed on the Indonesia Stock Exchange, namely the Kalbe Farma Pharmaceutical industry.	Qualitative content analysis of the company's sustainability report, published in 2021	The sustainability report (2021) demonstrates how the company's commitment to ESG aspects positively impacts the community and employees, ensuring that Kalbe Farma effectively aligns with regulations and carries out its business and policies responsibly.

Constantinescu (2021)	Investigates the relationship between sustainability disclosure measured through combined and individual environmental, social and governance (ESG) scores and the value of European companies in the energy and health sectors.	61 European companies of different categories in the energy sector and 45 European companies in the health sector.	Sample defined as panel data, two linear regressions.	For companies in the energy sector, a significant and negative relationship between environmental disclosure and the value of companies was observed. However, for sustainability disclosure, measured by the combined and individual ESG scores, no significant connection was found with the companies' market value. The adjusted R-squared value was insignificant, indicating that the variation in the value of the companies was not explained by the independent variables in the health sector. Unlike the results obtained for the energy sector, the hypotheses defined were not validated by statistical tests in the health sector.
Andrades et al. (2021)	Examines the level of sustainability disclosures provided by Spanish hospitals using exclusively the information disclosed on their institutional websites.	All Spanish hospitals.	Content analysis on official websites.	Spanish hospitals reveal little information on sustainability and these disclosures are fragmented between different categories. Spanish hospitals had better levels of general information disclosure compared to the specific information provided about their social and environmental performance. While general information tends to be qualitative and does not say much about the sustainability performance of hospitals, specific information refers to the quantitative assessment of the socio-environmental performance of hospitals. Based on the above considerations, it seems that the practice of sustainability disclosure is far from being institutionalized in Spanish hospitals.
Andrades Peña et al. (2020)	This article explores whether the extent of sustainability information disclosed by Spanish public hospitals is affected by the internal characteristics of such organizations, as well as by political ideology and socioeconomic variables.	All Spanish hospitals.	Content analysis on official websites.	Spanish public hospitals tend to disclose more information about general and social aspects of sustainability. Those who follow GRI-based reporting standards have better disclosure than those who do not. The low level of disclosure is attributed to the lack of standardization and professionalization of reforms in Spain compared to Anglo-Saxon countries. The coercive influence of Spanish law is limited to public hospitals. Hospitals that disclose more are motivated by legitimacy and meeting the needs of stakeholders. The most influential variables include size, internet access, political ideology and reputation.

| Farghaly Abdelaliem et al. (2023) | The study seeks to investigate the impact of private business participation in health-related programs through sustainable corporate reporting (or corporate social responsibility disclosures; CSRD). | 117 companies listed in Saudi Arabia. | Descriptive-correlational analysis, a balanced data panel of 117 companies listed in Saudi Arabia. | The study reveals a statistically significant difference between the sustainable reports of non-financial companies and their participation in health programs. It shows that sustainability reports in hospitals are rare and few companies consider using indicators in these reports. Only a small percentage of organizations and companies use corporate reporting guidelines to report their sustainability performance. |

Source: Own elaboration

3. METHODOLOGY

3.1. Sample

The sample of this study consists of hospitals located in Portugal, including the Autonomous Region of the Azores and Madeira. The list of Portuguese hospitals was taken from the database of previous studies conducted on the sector. From a total of 91 Hospitals, only the organizations with active website were considered, resulting in a final sample of 84 hospitals.

As represented in the table below, the majority of Portuguese hospitals belong to the Public Business sector which represents (45.24%) of the sample, followed by the Private sector with (40.48%). The sectors with the lowest number of hospitals are the Public Administration (4.76%), Public Private Partnership (2.38%), Holy House Mercy (2.38%) and Social Sector (4.76%). Finally, the Public Business and Private sector dominates the Portuguese hospital area.

Table 2. Characterization of the sample

Characteristics		n	% sample
	Total	84	100%
Sector	Public Business	38	45,24
	Public Administration	4	4,76
	Public Private Partnership	2	2,38
	Holy House Mercy	2	2,38
	Social Sector	4	4,76
	Private	34	40,48

Source: Own elaboration

3.2. Methods

As a methodology, a content analysis was performed on the websites of the hospitals of the sample, one of the techniques most used in studies on reporting information (e.g. Aleixo et al., 2020; Caputo et al., 2021; Izzo et al., 2020).

Through the websites of the hospitals and the specific documents (namely strategic plans, manuals/quality plans, as well as plans and activity and sustainability reports) available on the official websites of the same, we sought the keywords 'SDGs', 'Sustainable Development Goals', '2030 Agenda' and 'Sustainability'. The goal would be to find at least one reference to one of these concepts, and mentions in the news were not considered for analysis. Data were collected in September 2023.

For the generated results, the existence of a general and specific mention of the SDGs was analyzed, and the specific SDGs found were noted (similar to Aleixo et al., 2020), according to the first objective of the work. Subsequently, the respective location of this information was verified, namely in specific documents and specific sections, as defined in the 2nd objective of the investigation. It is important to note that the specific section considered not only the tabs with the name '2030 Agenda' or 'SDGs', but also others related to the theme, for example, 'Social Responsibility' and 'Sustainability', as long as they included information about the SDGs.

Table 3. Method of data collection and analysis

Objective	Topic	Description	Coding
1) Verify the existence of a mention of the SDGs/ 2030 Agenda/ Sustainability, in general and/ or specific terms	Disclosure of the SDGs/2030 Agenda/Sustainability	Visibility of the SDGs/2030 Agenda/ Sustainability, in general terms, and specific SDGs	0 – No disclosure; 1 – General disclosure only; 2 – Disclosure of specific SDGs;
2) Identify the location of information about the SDGs	Specific Document	Reference to the SDGs/2030 Agenda/ Sustainability at least in a non-financial document (manual strategic quality plan, plan or activity report)	0-No; 1-Yes;
	Specific Section	Existence of a tab or a specific section on the website with information on the SDGs/2030 Agenda/ Sustainability	0-No; 1-Yes;
3) Conduct a withdrawal of the characteristics of sustainability reports	Period	The year or time horizon covered by the report	-
	GRI Guidelines	Compliance with GRI guidelines/standards and their version	-
	Dimentions	The dimensions of sustainability prioritized	-
	Alignment with the SDGs	Whether the information organisation is linked to the SDGs	0-No; 1-Yes;
	External Verification	The existence of an external verification of the report	0-No; 1-Yes;
	Number of Pages	The total number of pages in the report	-

Source: Own elaboration

Based on previous research, the implementation of practices aligned with the SDGs is expected to be in its initial stage (e.g. Aleixo et al., 2016, 2020). However, it is expected that most hospitals still do not disclose SDGs, the 2030 Agenda or Sustainability and do not have sustainability reports aligned with the 2030 Agenda.

4. RESULTS DISCUSSION

4.1. General and Specific Disclosure of the SDGs

According to the first objective of the research, in a first analysis, it was verified the existence of at least one mention of the SDGs, either in general or in specific terms. Of the 84 websites, in 79 (94.05%) no information was visible for the keywords searched ('SDGs', 'sustainable development

goals' and '2030 agenda'), and in 5 (5.95%) it was possible to find at least one reference to these concepts. However, by including in the search the keyword 'Sustainability' the number of hospital disclosers rises to 9 (10.71%), and the remaining 75 (89.29%) do not disclose any kind of sustainability-related information. Hospitals that contain information on the SDGs/ 2030 Agenda/ Sustainability on their website are defined in this study as "disclosers".

Of the 9 disclosures hospitals, the majority belong to the Private sector (3 - 33.34%), followed by the Public Business and Public Administration sector being (2 - 22.22%) each sector, and the remaining Holy House Mercy and Social sectors have the disclosure of (1 - 11.11%) for each sector. These data can be found in Table 4.

Table 4. Characterization of the disclosure hospitals

	N(9)	% disclosure
Private Sector	3	33,34%
Public Business Sector	2	22,22%
Public Administration Sector	2	22,22%
Holy House Mercy	1	11,11%
Social Sector	1	11,11%

Source: Own elaboration

On the disclosure of the SDGs, of the 9 disclosers' hospitals, only 5 of them mention the keyword SDG or 2030 Agenda. Since 2 (22.22%) only make a general disclosure of the concept, there is no specific approach to any SDGs. This specific disclosure of at least one SDG was found in 3 (33.33%) public hospitals (see Figure 1).

■ Sustainability Disclosure with Mention to the Keyword SDG or Agenda 2030

■ Specific Disclosure

■ General Disclosure
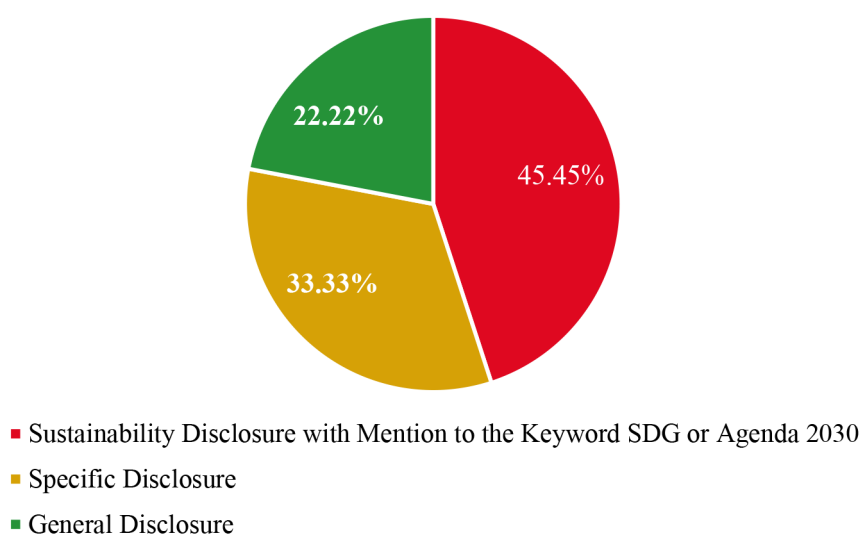
Figure 1. SDGs Disclosure
Source: Own elaboration

Considering the specific disclosure of the SDGs, the following Figure 2. indicates the number of Hospitals in which it was visualized, at least once, each of these objectives.

In this sense, we realize that the disclosure of the SDGs in Portuguese hospitals does not show a significant difference in the visibility of a specific SDG.
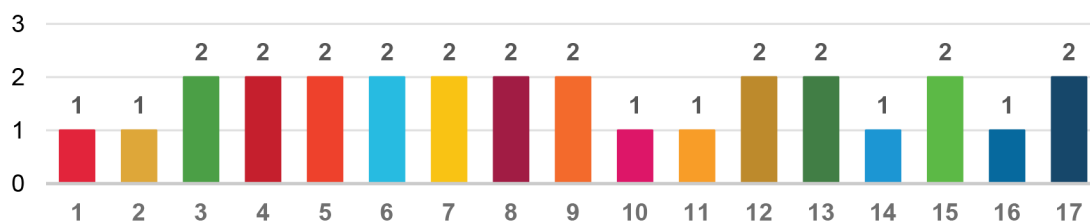
Figure 2. Visibility of specific SDGs
Source: Own elaboration

4.2. Disclosure Practices of SDGs

According to the 2nd objective, it is intended to identify the location of the information related to the SDGs. The analysis of disclosure practices will consider only the 5 hospitals that disclose the SDGs.

Through the analysis of Figure 3, it is possible to realize that of the 5 Hospitals that disclose 4 (80%) reference the SDGs in at least one specific document (such as quality plans/manuals, strategic plans or plans and reports of activities and sustainability). Finally, only 2 (40%) of the hospitals present a specific section on the website with information on the SDGs.
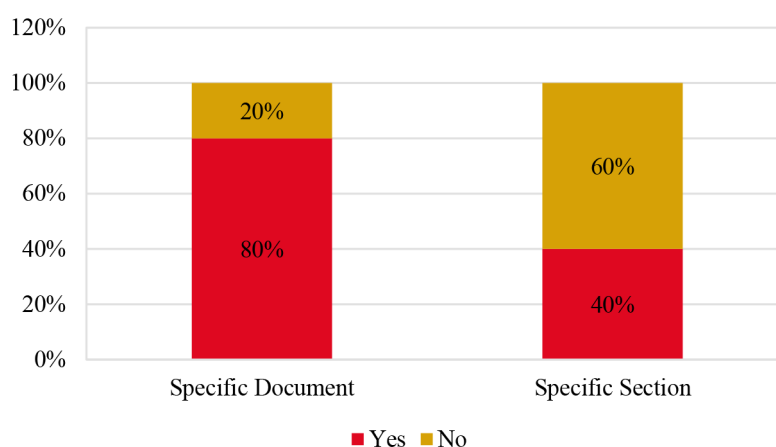
Figure 3. Location of SDGs on Websites
Source: Own elaboration

According to these data, it appears that as the location of the information is more specific, less likely is the disclosure of the SDGs there.

4.3. Sustainability Reports

Regarding the 3rd objective of the study, it was possible to verify the existence of sustainability reports in 3 Portuguese hospitals, namely in the Hospital Center of Trás-os-Montes and Alto Douro - EPE, CUF and Lusíadas. First, it is emphasized that the approach to such reports differs between hospitals, because there is no standard of disclosure, and only CUF follows the Global Reporting Initiative (GRI) rules of sustainability reports (GRI, 2021).

Through the analysis of Table 3, it is found that the hospital with the most recent report is the CUF hospital, since it concerns the year 2022, while the reports of the Hospital Center of Trás-os-Montes and Alto Douro - EPE and Lusíadas are related to the year 2021.

A total of 77 pages, the informative organization of the sustainability report of the CUF hospital is aligned with the SDGs, being divided into the 5P's recommended by the UN (United Nations Organization): people, planet, prosperity, and partnerships, and is by the GRI 2021 standards (GRI, 2021). In the Hospital Center of Trás-os-Montes and Alto Douro the report, with 106 pages, is not aligned with the SDGs but mentions the dimensions of the planet and people and does not follow the GRI. Finally, the Lusiadas report is smaller than the others (26 pages), regarding 2021, aligning its information with the SDGs, which focuses its guidelines on people, the planet, prosperity, and partnerships.

Table 5. Characteristics of the sustainability reports

	Trás-os-Montes	**CUF**	**Lusíadas**
Period	2020-2021	2022	2021
GRI Guidelines	-	GRI 2021	-
Dimensions	People, planet	People, Planet, Prosperity, Peace, and Partnerships	People, Planet, Prosperity, and Partnerships
Alignment with the SDGs	No	Yes	Yes
Number of Pages	106	77	26

Source: Own elaboration

Given the above, as expected, there is little adherence of Portuguese hospitals to sustainability reports, demonstrating that the inclusion of SDGs in reporting processes still has much room to evolve.

5. CONCLUSION

This exploratory study allows to present a "portrait" of the practices of disclosure of the SDGs on the web, in Portuguese hospitals, a very little explored line of research. In the same line of the works of Di Tullio and La Torre (2022), this study showed that there are several untapped potentials offered by the web in the process of reporting sustainability issues.

Consistent with the objectives of this study, it was possible to observe that there are still many hospitals 79 (94.05% of the sample) that do not disclose the SDGs on their websites and that even those that do, most do not disclose all 17 SDGs. Therefore, as Aleixo et al. (2020), this investigation also shows a gap in the disclosure of the SDGs, being less likely the visibility of specific SDGs. We can also see that the majority belongs to the Private sector (3 - 33.34% of the sample).

In terms of location of information, it is more likely to find information in the non-financial reports published on the websites, than in thematic sections on the 2030/SDG Agenda. The lack of adherence to other specific sections on the site on sustainability issues was also proven by other authors (e.g. Aleixo et al., 2016; Katiliute & Daunoriene, 2015).

This study is especially useful not only for hospitals that do not yet disclose the SDGs, but also for those that only disclose generally, or that do not include the SDGs in a specific section and in at least one non-financial reporting document, as state De Iorio et al. (2022). These findings highlight the need for improved sustainability/SDG reporting and metrics in the healthcare sector. We therefore agree with Eckelman et al. (2024) that healthcare sustainability metrics should be standardised, reliable, meaningful, integrated with data management systems, fair and aligned with the core mission of healthcare.

In line with the objectives of this research, ideally there should be an interconnection of the activities and policies of hospitals with each of the SDGs, not only in a specific section dedicated to the theme on the website, but also in non-financial reporting documents. Thus the SDGs should be included and

associated with the planning and standards of organizations, and their monitoring and performance results disclosed in the activity and/ or management reports, or preferably in a sustainability report. These practices should guide progress towards the SDGs, promoting continuous improvement, in an active and constant reporting process that facilitates the accessibility of information by stakeholders.

This study has some limitations to take into account. The results presented are limited to the availability of information regarding the keywords 'SDGs', 'Sustainable Development Goals' and '2030 Agenda', at the date of data collection (August 2023), being a subjective analysis. Given that the information contained in the websites are upgradeable, it becomes pertinent to repeat this analysis in later studies in order to find new information.

This study only examined whether there was at least one mention of the SDGs and their location of information, and did not assess the quantity and quality of information on the SDGs. In this sense, future studies could deepen the content analysis of websites, verifying, for example, the number of specific documents in which the SDGs are published. In addition, inspired by the work of Garzoni et al. (2024), could investigate the relationship between hospital characteristics and SDG disclosure, focusing on: hospital size, public vs. private status, internet visibility, and teaching status.

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References

Aleixo, A. M., Azeiteiro, U. M., & Leal, S. (2016). Toward Sustainability Through Higher Education: Sustainable Development Incorporation into Portuguese Higher Education Institutions. *Management and Industrial Engineering*, 159-187. https://doi.org/10.1007/978-3-319-23705-3_7

Aleixo, A. M., Azeiteiro, U. M., & Leal, S. (2020). Are the sustainable development goals being implemented in the Portuguese higher education formative offer? *International Journal of Sustainability in Higher Education, 21*(2), 336-352. https://doi.org/10.1108/ijshe-04-2019-0150

Andrades, J., Larrán, M., Muriel, M. J., Calzado, M. Y., & Lechuga Sancho, M. P. (2021). Online sustainability disclosure by Spanish hospitals: an institutionalist approach. *International Journal of Public Sector Management, 34*(5), 529-545. https://doi.org/10.1108/ijpsm-09-2020-0259

Andrades Peña, F. J., Larrán Jorge, M., Muriel de los Reyes, M. J., & Calzado Cejas, M. Y. (2020). Influential Variables of Sustainability Disclosures by Spanish Public Hospitals. *Public Performance & Management Review, 43*(6), 1390-1412. https://doi.org/10.1080/15309576.2020.1765816

Asmara, S. M., & Rahmawati, I. P. (2024). Analysis of ESG Disclosure Practices in Healthcare Sector Companies. *AKUMULASI: Indonesian Journal of Applied Accounting and Finance, 3*(1), 14-36. https://doi.org/10.20961/akumulasi.v3i1.1677

Banerjee, S. (2024). Achieving sustainable development goals in healthcare infrastructure: a study of selected nifty-50 companies. *International Journal of Global Research Innovations & Technology, 02*(04)*,* 112-118. https://doi.org/10.62823/ijgrit/2.4.7057

Bonollo, E. (2015). Disclosures in local healthcare organizations' social reports. 'What?'and 'Why?' an empirical analysis of the Italian National Healthcare System, *Financial Reporting*, 1, pp. 41-75

Caputo, F., Ligorio, L., & Pizzi, S. (2021). The Contribution of Higher Education Institutions to the SDGs—An Evaluation of Sustainability Reporting Practices. *Administrative Sciences, 11*(3), 97. https://doi.org/10.3390/admsci11030097

Consolandi, C., Phadke, H., Hawley, J., & Eccles, R. G. (2020). Material ESG outcomes and SDG externalities: Evaluating the health care sector's contribution to the SDGs. Organization & Environment, 33(4), 511-533.

Constantinescu, D. (2021). Sustainability disclosure and its impact on firm's value for Energy and Healthcare industry. *Central European Economic Journal, 8*(55), 313-329. https://doi.org/10.2478/ceej-2021-0022

De Iorio, S., Zampone, G., & Piccolo, A. (2022). Determinant Factors of SDG Disclosure in the University Context. *Administrative Sciences, 12*(1), 21. https://doi.org/10.3390/admsci12010021

Di Tullio, P., & La Torre, M. (2022). Sustainability Reporting at a Crossroads in Italian Universities: Is Web-Based Media Adoption Deinstitutionalising Sustainability Reporting? *Administrative Sciences, 12*(1), 34. https://doi.org/10.3390/admsci12010034

Eckelman, M. J., Weisz, U., Pichler, P.-P., Sherman, J. D., & Weisz, H. (2024). Guiding principles for the next generation of health-care sustainability metrics. *The Lancet Planetary Health, 8*(8), e603-e609. https://doi.org/10.1016/s2542-5196(24)00159-1

Farghaly Abdelaliem, S. M., Alharbi, K. M., Baghdadi, N. A., & Malki, A. (2023). Exploring the Impact of Private Companies' Participation in Health-Related Programs through Corporate Sustainable Reporting. *Sustainability, 15*(7), 5906. https://doi.org/10.3390/su15075906

Garzoni, A., L'Abate, V., Raimo, N., & Vitolla, F. (2024). Exploring online sustainability disclosure in the healthcare industry: Evidence from best international hospitals. *Business Strategy and the Environment, 33*(4), 2669-2682. https://doi.org/10.1002/bse.3625

Global Reporting Initiative. (2021). *GRI Standards 2021.* Retrieved from https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-english-language/

Goswami, K., & Lodhia, S. (2014). Sustainability disclosure patterns of South Australian local councils: a case study. *Public Money & Management, 34*(4), 273-280. https://doi.org/10.1080/09540962.2014.920200

Government of Portugal. (2017). *National report on the implementation of rhe 2030 Agenda for Sustainable Development.* https://sustainabledevelopment.un.org/content/documents/15766Portugal2017_EN_REV_FINAL_29_06_2017.pdf

Izzo, M. F., Ciaburri, M., & Tiscini, R. (2020). The Challenge of Sustainable Development Goal Reporting: The First Evidence from Italian Listed Companies. *Sustainability, 12*(8), 3494. https://doi.org/10.3390/su12083494

Katiliute, E., & Daunoriene, A. (2015). Dissemination of Sustainable Development on Universities Websites'. *Procedia - Social and Behavioral Sciences, 191*, 865-871. https://doi.org/10.1016/j.sbspro.2015.04.337

Lopes, C., Scavarda, A., Vaccaro, G., Korzenowski, A., & Batista, E. (2015). Analysis of hospital's sustainability: Economical, environmental, and social lenses. Proceedings of the 2015 Industrial and Systems Engineering Research Conference, Nashville, Tennessee.

Manes-Rossi, F., Nicolò, G., & Argento, D. (2020). Non-financial reporting formats in public sector organizations: a structured literature review. *Journal of Public Budgeting, Accounting & Financial Management, 32*(4), 639-669. https://doi.org/10.1108/jpbafm-03-2020-0037

Siregar, P. A., Tambunan, R. P., Puspito, E., & Muda, I. (2022). Sustainability reporting in the health sector by considering economic, environmental, social and governance (ESG) aspects in the Kalbe Farma pharmaceutical industry. *Journal of Pharmaceutical Negative Results, 13*(9), 6688-6695.

Traxler, A. A., & Greiling, D. (2019). Sustainable public value reporting of electric utilities. *Baltic Journal of Management, 14*(1), 103-121. https://doi.org/10.1108/bjm-10-2017-0337

Tremblay, D., Fortier, F., Boucher, J.-F., Riffon, O., & Villeneuve, C. (2020). Sustainable development goal interactions: An analysis based on the five pillars of the 2030 agenda. *Sustainable Development, 28*(6), 1584-1596. https://doi.org/10.1002/sd.2107

Mapping Eco-Innovation Dynamics in the EU: A Neural Network Approach

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Abstract: *This paper compares the eco-innovation performance of EU member states based on the eco-innovation index. The comparison was made between two periods, 2013-2017 and 2018-2022, taking into account five groups of indicators of the eco-innovation index. The authors used a software solution grounded on neural networks to determine the correlation, relationship structure, and contribution of the indicators for eco-innovation performances. The research paper seeks to provide novel insights into the complex relationships between different variables influencing eco-innovation, thereby enhancing the understanding of sustainable development pathways in the EU. The structure of the neural network showed the importance of certain indicators that contributed the most to the value of the eco-innovation index. The results showed that in the first period, the best overall performance was achieved in the areas of REO and SCO, while in the second period, in addition to REO and SCO, EA also stood out.*

1. INTRODUCTION

The growing number of environmental problems and the untimely taking of the necessary measures to prevent them, increase the pressure for the transition to a green economy. The aim is to move from traditional production methods to sustainable production, introduce resource-efficient practices, and more efficient processes, reduce the impact of climate change, etc. One of the paths leading to the transition to a circular economy is eco-innovation, which reduces the impact on the environment and encourages more efficient use of resources (Talić et al., 2023). Innovation has been used for a long time to boost the growth and competitiveness of countries, and now they have another role, to improve people's well-being and quality of life (Chaparro-Banegas et al., 2023). Eco-innovation can reduce environmental impacts while simultaneously improving the economic competitiveness of countries (Chaparro-Banegas et al., 2023). The European Commission has prescribed numerous directives related to sustainable development, energy efficiency and environmental protection. The promotion of eco-innovation at the national level is a goal promoted by various EU initiatives (Al-Ajlani et al., 2022). In this sense, it is of great importance to monitor and measure the progress of EU countries in terms of eco-innovation. For this purpose, the Eco-Innovation Index was created. Every year, the member states are ranked based on the eco-innovation index, which will be used in this paper as a starting point for monitoring the dynamics of eco-innovations in the observed countries.

This paper aims to provide novel insights into the complex relationships between different variables influencing eco-innovation by utilizing a neural network model and to compare the performance dynamics of eco-innovation in the EU countries in the observed periods.

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The paper is structured as follows: after the introduction it provides an overview of the previous literature on the determination of eco-innovations. After that, a review of the existing measures of eco-innovation at the macro level was given. The following is a description of the methodology used, a presentation of the results, and their discussion, based on which the conclusions are drawn below.

2. LITERATURE REVIEW

In building a sustainable economy and mitigating the negative effects of economic growth on the environment, eco-innovation plays a crucial role (Hajdukiewicz & Pera, 2023). Increasing pressure on the marketplace and government concerns ensured that eco-innovation development strategy has become a vital part of sustainable development (Bag et al., 2022). For enhancing countries' competitiveness and enabling more sustainable development, eco-innovation is a key strategy that might be implemented at local, national, regional, and international levels. At the level of the economic system, the primary goal of eco-innovation relates to countries' efforts to minimize adverse ecological impacts, maximize the use of renewable resources, and achieve green growth (Terzić, 2023, p. 16). Eco-innovation represents an answer to environmental problems and natural reaction to high resource prices.

Eco-innovation is a relatively new concept, but in conditions where we face problems caused by climate changes, air and water pollution, and loss of biodiversity, it gains importance and becomes the subject of various interest groups. In the last few decades, the concept of eco-innovation has attracted significant attention from researchers, practitioners, and policymakers. The idea of eco-innovation emerged in the 1990s, in the third industrial revolution, and extended during the fourth industrial revolution, as a global concept to support sustainable development on macro and micro levels. Eco-innovation is a multidimensional concept with potentially challenging development and implementation. The nature of eco-innovation is characterized by cognate terms and concepts that are heterogeneous. Some of the most common terms that have been widely used by scholars are green innovation, environmental innovation, and sustainable innovation.

Although exist different definitions of eco-innovation in the literature, the consensus mainly focuses on environmental management and sustainability. One of the earliest definitions of eco-innovation was proposed by Fussler and James (1996). These authors stated that eco-innovation refers to a new product or method that creates value for the company and customers, while substantially lowering negative environmental impacts. According to Rennings (2000), eco-innovation represents all the efforts of relevant actors in introducing, developing and applying new ideas, behaviours, and products, aiming to fulfil certain sustainability goals and mitigate the negative impact on the environment. Some researchers argued that eco-innovation besides organizational, product and process changes in companies, encompass also social, and political changes and changes in environmental regulations in one country (Hellström, 2007). According to OECD (2010), eco-innovation means carrying out marketing activities, processes and organizational structures that foster developing new or existing products and services, while considering environmental impact. On the other hand, eco-innovation is a sustainable tool that advances the performance of environmental actions (Carrillo-Hermosilla et al., 2010), contributing to environmental and economic benefits (Urbaniec, 2015).

By developing and implementing eco-innovation, countries can prevent resource exhaustion and provide favorable environments for obtaining sustainable growth (Jia et al., 2020). Eco-innovation

can be comprehensively understood as an entrepreneurial process that includes product design phases and integrated management throughout its entire life cycle and encourages the ecological modernization of the economy and society (Sobczak et al., 2022). Eco-innovation combines innovation and sustainable development and integrates innovation policy and environmental protection policy (Androniceanu & Georgescu, 2023).

3.   MEASURING ECO-INNOVATION

Measuring eco-innovation is important for several reasons. Eco-innovation requires continuous improvement, so the use of measurement for their development provides significant feedback and a starting point for their improvement. Measuring eco-innovation is of great importance for policy monitoring and evaluation (Inno4sd, 2019). Based on eco-innovation indicators, policymakers identify, evaluate, and direct the contribution of innovation to pre-set environmental goals. It helps policymakers to analyze and compare trends related to eco-innovations, as well as drivers and limiting factors for their development, which contributes to the creation of more effective policies (OECD, 2010). Measuring eco-innovation helps to assess the progress of countries in different categories of eco-innovation, enables the analysis of drivers of eco-innovation, helps policymakers, and businesses, and generally contributes to the promotion of eco-innovation (OECD, 2010).

Eco-innovations can be classified into four dimensions: product, process, organization, and marketing, therefore, developing an instrument to measure them requires identifying their key performance factors due to adequate measurement of eco-innovation implementation (García-Granero et al., 2020). According to the Green EU report on measuring eco-innovation and green growth (Arundel et al., 2017), measuring eco-innovation and the green economy must include four types of indicators: eco-innovation, eco-policy, environmental indicators, and welfare indicators. Each measurement approach has its advantages and disadvantages and does not comprehensively represent all elements of eco-innovation (OECD, 2010). A systematic approach to measuring eco-innovation is provided by several organizations such as metrics developed by the Eco-Innovation Observatory in Europe, ASEIC and the Clean Technology Group (Inno4sd, 2019).

The Eco-Innovation Observatory developed the Eco-Innovation Index (Eco-IS), a composite index based on 12 indicators grouped into five thematic areas: eco-innovation inputs (EI), eco-innovation activities (EA), eco-innovation outputs (EO), resource efficiency outcomes (REO), and socio-economic outcomes (SCO) (EEA, 2023). The number of indicators within this index has changed over time. It is used to measure and compare the progress of European countries. The Eco-Innovation Index groups countries based on their performance and shows where their weaknesses and strengths are in terms of eco-innovation. Another important EU index is the European Innovation Scoreboard (EIS), an annual index that measures and compares the research and innovation performance of European countries. It includes indicators related to eco-innovation: resource productivity and development of environment-related technologies.

The ASEM Environmental Innovation Index (ASEI) was created with the aim of being an international tool for quantitatively and qualitatively measuring the level and status of eco-innovations. The ACEI index relies on the same definition of eco-innovation used in the European Union. This index is intended primarily to measure eco-innovations at the level of Europe and Asia, to promote eco-innovations and to motivate governments to improve their policies and regulations in this area. It relies on four groups of indicators: eco-innovation capacity, eco-innovation activity, eco-innovation supporting environment, and eco-innovation performance (ASEIC, 2015).

The Global Cleantech Innovation Index (GCII) is a tool that should facilitate governments and policymakers in making decisions and policies related to eco-innovation. It is intended for global application and includes countries from different parts of the world. The scope and focus of this index are narrower compared to the previous indices, Eco-IS and ASEI, and its indicators mainly focus on companies. The GCII contains four sub-categories of indicators: general innovation drivers, Cleantech-specific innovation drivers, evidence of emerging Cleantech innovation and evidence of commercialized Cleantech innovation (Cleantech Group & WWF, 2017).

4. METHODOLOGY

The applied methodology in this research is based on the analysis of the eco-innovation performances of the member states of the European Union and the mapping of their potential for improving the eco-innovation sector. The comparison of the achieved performances of the countries of the European Union was carried out by observing the values of the following five sub-indicators of the overall eco-innovation index (European Commission, 2022), taking into account their average values for the period 2013-2017 and the period 2018-2022:

- Eco-innovation inputs (EI) - Eco-innovation inputs comprise investments (financial or human resources) aiming to trigger eco-innovation activities.
- Eco-innovation activities (EA) - Eco-innovation activities include indicators to monitor the scope and scale of eco-innovation activities undertaken by companies. The component focuses on efforts and activities rather than on the actual results of innovation activity.
- Eco-innovation outputs (EO) - Eco-innovation outputs describe the immediate results of eco-innovation activities. Indicators in this component are used to monitor the extent to which knowledge outputs generated by businesses and researchers relate to eco-innovation.
- Resource efficiency outcomes (REO) - Resource efficiency outcomes relate to the wider effects of eco-innovation on improved resource productivity. Eco-innovation can have a twofold positive impact on resource efficiency: it can increase the generated economic value, while at the same time decreasing pressures on the natural environment.
- Socio-economic outcomes (SCO) - Socio-economic outcomes of eco-innovation depict wider effects of eco-innovation activities for society and the economy. This includes changes in employment, turnover, or exports that can be related to broadly understood eco-innovation activities.

Descriptive statistics of the average value of the overall eco-innovation index are shown in Figure 1 to see the fluctuation of its values in the mentioned periods for each member country individually.

Analysis of the dynamics of the movement of sub-indicators of the aforementioned index was carried out using the software package for neural networks Neural Designer - Machine Learning Software (Neural Designer, 2020). The process of modeling the neural network structure for the sub-indicators of the eco-innovation index consists of a cycle of five phases: data exploration, model training, feature engineering, model testing, and deployment. Neural Designer - Machine Learning Software uses innovative algorithms for simulating and optimizing data of the eco-innovation performances, as growing inputs for evaluating the correlation of each input with each output variable (Rađenović et al., 2020). After collecting data on all sub-indicators of the overall eco-innovation index for both observed periods, the Neural Designer-Machine Learning Software recalculates the degree of correlation that exists between the variables (sub-indicators) of the created model. Consequently, it can be seen that in the period 2013-2017, the highest correlation coefficient was between the variable eco-innovation activities and resource efficiency outcomes (0.822). On

the other hand, for the observed period 2018-2022. year, the highest correlation coefficient and positive relationship exists between the variables eco-innovation inputs and eco-innovation outputs (0.647), as well as between eco-innovation inputs and socio-economic outcomes (0.602) (Table 1).
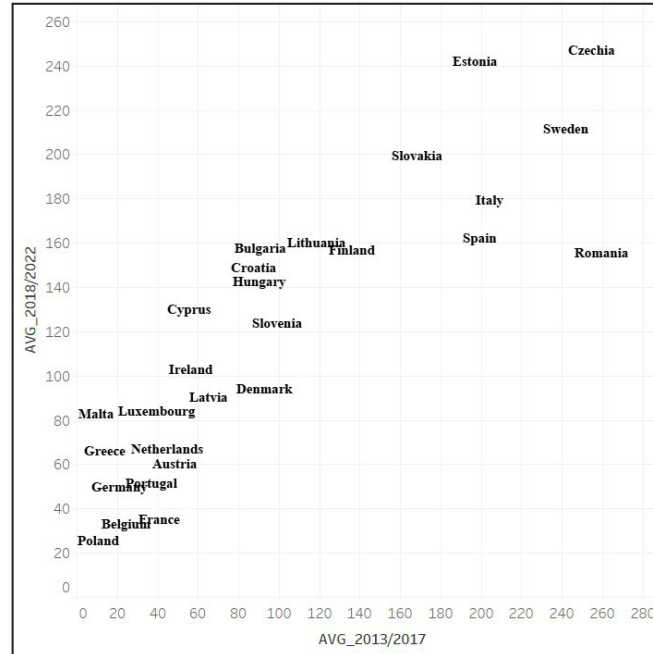

Figure 1. Descriptive statistics with changes in the overall eco-innovation index performances of the EU members for the two analyzed periods

Source: Authors' calculation according to available data

Table 1. Correlation coefficients for the analyzed variables

VAR	2013-2017				
	EI	EA	EO	REO	SCO
EI	1	0.172	0.154	0.204	0.207
EA	0.172	1	0.159	**0.822**	0.159
EO	0.159	0.159	1	0.061	-0.195
REO	0.204	**0.822**	0.061	1	0.331
SCO	0.207	0.159	-0.195	0.331	1
VAR	2018-2022				
	EI	EA	EO	REO	SCO
EI	1	-0.276	**0.647**	0.266	0.267
EA	-0.276	1	-0.212	-0.299	0.212
EO	**0.647**	-0.212	1	0.268	**0.602**
REO	0.266	-0.299	0.268	1	-0.288
SCO	0.267	0.212	**0.602**	-0.288	1

Source: Authors' calculation according to available data

5. RESULTS AND DISCUSSION

Based on the collected data, the Neural Designer created an output value in the form of a neural network architecture for the first analyzed period. Figure 3 shows the network architecture where, after several iterations, the variables resource efficiency and socio-economic outcomes are singled out as dominant in determining the eco-innovation performances of the selected EU countries. A formed neural network consists of scaling and unscaling layered where yellow circles depict scaling neurons, the blue circles' perceptron neurons, and the red circles' unscaling neurons.

In the period 2018-2022, there was a change in the structure of the neural network as well as in the dominance of certain variables on the overall eco-innovation performances. Namely, the variable eco-innovation activities are included in the model, which indicates the fact that countries have taken certain steps in developing awareness of eco-innovation.

Figure 2. Neural network architecture for the eco-innovation performances of the EU members 2013-2017

Source: Authors' calculation according to available data

The phase of testing the correlation of each input with each output variable in each iteration of the algorithm by gradient information shows the number of training and selection errors (Figure 2). In this type of training, the Quasi-Newton method is used which uses the Hessian of the loss function, a matrix of second derivatives, to calculate the learning direction (Song, 2018).
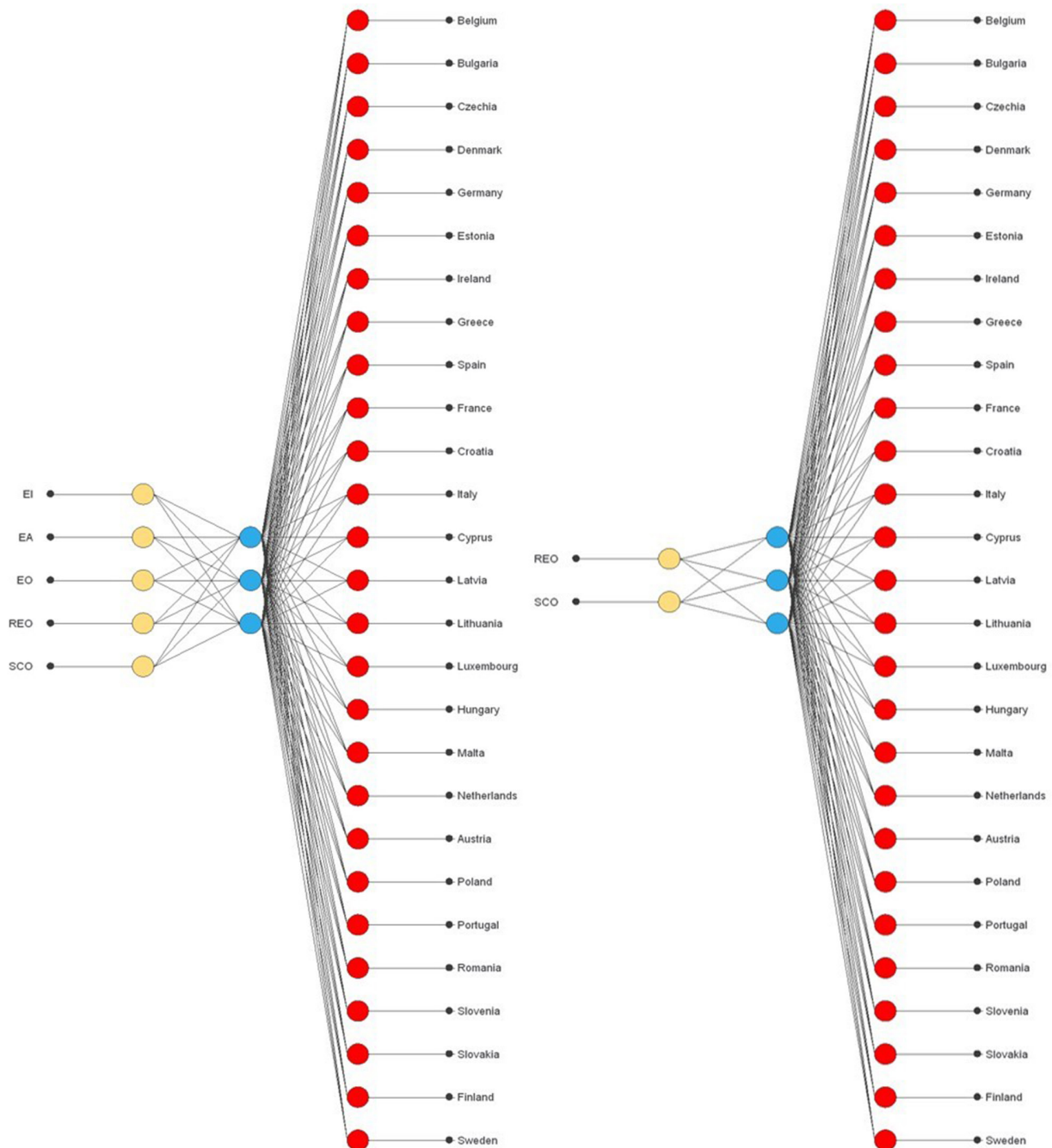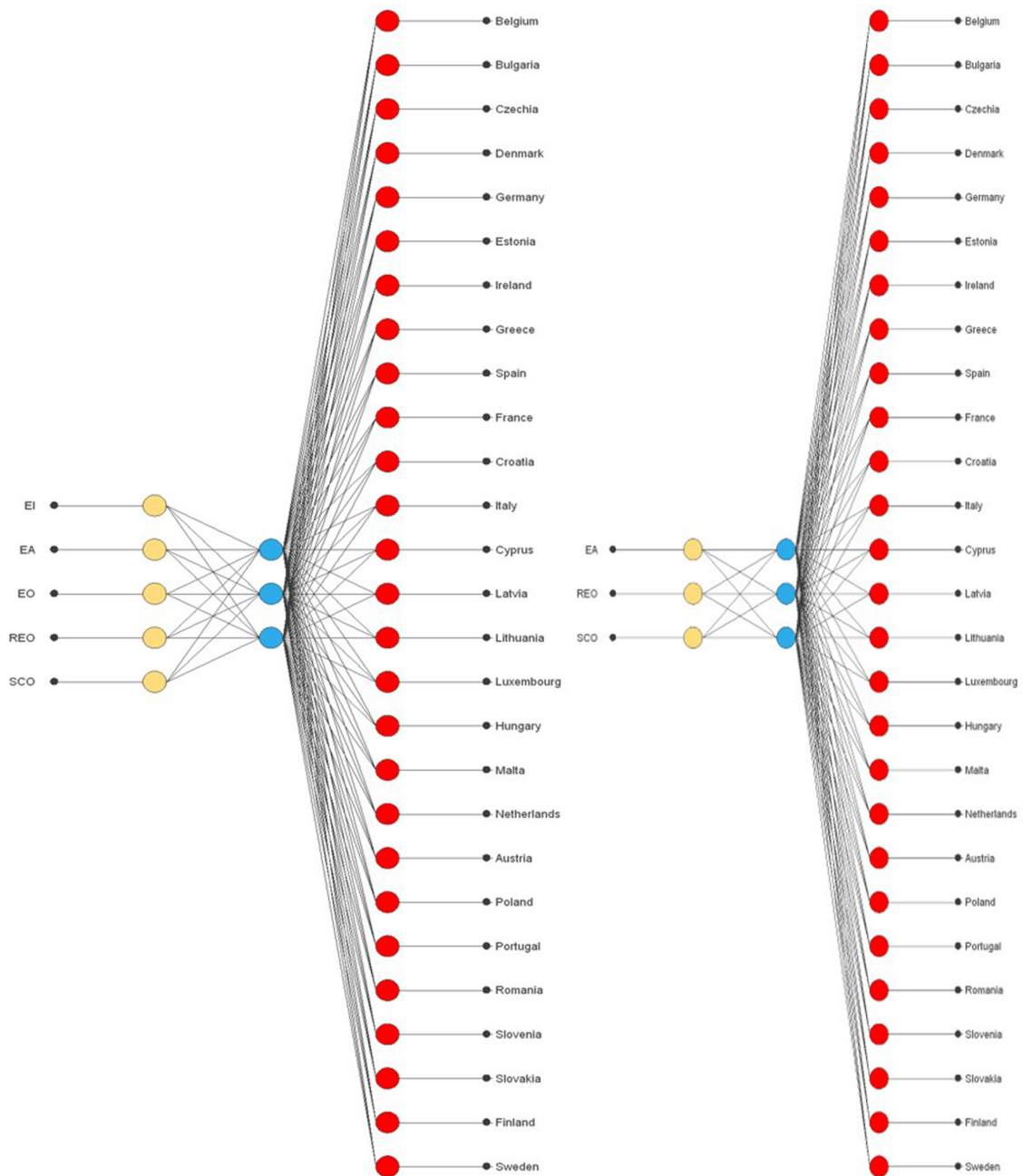
Figure 3. Neural network architecture for the eco-innovation performances of the EU members 2018-2022

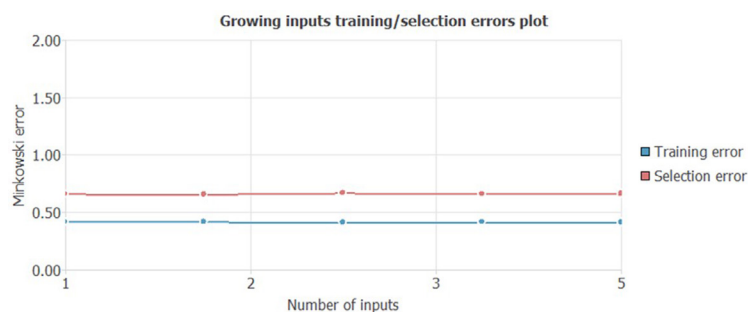**Source:** Authors' calculation according to available data

Figure 4. Quasi-Newton method and training sessions

Source: Authors' calculation according to available data

6. FUTURE RESEARCH DIRECTIONS

Possible future research could refer to the application of methods for multi-criteria decision-making in the ranking of European Union countries according to eco-innovation performances. Furthermore, different methods should be used to determine the value of the weighting coefficients of the sub-indicators, whereby neural network algorithms can have a significant contribution.

7. CONCLUSION

According to presented research and analysed data, Slovenia, Czechia, Estonia and Sweden have achieved significant improvement in eco-innovation activities, especially from 2018 to the 2022 year. Estonia's performance on CE indicators shows relative strength in business operations and relative weakness in societal behaviors. SMEs play a crucial role in the Estonian economy and contribute to 76 % of the added value generated by all Estonian companies (this is 18% above the respective EU average). They have advantages in terms of flexibility that put them into a central role in the implementation of the circular economy. On the other side Estonia, Italy, Luxembourg and Malta have shown great potential in resource efficiency outcomes and in socio-economic outcomes where Denmark, Austria and Finland have leadership roles. Luxembourg's relative strengths are in resource efficiency outcomes, and its relative weaknesses are in eco-innovation activities. The driving policy is the national circular economy strategy, which has strong connections with other national strategies and policy documents. The challenges to transitioning towards a circular economy in Luxembourg include the scarcity of circular business models, the complexity of value chains with large segments outside of Luxembourg, and the lack of awareness from the general public and the business community. Italy's National Strategy for a Circular Economy sets a comprehensive plan for improving its performance in waste management, supporting the reuse and repair of products, and strengthening the existing regulatory instruments targeting specific sectors and initiatives. Policymakers can use the results of neural network analysis to identify promising areas for research and development and eco-innovation investment, evaluate the effectiveness of eco-innovation policies over time, and analyze public awareness around environmental issues and eco-innovations.

Acknowledgment

References

Al-Ajlani, H., Cvijanović, V., Es-Sadki, N., & Müller, V. (2022). *EU Eco-Innovation Index 2022*: *Policy brief.* 10.13140/RG.2.2.11440.43522.

Androniceanu, A., & Georgescu, I. (2023). The impact of CO_2 emissions and energy consumption on economic growth: a panel data analysis. *Energies, 16*(3), 1342. https://doi.org/10.3390/en16031342

Arundel, A., Bassi, A., Janzen, J., Kemp, R., Turkeli, S., Gatenby-Clark, S., Rammer, C., Tapia Garcia, C., Miedzinski, M., Mazzanti, M., & Diaz Lopez, F. (2017). *Measuring eco-innovation, green growth and the green economy.* Deliverable 2.4 for green.eu project.

ASEIC. (2015). *2015 ASEM Eco-Innovation Index (ASEI).* Retrieved from http://www.aseic.org/resources/download/asei/result_2015/2015_ASEM_Eco-Innovation_Index_Final_Report.pdf

Bag, S., Dhamija, P., Bryde, D. J., & Singh, R. K. (2022). Effect of eco-innovation on green supply chain management, circular economy capability, and performance of small and medium enterprises. *Journal of Business Research, 141*, 60-72. https://doi.org/10.1016/j.jbusres.2021.12.011

Carrillo-Hermosilla, J., del Río, P., & Könnölä, T. (2010). Diversity of eco-innovations: Reflections from selected case studies. *Journal of Cleaner Production*, *18*(10-11), 1073-1083. https://doi.org/10.1016/j.jclepro.2010.02.014

Chaparro-Banegas, N., Mas-Tur, A., Park, H. W., & Roig-Tierno, N. (2023). Factors driving national eco-innovation: New routes to sustainable development. *Sustainable Development*, *31*(4), 2711–2725. https://doi.org/10.1002/sd.2541

Cleantech Group & WWF. (2017). *The Global Cleantech Innovation Index 2017 – Global Cleantech Innovation Programme (GCIP) Country Innovation Profiles*. Retrieved from https://s3.amazonaws.com/i3.cleantech/uploads/additional_resources_pdf/17/117/GCII_GCIP_report_2017_20nov.pdf

EEA. (2023). *Eco-innovation index*. Retrieved from https://www.eea.europa.eu/en/analysis/indicators/eco-innovation-index-8th-eap

European Commission. (2022). *Eco-Innovation at the heart of European policies*. Retrieved from https://green-business.ec.europa.eu/eco-innovation_en

Fussler, C., & James, P. (1996). *Driving eco-innovation: a breakthrough discipline for innovation and sustainability*. Pitman Publishing, UK: London.

García-Granero, E. M., Piedra-Muñoz, L., & Galdeano-Gómez, E. (2020). Measuring eco-innovation dimensions: The role of environmental corporate culture and commercial orientation. *Research Policy*, 49(8), 104028. https://doi.org/10.1016/j.respol.2020.104028

Hajdukiewicz, A., & Pera, B. (2023). Eco-innovation in the European Union: Challenges for catching-up economies. *Entrepreneurial Business and Economics Review, 11*(1), 145-164. https://doi.org/10.15678/eber.2023.110108

Hellström, T. (2007). Dimensions of environmentally sustainable innovation: the structure of eco-innovation concepts. *Sustainable Development*, *15*(3), 148-159. https://doi.org/10.1002/sd.309

Inno4sd (Innovation for Sustainable Development Network). (2019). *How to measure eco – innovation and assess its impacts?* Brussels, Belgium. March 2019.

Jia, F., Yin, S., Chen, L., & Chen, X. (2020). The circular economy in the textile and apparel industry: a systematic literature review. *Journal of Cleaner Production*, *259*(2), 120728. https://doi.org/10.1016/j.jclepro.2020.120728

Neural Designer. (2020). https://www.neuraldesigner.com/learning/tutorials/training-strategy

OECD. (2010). *Eco-Innovation in Industry: Enabling Green Growth*, OECD Publishing, Paris. https://doi.org/10.1787/9789264077225-en

Rađenović, Ž., Krstić, B., & Marković, M. (2020). Smart farming in agricultural industry: Mobile technology perspective. *Ekonomika poljoprivrede*, 67(3), 925-938. https://doi.org/10.5937/ekoPolj2003925R

Rennings, K. (2000). Redefining innovation-eco-innovation research and the contribution from ecological economics. *Ecological Economics*, *32*(2), 319-332. https://doi.org/10.1016/S0921-8009(99)00112-3

Sobczak, E., Głuszczuk, D., & Raszkowski, A. (2022). Eco-Innovation and Innovation Level of the Economy as a Basis for the Typology of the EU Countries. *International Journal of Environmental Research and Public Health, 19*(4), 2005, 1-17. https://doi.org/10.3390/ijerph19042005

Song, H. (2018). *Nature-Inspired VLSI Circuits - From Concept to Implementation*. Lulu.com, USA.

Talić, M., Stefanović, S., & Milenković, A. (2023). Eko-inovacije u malim i srednjim preduzećima: analiza regulatornog okvira u Republici Srbiji. Proceeding of International Scientific Conference:

Smart and sustainable economy: Trends and perspectives. (pp. 211-219). Faculty of Economics, University of Niš.

Terzić, L. (2023). Why is the transition to a green economy important for achieving sustainability? A review of some theoretical approaches and empirical research presented in the literature, *Economic Thought Journal*, *68*(3), 307-332. https://doi.org/10.56497/etj2368303

Urbaniec, M. (2015). Towards Sustainable Development Through Eco-Innovations: Drivers and Barriers in Poland. *Economics & Sociology; Ternopil*, *8*(4), 179-190. http://dx.doi.org.ezproxy.its.uu.se/10.14254/2071-789X.2015/8-4/13

The Impact of COVID-19 Pandemic on Agri-Food and Biofuel Sector in the EU

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Abstract: Biofuels refer to sustainable alternatives derived from biomass to replace fossil fuels, contributing significantly to reducing carbon dioxide emissions. However, the biofuel and food price debate is a long-standing, controversial one, with wide-ranging views, both in the public debate and in the scientific literature. The major problem of preferred feedstocks for the 1st generation biofuel production is that these feedstocks are also used for food and feed production. Moreover, there is persistent concern that biofuels compete with food production and that increasing biofuels prices lead to an increase in agricultural commodity prices. The lockdowns as a consequence of the COVID-19 pandemic hit the biofuel sector and reduced demand for all transport modes as energy demand around the world has decreased by 18–25%. Lower demand for biofuels affects the demand for its feedstocks, maize and oilseeds, which, in turn, affect the markets for other crops and animal products. The paper intends to provide an expert perspective on the issue of the consequences of the COVID-19 pandemic on agri-food and biofuel sector in the EU –the world leader in the production and use of biodiesel for transport. More specifically, the linkages between the first-generation biofuels and agri-food commodity prices will be examined using co-integration analysis and VECM-type models.

1. INTRODUCTION

Interest in biofuels has increased over the past decade with the development of climate change mitigation policies and strategies to reduce greenhouse gas emissions from the transportation sector. Antar et al. (2021) argue that biofuels are among the most effective strategies for reducing greenhouse gas emissions and global warming while meeting energy requirements. More than 66% of the world's renewable energy comes from biofuels and waste, 59% is solid biofuels, while liquid biofuels represent 4.9% and biogas 1.7% (International Energy Agency (IEA), 2020). Solomon (2010) also notes that biofuels can play a key role in solving these problems in many nations, as long as the biomass sources are grown, converted, and used sustainably. Takeuchi et al. (2018) state that one of the reasons for the worldwide introduction of biofuels are their properties: 1) Carbon neutral character (The Kyoto Protocol considers biofuels to be carbon neutral because the CO_2 emissions for the combustion of biofuels are offset by the absorbed CO_2 during the growth of plants intended for the production of biofuels); 2) Renewable energy; 3) Prevention of air pollution; 4) Contribution to energy security; 5) Contribution to the development of agriculture and the countryside (increasing agricultural profit, creating job opportunities in the agricultural sector, etc.).

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However, despite the mentioned benefits of biofuels, Cavelius et al. (2023) point out that during the global food demand crisis in 2007/2008, crops used for biofuel production became more important to be used as food, giving rise to the "food versus fuel" debate that continues to these days. In addition, the increased demand for crops for fuel production led to an increase in the market price of these foods. At present, about 60% of ethanol is produced from maize, 25% from sugarcane, 2% from molasses, 3% from wheat, and the remainder from other grains, cassava or sugar beets and about 75% of biodiesel is based on vegetable oils (20% rapeseed oil, 25% soybean oil, and 30% palm oil) or used cooking oils (20%) (OECD-FAO, 2021). Sobczak and Gołębiewski (2022) mention that even though the issue is not new, it is still highly important to take into consideration the expansion of energy crops, as well as national, European and world energy policy, particularly since, the use of plant products for the production of biofuels affects the condition of the food market. According to Lee and Ofori-Boateng (2013), the production of biofuels has various impacts on certain activities such as food production, water quality, biodiversity, etc., therefore, the choice of raw materials, plantation and harvesting technologies, production process designs, product delivery methods, etc., largely determine their sustainability. Thus, sustainability assurance is a key issue in trying to ensure that biofuels are as sustainable as possible and to avoid as far as is possible unintended negative effects of their adoption (IEA Bioenergy, 2008).

Recently, the COVID-19 pandemic and the conflict between Russia and Ukraine have affected the global economy, including the energy sector. Bergquist and Stengaard (2020) noted that Corona-virus Disease 2019 (Covid-19) was found as atypical pneumonia in central China in December 2019, growing to a million confirmed cases worldwide in just 10 weeks. This led the World Health Organization (WHO) to characterize the outbreak as a pandemic on 11 March 2020 (WHO, 2020). Ioannidis (2022) specifies that there are no widely accepted, quantitative definitions for the end of a pandemic such as COVID-19. He defines that the end of the pandemic due to a new virus and the transition to endemicity may be explained by a high proportion of the global population having some immunity from natural infection or vaccination. In addition, other factors might be considered such as diminished death toll, diminished pressure on health systems, reduced actual and perceived personal risk, elimination of restrictive measures and decreased public attention. The pandemic had both direct and indirect consequences on the bioenergy and bio-based product sectors, which were closely related to the fossil fuel industry and the market disruption brought on by COVID-19, as claimed by Galanakis et al. (2022). Zakeri et al. (2022) stressed that the COVID-19 pandemic has caused huge fluctuations in energy demand, oil price volatility, disruption of energy supply chains and hindered energy investment. According to Zhang et al. (2021), COVID-19 has created chaos in the energy system; from the micro perspective, the pandemic has diminished both energy prices and stock values of energy companies, resulting in huge fluctuation of the energy market and from the macro perspective, the spill-over effects of energy market volatility have affected both energy exporters and importers. The global economy has been destroyed by COVID-19, which has also seriously harmed the ever-emerging biomass supply chain and caused its sustainability to collapse, thus the pandemic has raised concerns over the sustainability of biomass feedstock (Sajid, 2021). Yaya et al. (2020) and Norouzi et al. (2020) mentioned that the nationwide lockdown policy during the pandemic restricted production, transport and trade both domestically and globally and directly reduced energy demand. Marcuta et al. (2023) clearly stated that, from 2010 to 2022, there was a rise in the production and consumption of biofuels on a global and local level, except for 2020–2021, when declines were seen as a result of the Covid-19 epidemic. Additionally, Elleby et al. (2020) noted that biofuel prices showed a significant drop down in 2020, followed by their main feedstocks, maize and oilseeds.

The paper provides an expert opinion on the issue of the consequences of the COVID-19 pandemic on agri-food and biofuel sector in the EU – the world leader in the production and use of biodiesel for transport. The paper focuses on biofuel-food market interactions, considering that biofuel issues and the use of farm crops in energy generation are highly topical and discussed not only in the agricultural community. Thus, the main objective of the paper is to assess the impact of biofuel production on agriculture, which is a source of biomass for energy purposes, purposefully cultivated or obtained as a by-product or agricultural waste during the COVID-19 pandemic. More specifically, the linkages between biodiesel and agri-food commodity prices (rapeseed) are examined in the case of Germany as the largest producer of biodiesel in the EU. The scientific level of the project will be ensured through a methodological approach designed for solving research issues and using quantitative research methods and techniques based on co-integration analysis and estimation of the Vector error correction model (VECM).

2. DATA AND METHODOLOGY

Europe is one of the largest producers of biodiesel in the world and uses oil crops as a raw material for the production of biodiesel, especially oilseed rape. The paper aims to examine price links between biodiesel prices and rapeseed prices in Germany to investigate the impact of biodiesel production on agriculture during the COVID-19 pandemic. Germany is the largest producer of biodiesel in Europe, followed by France and Spain (European Biodiesel Board, 2023). The paper intends to provide answers to the following questions:
1. Is there a nexus between rapeseed and biodiesel prices during the study period?
2. How do the prices of rapeseed and biodiesel relate to each other over the study period?

The price indices for producer prices of rapeseed in EUR/t and wholesale prices of biodiesel in ct/l excluding VAT were used from UFOP (Union for the Promotion of Oil and Protein Crops, 2020-2023). On January 9, 2020, China's CDC identified a new coronavirus as the cause of the COVID-19 outbreak (European Centre for Disease Prevention and Control, 2023) and on 5 May 2023, the WHO declared that COVID-19 is no longer a PHEIC (Sarker et al., 2023). Therefore, collected data are set up on a weekly basis, covering the period from January 2020 to April 2023. For the estimations, the prices are turned into natural logarithms, which allow the long-run coefficients to be interpreted as long-run price transmission elasticities.

Cointegration approaches have been widely applied to investigate the mechanisms underlying the transmission of agricultural prices. Sirohi et al. (2023) consider that cointegration models assume that variables that are integrated of order one (I(1)) are connected by a long-term (LR) relationship, and the residuals of this relationship are stationary. If time-series variables are cointegrated, then their long-run equilibrium relationship fits into a dynamic specification in the class of error-correction models (ECM), as stated by Jiang et al. (2015). Ivanova and Dospatliev (2023) explain that there are two varieties of Johansen cointegration tests for identifying long-run connections or long-run equilibrium between time series samples with unit roots (i.e. I(1)):
- The trace test:

$$\lambda_{trace} = -2 \, lnQ - T \sum_{t=r+1}^{p} \ln(1 - \lambda_t) \tag{1}$$

The H_0 hypothesis for the trace test states that there is no cointegration, i.e., $r = 0$. The alternative hypothesis (H_1) states that cointegration exists, i.e., $r > 0$.

- The maximum eigenvalue for testing the existence of a single cointegration vector:

$$\lambda_{max} = -2\ln(Q:r|r+1) = -T\ln(1-\lambda_{r+1}) \tag{2}$$

The H_0 hypothesis states that the number of cointegrating vectors is r against the H_1: r + 1 cointegrating vectors.

David et al. (2019) mention that since the test is based on the matrix coefficients β and α that make up the model, it is known that the cointegration process is directly related to the VECM. The long-run equilibrium is connected to the β parameters and the "speed adjustment parameters," or α parameters, explain how quickly the series tends to return to equilibrium following a disturbance.

When a large range of short-term fluctuations occurs, VECM (a constrained VAR model with a co-integration constraint in explanatory variables) will make endogenous variables converge to their long-term co-integration relationship (Zhou & Zou, 2007). According to Martignone et al. (2022), a description of the connections between and among the markets can be obtained through the VECM as well as a framework for evaluating nonlinear adjustment to the long-term equilibrium can be established using the error correction representation. However, Zhou et al. (2023) stress that the stationarity test must be performed before computing the VECM model in order to make sure that there won't be two erroneous results of a negative model coefficient and pseudo regression in the research. Thus, the augmented Dickey–Fuller (ADF) unit root test is used to determine if each of the logarithmic price series is stationary. Onubogu and Dipeolu (2021) report that the co-integration test is conducted if the unit root test verifies that there is a unit root (at level) in the price series and that the price series must be differentiated by the same order in order to achieve stationarity. Tested hypotheses include:

H_0: There is a unit root in the series and H_1: The unit root is absent.

Zhang et al. (2021) define the basic form of the model, VECM (p-1), set by Johansen as follows:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \tag{3}$$

Y_t is a $Kx1$ vector of variables, A_i is a KxK matrix of parameters and ε_t is a $Kx1$ vector of disturbance. ε_t has zero mean, covariance matrix $\sum$, and is i.i.d normal over time.

Bentivoglio et al. (2016) emphasize that that the Π matrix can be broken down into $\Pi = \alpha\beta'$ when it is not of full rank, with beta representing the matrix that represents the co-integrating relationship, furthermore, the error-correction model (ECM), derived from the co-integrating equations by inserting the lagged error-correction term, reintroduces the long-run information lost through differencing as well the short-run adjustment to long-run equilibrium trends is represented by the error-correction term.

3. RESULTS

3.1. Development Status in the Selected Biodiesel Markets

Overall, global biodiesel production increased by approximately 60% during the period 2016-2021 (Figure 1). A slowdown of 1.2 billion litres was recorded in 2020 compared to 2019 as a consequence of the COVID-19 crisis that hit the biofuel sector and reduced demand for all transport modes. However, global biodiesel production overcame pre-pandemic levels and reached a volume of 60.7 billion litres in 2022. With a biodiesel volume of 17.7 billion litres in 2022, Europe remained the world´s largest producer. The United States produced 14.5 billion litres and in the case of Indonesia, the production of biodiesel was over 9 billion litres in 2022.
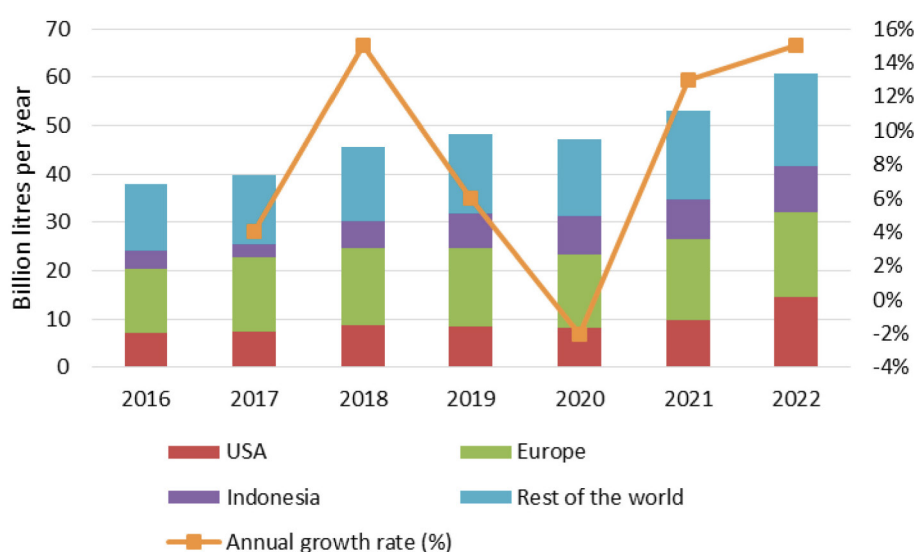
Figure 1. Global biodiesel production by country/region (in billion litres)
Source: International Energy Agency (2021), Own processing

3.2. Empirical Findings

Based on the results, the time series have a unit root and are not stationary. The ADF test indicates that all levels of variables are non-stationary and integrated of the first order I (1) at the 1% significance level. On the contrary, the variables are stationary in the first differences (Table 1). VAR modelling determines the optimal number of lags using the Akaike criterion, Schwarz Bayesian criterion, and Hannan-Quinn criterion. The results indicate that co-integration techniques can be used to investigate the nexus between variables. Therefore, co-integration is examined using the Johansen trace test and the L-max test. According to the findings provided in Table 2, the null hypothesis of no cointegration is rejected, thus the alternative hypothesis ´There is evidence for a cointegrating relationship´ is accepted.

Table 1. ADF test results for prices of biodiesel and rapeseed

Price	Test without constant		Test with constant		Test with constant and trend	
	Level	FD	Level	FD	Level	FD
Biodiesel	0.7845	1.956e-012***	0.5229	3.478e-011***	0.8574	1.5e-010***
Rapeseed	0.7356	5.961e-005***	0.6559	0.00147***	0.9941	0.003867***

Notes: FD: First difference; *** significant at 1% level

Source: Own processing

Table 2. Results of Johansen co-integration test for prices of biodiesel and rapeseed

Variables	L – max test		Trace test	
	r = 0	r = 1	r = 0	r = 1
Biodiesel-Rapeseed	18.966	5.3278**	13.639	5,3278**

Notes: r = 0 – no co-integration relationship;

      r = 1 – at most one co-integration relationship;

      ** significance at 5% level

Source: Own processing

The nature of the long-term nexus between the variables is represented by the cointegration vector β and the coefficient represents the long-run elasticities. The results provided in Table 3 have revealed the cointegration vector as follows: (1.000; -0.87521) implying that a 1% increase in rapeseed prices results in a 0.87521% increase in biodiesel prices. The adjustment coefficient α is statistically significant at the 1% level only in the case of biodiesel prices. Biodiesel prices have revealed negative signs of ECT– indicating a move back towards equilibrium. Besides, the adjustment coefficient α indicates that the response to price changes is rather fast; 45.83% of the disequilibrium inaccuracy has been fixed. In addition, rapeseed prices appear to be weakly exogenous and the findings provide evidence that biodiesel prices adjust to shifts in the price of rapeseed over the examined period. To sum up, rapeseed prices have an impact on biodiesel prices, thus the linkage between the pairs of studied series is one-way during the COVID-19 pandemic. The findings are not surprising given the fact that the production of biodiesel and hydrogenated vegetable oil (HVO) in Germany and Europe depends increasingly on the supply of rapeseed (Biofuels International, 2022). We assume, that the relationship between the rapeseed – biodiesel prices is not simultaneous given that there are other key elements pressuring rapeseed prices in the period under review. As stated by the Council of the European Union (2022), the agri-food sector handled the crisis caused by the disease COVID-19 relatively well, however, in 2021 and the last period inflationary pressures in the area of energy, raw materials, fertilizers (in particular, fertilizer prices increased by 225% from 2020 to March 2022) and freight transport rose sharply. Moreover, the Russian-Ukraine conflict has brought new shocks and uncertainty to world markets, while the EU was particularly exposed to the conflict due to its proximity and trade relations.

Diagnostic tests demonstrate that the ARCH test confirms the null hypothesis of homoscedasticity and the null hypothesis of no autocorrelation is accepted as well. The regression model accounts for roughly 36% of the variance (Table 3).

Table 3. VECM estimation - biodiesel prices and rapeseed prices

	l_biodiesel
Constant	-0.146135**
Cointegration vector β	-0.87521
Adjustment coefficient α	l_biodiesel -0.458257*** l_rapeseed 0.128754
Unadjusted R-squared	0.360109
ARCH*	0.36323
Autocorrelation*	0.549

Notes: ***significance at 1% level, ** significance at 5% level, *p-value

Source: Own processing

4. CONCLUSION

The paper investigated the linkages between biodiesel and rapeseed prices in the case of Germany as the largest producer of biodiesel in the EU during the COVID-19 pandemic. The long-term relationship between variables was confirmed using the Johansen co-integration test. The biodiesel-rapeseed price linkage was not simultaneous, according to the vector error correction model. The model revealed that there was a one-way link indicating that biodiesel prices adjusted to shifts in the price of rapeseed during the COVID-19 crisis. We assume that the price-interconnection of biodiesel and rapeseed prices was not simultaneous since there were other significant factors influencing the agricultural sector in the EU over the review period, e.g. inflationary pressures in the area of energy, raw materials, fertilizers, and freight transport. On the contrary, Sobczak and Gołębiewski (2022) analyzed the volatility and dependence of biodiesel and rapeseed prices during the pre-Covid-19 pandemic (2016-2019) by the vector error correction model and found that biodiesel prices were influenced by the previous week's prices of biofuel and rapeseed, however, the rapeseed prices were influenced by biodiesel prices as well. We posit that crucial elements of the future time perspective, which apply to the studied issue, include considering all aspects of the agricultural process involved in the production of rapeseed (and/or other crops used as feedstock for biofuels), encompassing three pillars of sustainability: environmental, social and economic. These metrics are critical for quantifying not only the benefits but also the drawbacks of producing biodiesel.

References

Antar, M., Lyu, D., Nazari, M., Shah, A., Zhou, X., & Smith, D. L. (2021). Biomass for a sustainable bioeconomy: An overview of world biomass production and utilization. *Renewable & Sustainable Energy Reviews*, *139*, 110691. https://doi.org/10.1016/j.rser.2020.110691

Bentivoglio, D., Finco, A., & Bacchi, M. R. P. (2016). Interdependencies between Biofuel, Fuel and Food Prices: The Case of the Brazilian Ethanol Market. *Energies, 9*(6), 464. https://doi.org/10.3390/en9060464

Bergquist, R., & Stengaard, A. (2020). COVID-19: End of the beginning? *Geospatial Health*, *15*(1). https://doi.org/10.4081/gh.2020.897

Biofuels International. (2022). The impact of rapeseed in Germany and Europe. Retrieved from https://biofuels-news.com/news/the-impact-of-rapeseed-in-germany-and-europe/

Cavelius, P., Engelhart-Straub, S., Mehlmer, N., Lercher, J., Awad, D., & Brück, T. (2023). The potential of biofuels from first to fourth generation. *PLoS Biology*, *21*(3), e3002063. https://doi.org/10.1371/journal.pbio.3002063

Council of the European Union. (2022). The situation on the agricultural market, especially after the invasion of Ukraine (Situácia na poľnohospodárskom trhu, najmä po invázii na Ukrajinu). Retrieved from https://data.consilium.europa.eu/doc/document/ST-9221-2022-INIT/sk/pdf

David, S. A., Inácio, C. M. C., & Machado, J. a. T. (2019). Ethanol Prices and Agricultural Commodities: An investigation of their relationship. *Mathematics, 7*(9), 774. https://doi.org/10.3390/math7090774

Elleby, C., Domínguez, I. P., Adenauer, M., & Genovese, G. (2020). Impacts of the COVID-19 pandemic on the global agricultural markets. *Environmental & Resource Economics*, *76*(4), 1067–1079. https://doi.org/10.1007/s10640-020-00473-6

European Biodiesel Board. (2023). Statistical Report 2023. Retrieved from https://ebb-eu.org/wp-content/uploads/2024/03/EBB_Statistical_Report2023-Final.pdf

European Centre for Disease Prevention and Control. (2023). Lessons from the COVID-19 pandemic. Stockholm: ECDC. 10.2900/151256.

Galanakis, C. M., Brunori, G., Chiaramonti, D., Matthews, R., Panoutsou, C., & Fritsche, U. R. (2022). Bioeconomy and green recovery in a post-COVID-19 era. *Science of the Total Environment, 808*, 152180. https://doi.org/10.1016/j.scitotenv.2021.152180

IEA Bioenergy. (2008). Biofuels for Transport – Part of a Sustainable Future? Summary and Conclusions from the IEA Bioenergy ExCo61 Workshop. IEA Bioenergy: ExCo: 2008:04. Retrieved from www.ieabioenergy.com

International Energy Agency. (2020). The Covid-19 crisis is hurting but not halting global growth in renewable power capacity – News. Retrieved from https://www.iea.org/news/the-covid-19-crisis-is-hurting-but-not-halting-global-growth-in-renewable-power-capacity

International Energy Agency. (2021). Biofuel production by country/region and fuel type, 2016-2022, IEA, Paris https://www.iea.org/data-and-statistics/charts/biofuelproduction-by-country-region-and-fuel-type-2016-2022, Licence: CC BY 4.0

Ioannidis, J. P. A. (2022). The end of the COVID-19 pandemic. *European Journal of Clinical Investigation, 52*(6). https://doi.org/10.1111/eci.13782

Ivanova, M., & Dospatliev, L. (2023). Effects of diesel price on changes in agricultural commodity prices in Bulgaria. *Mathematics, 11*(3), 559. https://doi.org/10.3390/math11030559

Jiang, J., Marsh, T. L., & Tozer, P. R. (2015). Policy induced price volatility transmission: Linking the U.S. crude oil, corn and plastics markets. *Energy Economics, 52*, 217–227. https://doi.org/10.1016/j.eneco.2015.10.008

Lee, K. T., & Ofori-Boateng, C. (2013). Introduction to sustainability of biofuels toward sustainable Development. In Green energy and technology (pp. 3–30). https://doi.org/10.1007/978-981-4451-70-3_1

Marcuta, L., Cazacu, M., & Marcuta, A. (2023). Study on the development of the biofuel market and their future in sustainable production. Scientific Papers. *Series "Management, Economic Engineering in Agriculture and rural development", 23*(3). ISSN 2284-7995, 565-572.

Martignone, G. B., Behrendt, K., & Paparas, D. (2022). Price transmission analysis of the international Soybean Market in a Trade war context. *Economies, 10*(8), 203. https://doi.org/10.3390/economies10080203

Norouzi, N., De Rubens, G. Z., Choupanpiesheh, S., & Enevoldsen, P. (2020). When pandemics impact economies and climate change: Exploring the impacts of COVID-19 on oil and electricity demand in China. *Energy Research & Social Science, 68*, 101654. https://doi.org/10.1016/j.erss.2020.101654

OECD-FAO. (2021). Agricultural Outlook 2021-2030. https://doi.org/10.1787/19428846-en

Onubogu, O. H., & Dipeolu, A. O. (2021). Agricultural price transmission across space and time: The case of cowpea and yam markets in Nigeria. *African Journal of Agricultural and Resource Economics, African Association of Agricultural Economists, 16*(1), https://ideas.repec.org/a/ags/afjare/333936.html

Sajid, Z. (2021). A dynamic risk assessment model to assess the impact of the coronavirus (COVID-19) on the sustainability of the biomass supply chain: A case study of a U.S. biofuel industry. *Renewable & Sustainable Energy Reviews, 151*, 111574. https://doi.org/10.1016/j.rser.2021.111574

Sarker, R., Roknuzzaman, A., Hossain, M. J., Bhuiyan, M. A., & Islam, M. R. (2023). The WHO declares COVID-19 is no longer a public health emergency of international concern: benefits, challenges, and necessary precautions to come back to normal life. *International Journal of Surgery, 109*(9), 2851–2852. https://doi.org/10.1097/js9.0000000000000513

Sirohi, J., Hloušková, Z., Bartoňová, K., Malec, K., Maitah, M., & Koželský, R. (2023). The vertical price transmission in pork meat production in the Czech Republic. *Agriculture, 13*(6), 1274. https://doi.org/10.3390/agriculture13061274

Sobczak, W., & Gołębiewski, J. (2022). Price dependence of biofuels and agricultural products on selected examples. *Bio-based and Applied Economics, 11*(3), 265–275. https://doi.org/10.36253/bae-9753

Solomon, B. D. (2010). Biofuels and sustainability. Annals of the New York Academy of Sciences, 1185(1), 119–134. https://doi.org/10.1111/j.1749-6632.2009.05279.x

Takeuchi, K., Shiroyama, H., Saito, O., & Matsuura, M. (2018). Biofuels and sustainability. *In Science for Sustainable Societies*. https://doi.org/10.1007/978-4-431-54895-9

Union for the Promotion of Oil and Protein Crops. (2020-2023). UFOP Market Information. https://www.ufop.de/english/ufop-association/

World Health Organization. (2020). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. (2020, March 11). https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

Yaya, S., Otu, A., & Labonté, R. (2020). Globalisation in the time of COVID-19: repositioning Africa to meet the immediate and remote challenges. *Globalization and Health*, *16*(1). https://doi.org/10.1186/s12992-020-00581-4

Zakeri, B., Paulavets, K., Barreto-Gomez, L., Echeverri, L. G., Pachauri, S., Boza-Kiss, B., Zimm, C., Rogelj, J., Creutzig, F., Ürge-Vorsatz, D., Victor, D. G., Bazilian, M. D., Fritz, S., Gielen, D., McCollum, D. L., Srivastava, L., Hunt, J. D., & Pouya, S. (2022). Pandemic, war, and global energy transitions. *Energies*, *15*(17), 6114. https://doi.org/10.3390/en15176114

Zhang, L., Li, H., Lee, W., & Liao, H. (2021). COVID-19 and energy: Influence mechanisms and research methodologies. *Sustainable Production and Consumption*, *27*, 2134–2152. https://doi.org/10.1016/j.spc.2021.05.010

Zhang, Q., Di, P., & Farnoosh, A. (2021). Study on the impacts of Shanghai crude oil futures on global oil market and oil industry based on VECM and DAG models. *Energy, 223*, 120050. https://doi.org/10.1016/j.energy.2021.120050

Zhou, S., Gan, W., Liu, A., Jiang, X., Shen, C., Wang, Y., Yang, L., & Lin, Z. (2023). Natural Gas–Electricity Price linkage Analysis Method based on Benefit–Cost and Attention–VECM Model. *Energies, 16*(10), 4155. https://doi.org/10.3390/en16104155

Zhou, Y. H., & Zou, L. G. (2007). Study on the Price relationship between Chinese soybean futures Market and international soybean futures Market—An Empirical Analysis based on VAR Model. *J. Agrotech. Econ. 1*, 55–62.

Using Particular Time Series Algorithms to Model Natural Gas Indicators for the US

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Abstract: Natural gas is a gaseous material that primarily consists of hydrocarbons. This is a primary component of energy resources and a fossil fuel. Its primary attribute is that it produces energy with great efficiency while generating negligible amounts of pollution. Natural gas is used in a wide range of industries. It is widely used as fuel for automobiles, to produce electricity, and for home heating. Because of its benefits, which include lower carbon emissions than other energy sources, natural gas is a desirable choice for both consumers and businesses. The purpose of this paper is to use the SARIMA (Seasonal Autoregressive Integrated Moving Average) model and the additive Holt-Winters model to forecast changes in natural gas prices in the United States and compare both models. These are a few of the most popular models for forecasting and time-series analysis.

1. INTRODUCTION

This paper intends to forecast the natural gas prices over a months-long period using two fundamental time series models. It used the SARIMA model and the additive Holt-Winters model to forecast the evolution of natural gas prices in the United States. Time series that show seasonality can use this model without having to eliminate it. SARIMA is a seasonal component-based univariate time series model that is an extension of the ARIMA (Autoregressive Integrated Moving Average) model. Stated differently, the ARIMA model is transformed into a SARIMA model by incorporating seasonal elements. It is worth noting that in May 2021, in the United States, a cyber-attack occurred at one of the major fuel suppliers, three years after a similar event occurred in 2018. Then, in April, several US natural gas pipeline operators, including Energy Transfer Partners LP and TransCanada Corp., reported that a third-party electronic communications system had been compromised by a cyberattack. Five of the companies confirmed that he was responsible for service disruptions. While the cyber-attack did not disrupt gas supplies to US homes and businesses, it demonstrated how even minor attacks can have far-reaching consequences. The attack forced utilities to warn of widespread billing delays and made it difficult for analysts and traders to forecast a key government report on gas stocks.

Forecasting natural gas prices and energy consumption is an important policy tool for many decision-makers around the world (Bilgili & Pinar, 2023). It must be acknowledged that rising energy and natural gas prices, which are sometimes caused by inherent and unforeseeable events (such as war or pandemic), cause inflation to rise and economic growth to slow.

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The creation of models to forecast natural gas prices, yielding results consistent with socio-economic expectations, significantly aids in the formulation of policies and decisions conducive to sustainable development. This concept is crucial to comprehend and address, as it significantly influences the fulfillment of current needs without jeopardizing future generations' capacity to satisfy their requirements. This sustainable development aims to achieve a balance between economic advancement and the preservation of social and ecological equilibrium. Natural gas, energy, and natural resources are fundamental to development and survival; thus, it is essential to assess their prices to formulate policies and decisions that promote improved living standards and a robust economy.

2.   LITERATURE REVIEW

In the recent literature, Gao et al. (2021) proposed a study of the markets in the United States, Japan, and the European Union through the perspective of the natural gas price, following its forecasting through a comparative approach that begins with the use of several models, such as time-varying coefficient with stochastic volatility models, Markov switching models, and hybrid models. The authors find reliable proof that models with time-varying covariance are critical for predicting gas prices throughout the three markets.

Peng (2023) used the MVMQ-CAViaR multiple market model to examine the impact of oil and natural gas prices on overnight risk in the HKD, RMB, and Yen markets. Proceeding in this manner, he concluded that the impact of oil price risk on the overnight risk of the three currencies is greater than that of natural gas prices. This can also be explained by the fact that oil is consumed more than natural gas.

In terms of the natural gas and energy markets, the recent literature contains numerous studies on the development of machine learning models for forecasting such indicators. These models include the following: nonlinear autoregressive neural network (Jin & Xu, 2024), neural networks (Herrera et al., 2019; Pei et al., 2023), support vectors regressions (Su et al., 2019; Čeperić et al., 2017), regression trees (Mouchtaris et al., 2021), boosting (Su et al., 2019), Gaussian process regressions (Mouchtaris et al., 2021).

To sustain a balance between natural gas demand and supply, a model that makes an efficient prediction must be identified because most countries must maintain a stable economy without incurring significant losses. To overcome the limitations of single models, Gao et al. (2023) proposed a hybrid model based on the Choquet integral for NGC forecasting time series. Before combining models, the prediction problem requires a decision support model to evaluate model performance effectively during model selection. Additionally, the proposed model uses LSTM, GHW, and SARIMA to collect information in time series. Interactions between models are introduced to improve model stability, particularly in the context of incidents. The efficacy of the model is demonstrated using datasets of natural gas consumption in the United States.

Su et al. (2025) analyze the characteristics and laws governing natural gas price fluctuations, turning points, and the scope of influence in Asia-Pacific natural gas markets. Japan/Korea Maker natural gas spot price time series has been transformed into a visibility graph network of natural gas prices and a visibility graph network of natural gas price fluctuations. The findings show that time series changes in Asia-Pacific natural gas prices are not random, but have long-term persistence, with it taking approximately 314 days to erase the historical memory of the natural gas price time series.

In addition, concerning natural resources, Guo et al. (2023) present methods associated with artificial intelligence to evaluate the most effective forecasting strategy for the price of crude oil futures in China. The processing of historical data, volatility, and non-linear characteristics is accomplished through the use of machine learning. They estimate the forecasting effects of RNN, LSTM, GRU, SVR, MLP, CNN, and BP models on China crude oil futures, respectively, by using daily data from March 26, 2018, to February 28, 2023. These periods span from March 26, 2018, to February 28, 2023. Using many different evaluation tests, we can demonstrate that the GRU model is superior to other models in terms of the accuracy of its forecasts and its overall performance for the price of crude oil futures in China.

Mati et al. (2023) investigate the performance of three models, namely the Autoregressive Integrated Moving Average (ARIMA), the Threshold Autoregressive Moving Average (TARMA), and the Evidential Neural Network for Regression (ENNReg), in forecasting the price of Brent crude oil. This is an important economic variable that has a significant impact on the economy of the entire world. The analysis suggests incorporating the impact of the war can significantly improve the forecasting accuracy of the models, with the ENNReg model exceeding the other models during the war.

Chaturvedi et al. (2022) compare the performance of four time-series models for predicting total and increased monthly energy demand in India. The existing trend-based model from India's Central Energy Authority (CEA) is compared to Seasonal Auto-Regressive Integrated Moving Average (SARIMA), Long Short Term Memory Recurrent Neural Network (LSTM RNN), and Facebook (Fb) Prophet models. Using 108 months of training data to predict 24 months of unseen data, the CEA model predicts monthly overall demand for energy with low root-mean-square error (RMSE 4.23 GWh) and mean absolute percentage error (MAPE, 3.4%), but significantly underestimates monthly peak energy demand. Also, researchers used various energy methods to forecast depending on the type, quality, and length of time resolution of the available data. ARIMA is the most general and commonly utilized time-series model for predicting future energy consumption (Akpinar & Yumusak, 2016; Al-Musaylh et al., 2018; Deb et al., 2017). Some studies rely on the fact that it is useful to combine hybrid approaches, integrating various prediction models in order to attain more versatility and prediction accuracy than a single model (Barassi & Zhao, 2018; Kim & Cho, 2019; Wang et al., 2012).

Meira et al. (2022) propose a new approach for forecasting natural gas consumption using ensembles. It combines Bootstrap Aggregation (Bagging), univariate time series forecasting, and modified regularization schedules. A novel version of Bagging is introduced, which employs Maximum Entropy Bootstrap (MEB) and an updated regularization routine to keep the data generation process within the group of data.

3. METHODOLOGY

In essence, seasonally adjusted ARIMA models have the same structure as non-seasonally adjusted ones, with the exception that, in the case of SARIMA, all factors will take into account multiple lags of order s, where s is the number of seasons (Banaś & Utnik-Banaś, 2021). As a result, SARIMA models are classified as ARIMA (p, d, q) x (P, D, Q) models, with the first part representing the non-seasonal component and the second, capitalized, the seasonal. They have the following meanings:
- p → the autoregressive term;
- d → the term regarding the integration order;
- q → the term moving average;

- P → the number of autoregressive seasonal terms (SAR);
- D → the number of seasonal differences;
- Q → the number of seasonal moving average terms (SMA).

Before determining whether or not a series exhibits seasonality, it is necessary to decide whether or not the series is stationary, as the majority of series in the economy are not stationary. Thus, we can use one of the following methods: graphical analysis (of the schedule and correlogram), evolution of the autocorrelation function (ACF) and partial autocorrelation (PACF), Bartlett, Box Pierce and Ljung Box tests, Dickey-Füller test. Another important test is the Hegy test, which determines whether or not the unit root exists in the series. Its assumptions are:

$$\begin{cases} H_0: \pi_i = 0 \\ H_1: \pi_i < 0 \end{cases}$$

If π_i are not equal to zero, the null hypothesis H_0 is rejected and H_1 is accepted, indicating that the series is stationary.

Once the series has been analyzed for stationarity, it will be possible to identify the seasonality of the relevant model. The first step is to determine whether a seasonal difference is required in addition to or instead of a non-seasonal difference by analyzing the model's graphs, the autocorrelation function, and the partial autocorrelation function and identifying all existing combinations of non-seasonal differences of order 0 or 1 and seasonal differences of order 0 and 1. When identifying them, it is also important to consider whether the seasonal component is strong and stable over time, in which case the seasonal difference should be used so that the chosen model can still make accurate forecasts. An important rule in this step is to avoid using more than one seasonal difference or more than two differences in total (seasonal and non-seasonal).

The next step is to adjust the autocorrelation for the seasonal period. If this is positive, a SAR term is added to the model as a variant; if it is negative, a SMA term is used. The value is positive when no seasonal difference is made, indicating that the seasonal pattern is unstable, and negative when a seasonal difference is used for a stable and logical model. In this situation, avoid using more than one or two seasonal parameters (SAR+SMA) in the same model, as this will result in data overfitting and/or estimation issues.

Long-term forecasts typically employ linear time series models, such as ARIMA and exponential smoothing methods, which forecast based on historical data. For exponential smoothing methods, the forecasts are weighted averages of the observations, with informational weight decreasing as the series becomes out of date. Holt-Winters is one example of such a method.

The Holt-Winters method, also known as triple exponential smoothing, estimates behavior, trend, and seasonality using a weighted moving average. As a result, there will be three parameters, one for each smoothing, and the method will have two models: additive and multiplicative. An additive model is suitable for a series in which the seasonal pattern's amplitude is not influenced by the average level of the series. This type of series is characterized by additive seasonality. Given the fluctuating nature of seasonality in the data series, this model will be employed for forecasting purposes.

The equations for the additive model are as follows, where a_t, b_t, s_t Represent the standardized estimates of behavior, trend, and seasonality, and α, β, γ denote the smoothing parameters:

$$a_t = \alpha(x_t - s_{t-p}) + (1 - \alpha)(a_{t-1} + b_{t-1}) \tag{1}$$

$$b_t = \beta(a_t - a_{t-1}) + (1 - \beta)b_{t-1} \tag{2}$$

$$s = \gamma(x_t - a_t) + (1 - \gamma)s_{t-p} \tag{3}$$

These parameters highlight the significance of differentiating between old and new data, as well as the exponential decay of information weight based on data age (Alonso-Brito et al., 2021).

4. DATA

The data source is The U.S. Energy Information Administration (EIA) - Short-Term Energy Outlook. The EIA is the primary statistical agency in charge of gathering, analyzing, and disseminating information about energy in economic and environmental contexts. The analyzed time horizon spans from January 1, 1981, to February 1, 2021. This period was chosen because it marked the start of oil price deregulation, with the Reagan administration allowing US producers to raise prices to market levels. The forecast horizon spans the next 24 months. Nominal prices were converted to comparable prices using the consumer price index, which was then logarithmized to work with returns for higher forecast accuracy.

5. RESEARCH RESULTS

The case study was developed with the help of the *RStudio* software. For the first time, the data set was divided into two parts: the training set, which contains 75% of the observations (January 1981 - December 2012), and the test set, which contains 25% of the observations (January 2013 - February 2021), with an out-of-sample forecast horizon of 24 months.

The analysis of Figure 1 shows that the series fluctuates in its evolution: it has an upward trend until 1985, then decreases until 2000, and finally reaches a maximum in 2008. Thus, the series is not stationary.
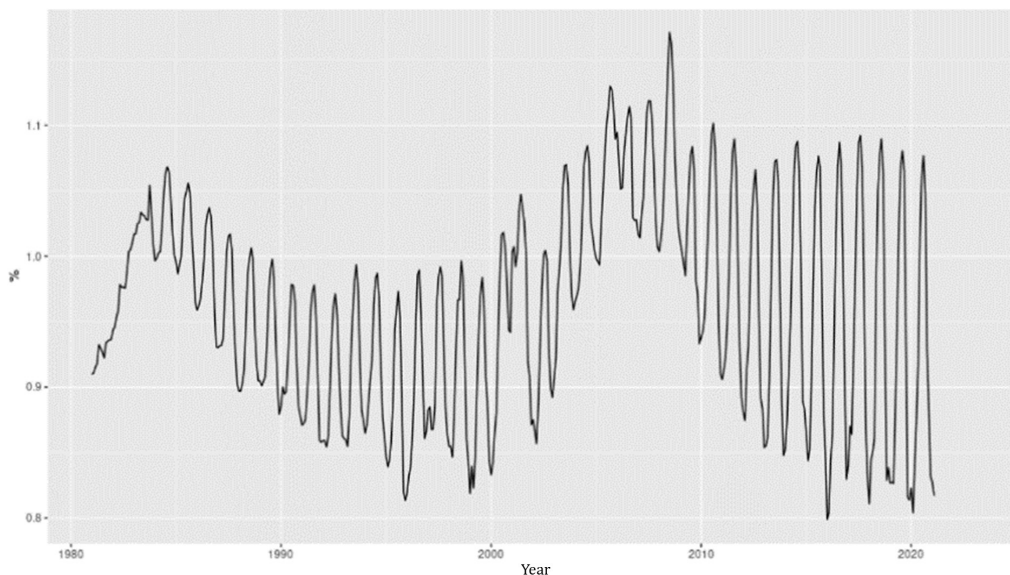
Figure 1. The evolution of the price of natural gas in the period 1981 – 2021
Source: Own processing

To be certain about stationarity, we will use the Augmented Dickey-Fuller (ADF) root test. Analyzing the ADF test results, which are summarized in Table 1, we can conclude that the series exhibits stochastic non-stationarity, with probabilities exceeding the 10% significance threshold. The null hypothesis is accepted, implying that the series admits a unit root, and thus the time series is first-order integrated, i.e. non-stationary.

Table 1. Augmented Dickey-Fuller (ADF) test results

	Critical values τ	τ_{calc}	Likelihood
Trend & Intercept			
Threshold 1%	-3.982988		
Threshold 5%	-3.421983	-2.445024	0.3556
Threshold 10%	-3.133816		
Statistically insignificant coefficient for deterministic trend			
Intercept			
Threshold 1%	-3.447770		
Threshold 5%	-2.869113	-2.364803	0.1526
Threshold 10%	-2.570871		
None			
Threshold 1%	-2.571210		
Threshold 5%	-1.941680	-0.099602	0.6488
Threshold 10%	-1.616127		

Source: Own processing

From Figure 2 it follows that the price of natural gas is higher in the summer and lower in the winter, indicating that the analyzed series is seasonal.
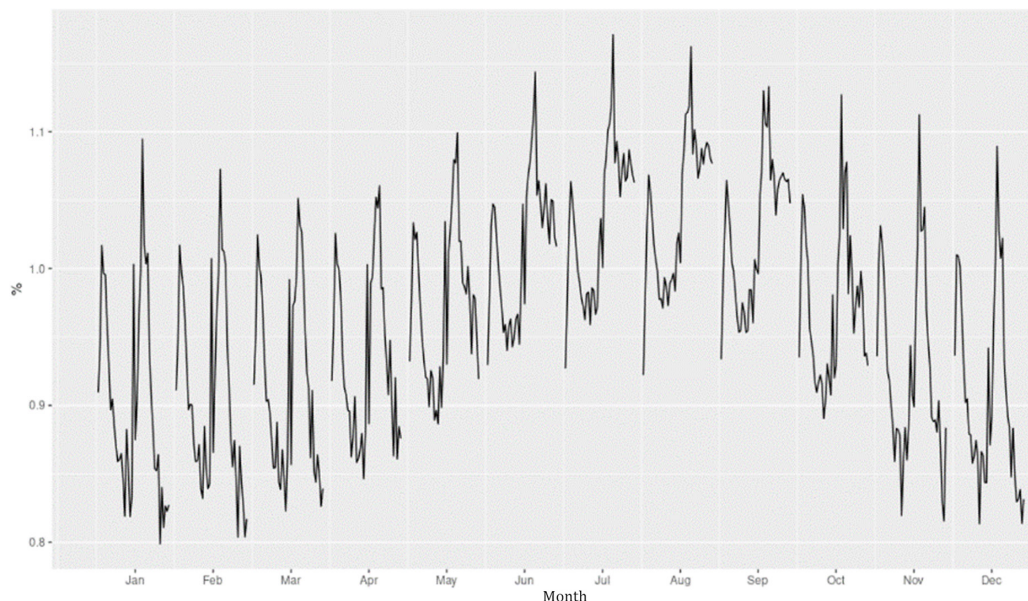
Figure 2. Chart of averages by season
Source: Own processing

Due to the presence of seasonal patterns in the data, we utilized the SARIMA model to predict future values for the specified period. To eliminate non-stationarity, we conducted the HEGY (Seasonal Unit Root Test) to determine whether non-seasonal or seasonal differentiation should be applied. This analysis determines if the series exhibits a seasonal unit root and if there is a peak at any seasonal frequency in its spectrum, excluding the zero frequency.

Based on the information presented in Figure 3, the first value is considered statistically insignificant (p-value > 0.1). Therefore, we cannot reject the presence of a unit root in the series, and we acknowledge that the series does have a unit root. Similarly, because the first frequency is insignificant and the probability exceeds the significance threshold, the presence of the seasonal unit root cannot be discounted. To be stationary, the analyzed series must have both a seasonal and non-seasonal difference.

```
          HEGY test for unit roots

data:  training

          statistic p-value
t_1        -1.6843  0.4185
t_2        -6.0976        0 ***
F_3:4       1.2123  0.3122
F_5:6       9.1131    1e-04 ***
F_7:8      49.7465        0 ***
F_9:10     46.7663        0 ***
F_11:12    72.2071        0 ***
F_2:12    229.155         0 ***
F_1:12    210.4974        0 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Deterministic terms: constant
Lag selection criterion and order: fixed, 0
P-values: based on response surface regressions
```

Figure 3. The HEGY test for determining the existence of unit roots

Source: Own processing

Analyzing the graphs in Figure 4 reveals that the series is now stationary. We also identified an SMA(1) process because the coefficient on the seasonal lag on ACF is significant and the partial autocorrelation function coefficients decrease slowly with seasonal lags.
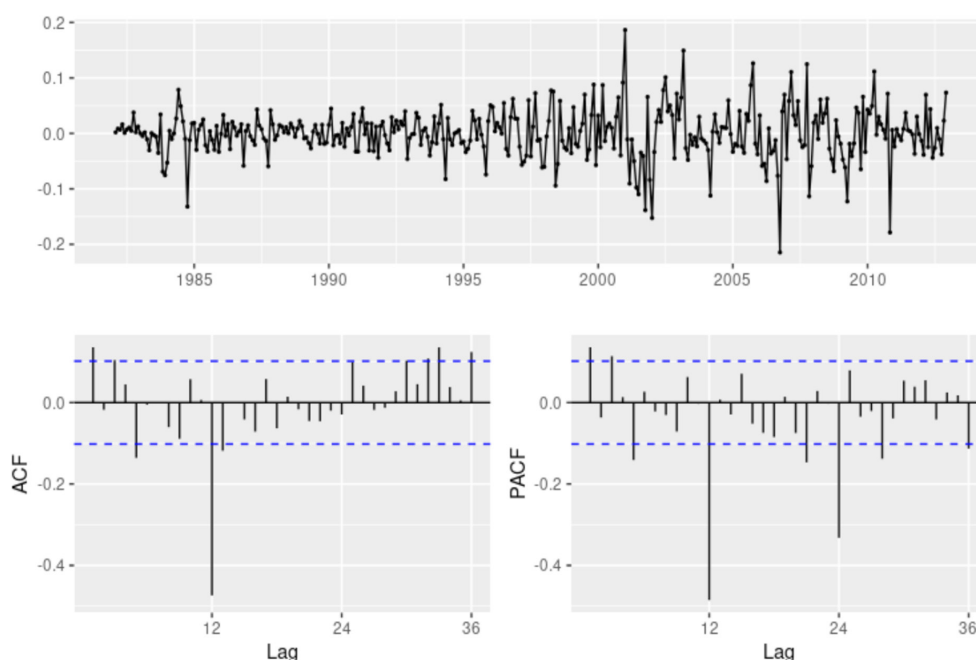
Figure 4. Stationary time series

Source: Own processing

For the non-seasonal component, the authors tested several models: SARIMA(1,1,1)(0,1,1), SARIMA(1,1,0)(0,1,1), SARIMA(0,1,1)(0,1,1), and SARIMA(2,0,0)(0,1,1). Considering that the first model has insignificant coefficients and Auto-Arima proposed a model with no non-seasonal differentiation, we compared models 2 and 3.

As can be seen in Table 2, The optimal model is SARIMA(1,1,0)(0,1,1) due to lower values for AIC, AICc, and BIC in the first model compared to the second.

Table 2. Performance indicators for each of these models

Model/Criteria	AIC	AICc	BIC
SARIMA(1,1,0)(0,1,1)	-1400.88	-1400.81	-1389.13
SARIMA(0,1,1)(0,1,1)	-1400.13	-1400.06	-1388.38

Source: Own processing

Finally, the forecast was made on the test set, and the results are provided in Figure 5.
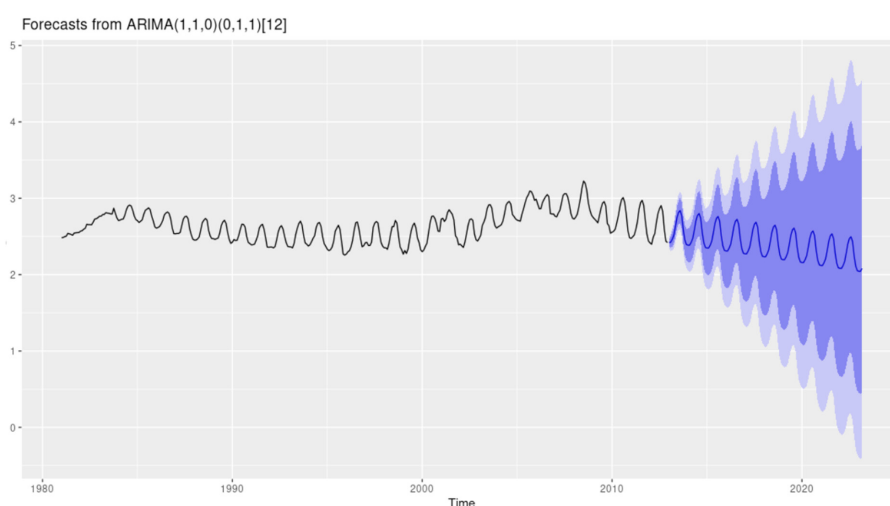
Figure 5. Natural gas prices forecast with SARIMA model

Source: Own processing

Regarding the Holt-Winters additive model, the results on the forecast horizon can be found in Figure 6.
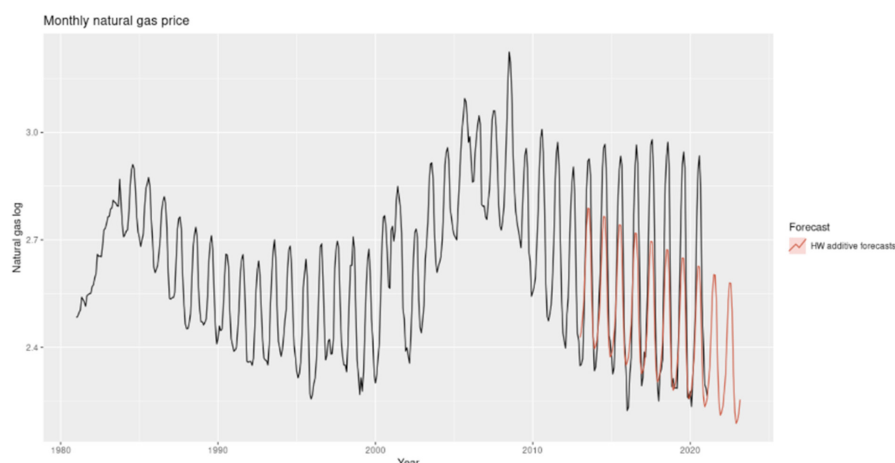
Figure 6. Holt-Winters additive model for gas prices forecast

Source: Own processing

Considering that both models presented in the article provide a forecast in line with realistic and economic expectations but have different accuracy, a final decision on the best model for forecasting natural gas prices will be made based on forecast accuracy indicators, with a conclusion to be formulated in this regard. Table 3 depicts the forecast performance indicators for the two models for the test set.

Table 3. Forecast performance measurement indicators

Model/Indicators	ME	RMSE	MAE	MPE	MAPE	MASE
SARIMA(1,1,0)(0,1,1)	0.2331	0.2471	0.2331	8.9121	8.9121	2.8605
Holt-Winters	0.1419	0.1790	0.1419	5.2316	5.2316	1.7419

Source: Own processing

6. FUTURE RESEARCH DIRECTIONS

Future research directions may include the use of other specific time series models (for example, VAR/VECM to analyze the impact of natural gas prices on electricity or oil prices). In addition, a hybrid model can be developed to overcome the limitations imposed by a single model and improve forecast accuracy. Such trends have been identified in the literature.

7. CONCLUSION

Summarizing all of the considerations presented in this article, the goal of the research is to forecast the price of natural gas in the US market, taking into account the importance of this indicator and the outcomes that decision-makers seek when developing policies and strategies, as well as selecting an optimal model that best captures expectations and socioeconomic reality. The overall goal of the research was to estimate results that will provide adequate support for decision-making to meet the high standard of living incorporated into the concept of sustainable development.

To perform the analysis, two-time series models, SARIMA and the Holt-Winters additive model, were used, with seasonality taken into account. The models were applied to monthly data from January 1981 to February 2021, with a forecast horizon of 24 months. Considering that the two final models chosen for the forecast have different accuracies, the forecast accuracy indicators for both models were compared on the test sets, with the Holt-Winters additive model emerging as the most suitable for forecasting, with the six indicators in Table 3 having lower values for this model. Beyond selecting the best model based on performance indicators, the article's two models can contribute to estimating the price of natural gas following economic expectations over a 24-month time horizon, which should not be too long to obtain a more accurate forecast. This also helps to support sustainable development because there are no unexpected fluctuations in gas prices over the forecasted time horizon, which would destabilize the economy and, implicitly, development.

References

Akpinar, M., & Yumusak, N. (2016). Year ahead demand forecast of city natural gas using seasonal time series methods. *Energies*, *9*(9), 727. https://doi.org/10.3390/en9090727

Al-Musaylh, M. S., Deo, R. C., Adamowski, J. F., & Li, Y. (2018). Short-term electricity demand forecasting with MARS, SVR and ARIMA models using aggregated demand data in Queensland, Australia. *Advanced Engineering Informatics, 35*, 1-16. https://doi.org/10.1016/j.aei.2017.11.002

Alonso-Brito, G. R., Rivero Villaverde, A., Lau Quan, A., & Ruíz Pérez, M. E. (2021). Comparison between SARIMA and Holt-Winters models for forecasting monthly streamflow in the western region of Cuba. *SN Applied Sciences, 3*(6). https://doi.org/10.1007/s42452-021-04667-5

Banaś, J., & Utnik-Banaś, K. (2021). Evaluating a seasonal autoregressive moving average model with an exogenous variable for short-term timber price forecasting. *Forest Policy and Economics*, *131*, 102564. https://doi.org/10.1016/j.forpol.2021.102564

Barassi, M., & Zhao, Y. (2018). Combination forecasting of energy demand in the UK. *The Energy Journal*, *39*(1_suppl), 209-238. https://doi.org/10.5547/01956574.39.si1.mbar

Bilgili, M., & Pinar, E. (2023). Gross electricity consumption forecasting using LSTM and SARIMA approaches: A case study of Türkiye. *Energy*, *284*, 128575. https://doi.org/10.1016/j.energy.2023.128575

Čeperić, E., Žiković, S., & Čeperić, V. (2017). Short-term forecasting of natural gas prices using machine learning and feature selection algorithms. *Energy*, *140*, 893-900. https://doi.org/10.1016/j.energy.2017.09.026

Chaturvedi, S., Rajasekar, E., Natarajan, S., & McCullen, N. (2022). A comparative assessment of SARIMA, LSTM RNN and Fb Prophet models to forecast total and peak monthly energy demand for India. *Energy Policy*, *168*, 113097. https://doi.org/10.1016/j.enpol.2022.113097

Deb, C., Zhang, F., Yang, J., Eang, L. S., & Shah, K. W. (2017). A review on time series forecasting techniques for building energy consumption. *Renewable and Sustainable Energy Reviews*, *74*, 902-924. https://doi.org/10.1016/j.rser.2017.02.085

Gao, S., Hou, C., & Nguyen, B. H. (2021). Forecasting natural gas prices using highly flexible time-varying parameter models. *Economic Modelling*, *105*, 105652. https://doi.org/10.1016/j.econmod.2021.105652

Gao, X., Gong, Z., Li, Q., & Wei, G. (2023). Model selection with decision support model for US natural gas consumption forecasting. *Expert Systems with Applications*, *217*, 119505. https://doi.org/10.1016/j.eswa.2023.119505

Guo, l., Huang, X., Li, Y., & Li, H. (2023). Forecasting crude oil futures price using machine learning methods: Evidence from China. *Energy Economics*, *127*(A), 107089. https://doi.org/10.1016/j.eneco.2023.107089

Herrera, G. P., Constantino, M., Tabak, B. M., Pistori, H., Su, J. J., & Naranpanawa, A. (2019). Long-term forecast of energy commodities price using machine learning. *Energy*, *179*, 214-221. https://doi.org/10.1016/j.energy.2019.04.077

Jin, B., & Xu, X. (2024). Price forecasting through neural networks for crude oil, heating oil, and natural gas. *Measurement: Energy*, *1*, 100001. https://doi.org/10.1016/j.meaene.2024.100001

Kim, T. Y., & Cho, S. B. (2019). Predicting residential energy consumption using CNN-LSTM neural networks. *Energy*, 182, 72-81. https://doi.org/10.1016/j.energy.2019.05.230

Mati, S., Radulescu, M., Saqib, N., Samour, A., Yousif, G. I., & Aliyu, N. (2023). Incorporating Russo-Ukrainian war in Brent crude oil price forecasting: A comparative analysis of ARIMA, TARMA and ENNReg models. *Heliyon*, *9*(11), e21439. https://doi.org/10.1016/j.heliyon.2023.e21439

Meira, E., Oliveira, F. L. C., & Menezes, L. M. (2022). Forecasting natural gas consumption using Bagging and modified regularization techniques. *Energy Economics*, *106*, 105760. https://doi.org/10.1016/j.eneco.2021.105760

Mouchtaris, D., Sofianos, E., Gogas, P., & Papadimitriou, T. (2021). Forecasting Natural Gas Spot Prices with Machine Learning. *Energies*, *14*(18), 5782. https://doi.org/10.3390/en14185782

Pei, Y., Huang, C.-J., Shen, Y., & Wang, M. (2023). A Novel Model for Spot Price Forecast of Natural Gas Based on Temporal Convolutional Network. *Energies*, *16*(5), 2321. https://doi.org/10.3390/en16052321

Peng, W. (2023). The impact of oil and natural gas prices on overnight risk in exchange rates based on the MVMQ-CAViaR models. *International Review of Economics & Finance*, *86*, 616-625. https://doi.org/10.1016/j.iref.2023.03.031

Su, J., Wang, W., Bai, Y., & Zhou, P. (2025). Measuring the natural gas price features of the Asia-Pacific market from a complex network perspective. *Energy*, *314*, 134133. https://doi.org/10.1016/j.energy.2024.134133

Su, M., Zhang, Z., Zhu, Y., & Zha, D. (2019). Data-Driven Natural Gas Spot Price Forecasting with Least Squares Regression Boosting Algorithm. *Energies*, *12*(6), 1094. https://doi.org/10.3390/en12061094

Su, M., Zhang, Z., Zhu, Y., Zha, D., & Wen, W. (2019). Data Driven Natural Gas Spot Price Prediction Models Using Machine Learning Methods. *Energies*, *12*(9), 1680. https://doi.org/10.3390/en12091680

Wang, Y., Wang, J., Zhao, G., & Dong, Y. (2012). Application of residual modification approach in seasonal ARIMA for electricity demand forecasting: A case study of China. *Energy Policy*, *48*, 284-294. https://doi.org/10.1016/j.enpol.2012.05.026

Unveiling the Sustainable Supply Chain Management Imperative: Bridging the Gap in Emerging Economies

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Abstract: In today's global marketplace, there is a growing recognition that supply chain management must integrate environmental and social considerations with economic factors. This paradigm shift has led to a growing interest in sustainable supply chain management in recent years. However, there remains a significant gap in research attention towards sustainable supply chain management in emerging economies compared to other economic contexts. This study undertakes a thorough review of the academic literature on sustainable supply chain management in emerging economies to uncover the reasons for this disparity. The findings of this research shed light on the specific challenges and nuances that emerging economies face in addressing sustainability within their supply chains.

1. INTRODUCTION

Throughout history, supply chains have developed to fulfill the varied requirements of individuals and societies, harness natural resources, and facilitate profitable engagement in trade (MacCarthy et al., 2016). New supply chains can emerge in different contexts such as when demand for a new product arises, but they can also disappear when demand is not sufficient to drive them (Lee et al., 2013; Wang et al., 2015).

Recently, however, the supply chain has been forced to pay more attention to environmental, ethical, and social responsibility issues, thus, different supply chain (SC) approaches have emerged and developed that respond to the interests of the new conditions. The most prominent approaches identified are green SC, responsible SC, ethical SC, and resilient SC, but the one that stands out most because of its broad scope and focus on the future is the sustainable supply chain (SSC) approach. The SSC approach provides a global vision that the authors of this research consider as integrating the rest of the approaches.

It is important to highlight that authors such as (Brandenburg et al., 2014; Brandenburg & Rebs, 2015; Seuring & Müller, 2008) state that currently, the integration of social, environmental and economic responsibilities in supply chain management (SCM) is a challenge for organizations and a very relevant area of research, and that although substantial improvement has been made towards this objective, there is still a long way to go.

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The diversity of published articles prompts questions about how to guide future research and advance the field and underscores the need to detect research gaps and direct research efforts accordingly, regardless of the methodology used (de Lima et al., 2022; Seuring et al., 2022). Authors of different studies (Khodakarami et al., 2015; Narimissa et al., 2020; Pagell & Shevchenko, 2014; Seuring et al., 2022; Zhu et al., 2022) argue that one is unlikely to become an SSC if you don't manage your sustainability, hence the growing interest of the international scientific community in sustainable supply chain management (SSCM). Reflecting the growing importance of sustainable development, research in SSCM has now become mainstream (Seuring et al., 2022). Recently, SSCM academics have been experimenting with diverse scenarios and coming up with discoveries and designs through scientific studies.

Despite advancements in SSCM research, a significant gap persists in the attention given to the context of emerging economies. There is a notable disparity in the number of case studies between established and emerging economies, which can be attributed to several underlying factors. Emerging economies often face distinct challenges, such as limited financial resources, weaker institutional capacities, and inadequate regulatory frameworks, which complicate the adoption of sustainable practices in supply chains. These barriers not only hinder the effective implementation of SSCM but also restrict the generation of empirical data and case studies necessary for advancing research in these regions. As a result, the unique dynamics and sustainability challenges of emerging economies remain underexplored, highlighting the need for more targeted research efforts to bridge this critical gap.

Given these challenges, this paper seeks to address the following research question: What are the primary barriers to the implementation of sustainable supply chain management practices in emerging economies?

To explore this question, an in-depth search was conducted using the Scopus and Web of Science databases, focusing on publications that examine sustainability management within supply chains in the context of emerging economies. The collected data were meticulously analyzed, and the key findings are presented and discussed in this article, shedding light on the current state and future directions of SSCM in these rapidly evolving markets.

2. METHODOLOGY

The systematic review was conducted using the SALSA (Search, Appraisal, Synthesis, and Analysis) framework, which provides a detailed methodological structure for organizing and evaluating the scientific literature in a rigorous manner. The individual stages of this framework are shown in Figure 1 and described below:

Search: An exhaustive search was conducted in the Scopus and Web of Science databases, selected for their prestige and recognition in the academic community. Keywords and specific criteria related to SSCM in the context of emerging economies were applied.

Appraisal: After the initial search, a critical evaluation of the articles identified was carried out to exclude those that did not meet the defined inclusion criteria. Studies that did not directly address the context of emerging economies or that did not focus on SSCM were discarded.

Synthesis: Selected studies were organized and synthesized to identify patterns, trends, and gaps in the existing literature. The results were systematically grouped to highlight methodological approaches, key findings and implications of the studies for SSCM.

Analysis: Finally, a detailed analysis of the synthesized data was performed, identifying the most significant contributions to the field of study. This analysis included evaluating the approaches used, identifying areas for improvement, and proposing possible directions for future research.

The use of the SALSA framework allowed for a systematic and structured review, ensuring the quality and relevance of the selected studies and providing a solid basis for the discussion of the results in this article.
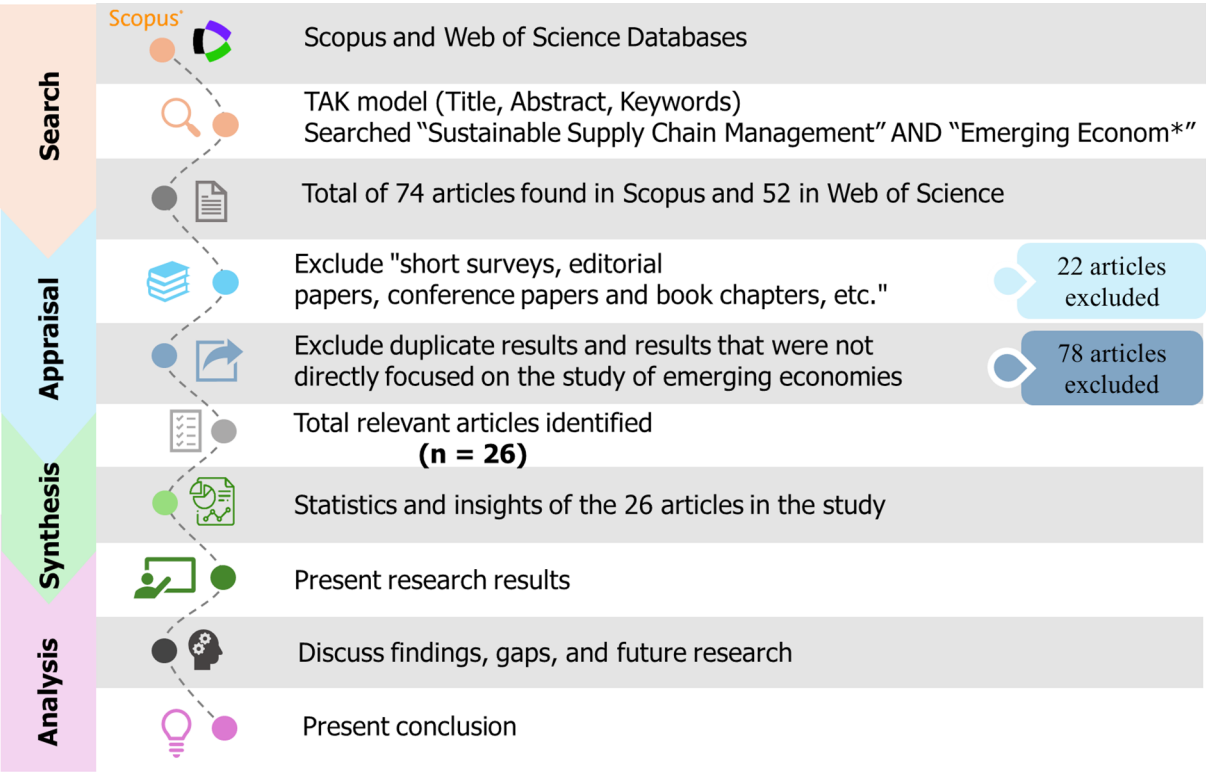
Figure 1. Research Methodology
Source: Own research

3. RESULTS

After the selection of the articles, a detailed descriptive analysis was carried out, focusing on statistics and general data obtained from each study. This analysis considered key variables such as year of publication, industry sector, country of study and research methodology employed. These dimensions provided a comprehensive overview of the current state of research on SSCM in emerging economies.

As shown in Figure 2, the chronological analysis revealed that academic production in SSCM in emerging economies has been irregular over the years, which is evidence that this area of research has not yet reached its maturity phase. The variability in the number of publications suggests that the topic, although emerging and relevant, has not managed to consolidate consistently within the academic literature. The year 2018 stood out as the most prolific, concentrating the highest number of publications, which could be related to a greater global focus on sustainability and the Sustainable Development Goals (SDGs) promoted by international organizations during that period.

Geographically, most research is concentrated in India (Jain et al., 2024; Moktadir et al., 2021; Roy et al., 2020; Sharma et al., 2021; Singh & Srivastava, 2022) and Brazil (de Vargas Mores et al.,

2018; Emberson et al., 2022; Morais & Silvestre, 2018; Pereira et al., 2023; Silvestre et al., 2018) (Figure 3), two of the world's largest and most dynamic emerging economies. This can be attributed to the relevance of their industrial sectors, their challenges in terms of sustainability, and a growing academic interest in exploring how these countries address the integration of sustainable practices into their supply chains. However, the concentration of studies in these countries also highlights the need to expand research to other underrepresented emerging economies, such as those in Africa and Southeast Asia, to obtain a more global and balanced view.
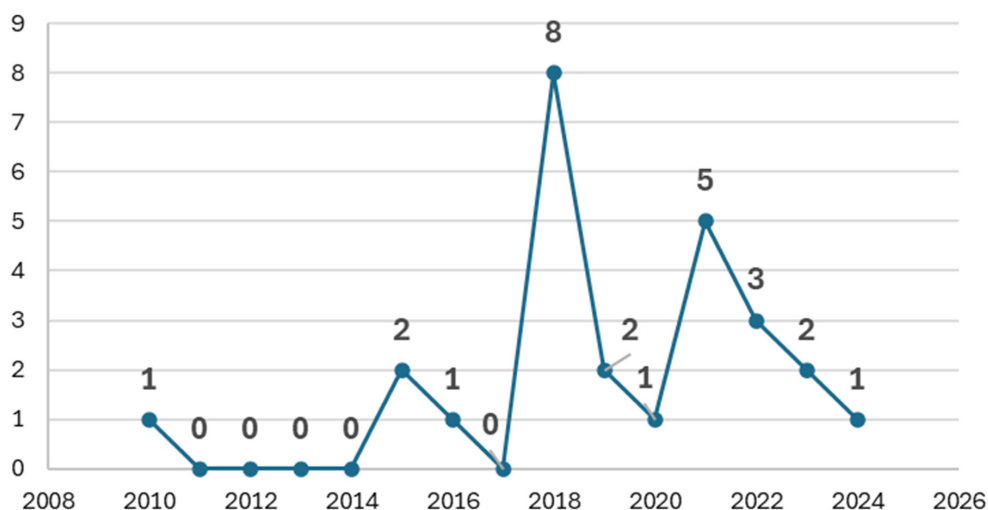
Figure 2. Distribution of publications by year
Source: Own processing
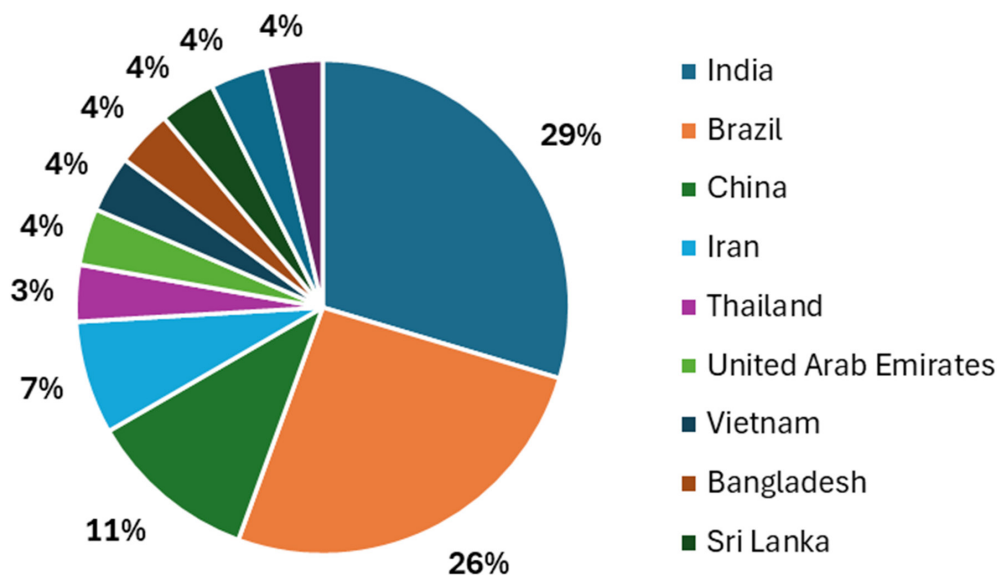
Figure 3. Distribution of publications by countries
Source: Own processing

Figure 4 shows that the manufacturing sector, with a particular focus on the apparel industry, predominates among the most studied industrial sectors (Ahmadi et al., 2023; Badri Ahmadi et al., 2022; Jain et al., 2024; Sharma et al., 2021). This sector is particularly relevant due to its high dependence on labor in emerging markets, its significant environmental impacts, and its exposure to ethical and social issues such as precarious working conditions. This pattern reflects the need to address sustainability issues in industries with complex supply chains exposed to globalization.
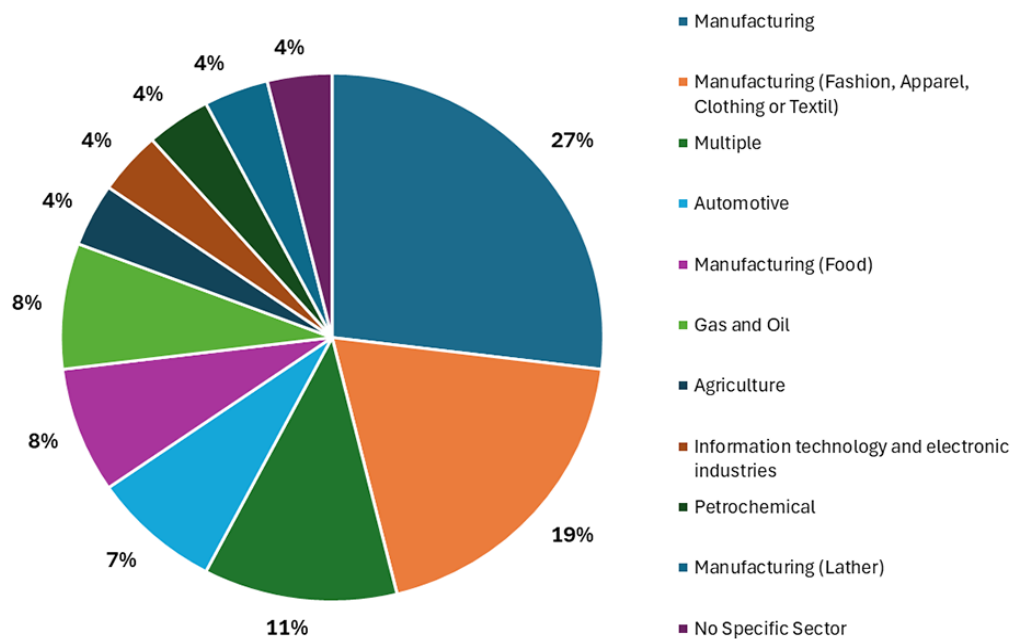
Figure 4. Distribution of research by sector

Source: Own processing

In terms of methodological approaches, most studies employ analytical and mathematical methodologies (54%), including optimization models, simulations and quantitative analysis to address specific SSCM problems. These approaches allow an accurate assessment of the efficiency and effectiveness of sustainable practices. They are followed by case studies (35%), which provide in-depth understanding of specific contexts, highlighting the practical complexities of implementing SSCM in different industrial settings. Finally, systematic literature reviews account for 11%, serving as a basis for synthesizing prior knowledge and establishing the theoretical foundations of the field.

Taken together, these findings highlight both the progress and current limitations of SSCM research in emerging markets. While there is growing interest, the uneven distribution of publications, the concentration on certain sectors and countries, and the predominance of quantitative methodologies point to areas where the field could benefit from further diversification and deepening.

4. DISCUSSION AND FUTURE RESEARCH DIRECTIONS

A key finding of this research is the identification of several barriers to the development of SSCM in emerging economies. Key barriers include limited financial resources and low institutional capacity, reflecting a complex and less developed business and regulatory environment compared to advanced economies. This hinders the implementation of sustainable practices due to the lack of financial support and robust policies that promote sustainability.

Another critical factor is the lack of awareness and understanding of the importance of sustainability within supply chains. In many cases, both companies and consumers in emerging economies are not fully informed about the long-term benefits of integrating sustainable practices, resulting in limited adoption of these measures. In addition, cultural, social and economic differences in these economies significantly influence the perception and adoption of sustainability, leading to practices that may be inconsistent or not aligned with international standards.

113

Restricted access to advanced technologies also represents a considerable barrier, as these technologies are critical for efficient SSCM. Emerging economies often face difficulties in accessing these tools due to high investment costs, inadequate infrastructure, and lack of technical training, which limits their ability to optimize processes and reduce environmental impact.

Finally, companies in emerging economies tend to prioritize short-term economic benefits over long-term sustainability objectives. This tendency is often driven by immediate financial pressures and market volatility, which force companies to focus on quick profitability to ensure their survival, leaving behind investments in sustainable practices that, although beneficial in the long term, require greater upfront resources.

These barriers highlight the need for a comprehensive approach that addresses not only sustainability awareness and education but also institutional capacity building and access to finance and technology to foster real and sustainable change in the supply chains of emerging economies.

During the study, several gaps were identified that limit the progress of research on sustainable supply chain management in emerging economies. One of the main ones is the lack of studies that specifically address local contexts, which generates insufficient knowledge on how the economic, social and cultural particularities of these regions affect the implementation of sustainable practices. This lack is compounded by the scarcity of empirical data and case studies that provide detailed evidence of the specific challenges and opportunities faced by supply chains in these markets.

In addition, there is limited attention to local challenges, such as labor market informality, poor infrastructure and economic instability, which require tailored approaches and innovative solutions. Cultural and social differences also play a crucial role, in influencing the perception and adoption of sustainability in such a way that models applied in developed economies are not always directly transferable or effective.

Another significant obstacle is resource constraints, both financial and technological, which limit the ability of local businesses to adopt sustainable practices. This situation is exacerbated by often inadequate or inconsistent regulatory and policy frameworks, which not only lack clear incentives for sustainability but can also create additional barriers through bureaucracy or lack of effective enforcement.

The influence of multinational companies also represents a duality: while they may drive better sustainable practices through their global supply chains, they may also impose standards that do not fit the local context or prioritize their economic interests over commitments to sustainability. Finally, the scarcity of interdisciplinary approaches limits the ability to approach SSCM from multiple perspectives, integrating knowledge from diverse areas such as economics, sociology, technology and environmental management, which are essential to developing more comprehensive and effective solutions.

These gaps highlight the need for more contextualized, diversified and collaborative research that considers the complexities and particularities of emerging economies to meaningfully advance sustainable supply chain management in these environments.

The study has three essential limitations that could have influenced the findings. First, the restriction in the selection of databases, as only a limited set was used, which may have excluded relevant studies

from other less traditional but equally valuable academic sources. Second, the use of specific keywords, although careful, may not have been comprehensive enough to capture the full breadth of the literature on SSCM in emerging economies, which may have led to a partial representation of the topic. Finally, the review was based on an analysis of only 26 articles, which, while providing relevant initial insight, limits the generalizability of the results and may not capture all the complexities of the field.

Despite these limitations, several lines of future research were identified that could significantly enrich the understanding of SSCM in emerging economies. These include the need to develop specific frameworks that are adapted to local contexts, as well as longitudinal studies to observe the evolution of sustainable practices over time. Comparative analyses between different emerging economies could provide valuable insights into contextual variations.

In addition, exploring the role of stakeholders, including governments, non-governmental organizations and local communities, is essential to understand how they influence the implementation of SSCM. It is also suggested to investigate the impact of policy and regulation on sustainability, as regulatory frameworks can be both drivers and barriers. Consumer behavior and its influence on the demand for sustainable products is another crucial aspect that deserves attention.

Likewise, training and education emerge as key factors in fostering a culture of sustainability within organizations and at the community level. Finally, technological innovations represent a promising field for transforming supply chains, improving efficiency and reducing environmental impacts. These lines of research offer a way to deepen knowledge and overcome current barriers to sustainable supply chain management in emerging economies.

5. CONCLUSION

The conclusions of this study highlight that the implementation of SSCM practices in emerging economies remains in its early stages and faces multiple obstacles. The main barriers identified include economic constraints, weak regulatory frameworks, inadequate infrastructure, and a lack of awareness and specialized knowledge in sustainability. Additionally, cultural and social factors, technological gaps, the inherent complexity of supply chains, limited stakeholder engagement, a predominant short-term business focus, and pressures from globalization further complicate the adoption of sustainable practices.

Despite these challenges, there is a noticeable trend towards the adoption of SSCM practices in these regions, reflecting a growing awareness of the importance of sustainability. Addressing these barriers requires a multifaceted approach that includes strengthening regulatory frameworks, improving infrastructure, enhancing access to financing and advanced technologies, and promoting education and capacity-building initiatives. Encouraging collaboration among stakeholders and fostering a long-term sustainability perspective are also essential elements for driving meaningful change.

This study underscores the urgent need for continued research to develop tailored strategies that consider the unique contexts of emerging economies. This involves designing frameworks that not only respond to local needs but also address the complexities and specificities of these markets. Future research should focus on closing the identified gaps and creating innovative solutions that enhance the sustainability of supply chains in emerging economies, ultimately contributing to more resilient and sustainable global supply chains and benefiting the global community.

References

Ahmadi, H. B., Pamucar, D., Pourhejazy, P., Kaya, S. K., & Liou, J. J. H. (2023). An Integrated Approach for Assessing Suppliers Considering Economic Sustainability Innovation. *IEEE Access*, *11*, 39675–39694. IEEE Access. https://doi.org/10.1109/ACCESS.2023.3268438

Badri Ahmadi, H., Lo, H.-W., Gupta, H., Kusi-Sarpong, S., & Liou, J. J. H. (2022). Analyzing inter-relationships among environmental sustainability innovation factors. *Clean Technologies and Environmental Policy*, *24*(4), 1191–1207. https://doi.org/10.1007/s10098-021-02086-z

Brandenburg, M., Govindan, K., Sarkis, J., & Seuring, S. (2014). Quantitative models for sustainable supply chain management: Developments and directions. *European Journal of Operational Research*, *233*(2), 299–312. https://doi.org/10.1016/j.ejor.2013.09.032

Brandenburg, M., & Rebs, T. (2015). Sustainable supply chain management: A modeling perspective. *Annals of Operations Research*, *229*(1), 213–252. https://doi.org/10.1007/s10479-015-1853-1

de Lima, F. A., Seuring, S., & Sauer, P. C. (2022). A systematic literature review exploring uncertainty management and sustainability outcomes in circular supply chains. *International Journal of Production Research*, *60*(19), 6013–6046. https://doi.org/10.1080/00207543.2021.1976859

de Vargas Mores, G., Finocchio, C. P. S., Barichello, R., & Pedrozo, E. A. (2018). Sustainability and innovation in the Brazilian supply chain of green plastic. *Journal of Cleaner Production*, *177*, 12–18. https://doi.org/10.1016/j.jclepro.2017.12.138

Emberson, C., Pinheiro, S. M., & Trautrims, A. (2022). Adaptations to first-tier suppliers' relational anti-slavery capabilities. *Supply Chain Management: An International Journal*, *27*(4), 575–593. https://doi.org/10.1108/SCM-10-2020-0505

Jain, P., Tambuskar, D., & Narwane, V. (2024). Identification of critical factors for big data analytics implementation in sustainable supply chain in emerging economies. *JOURNAL OF ENGINEERING DESIGN AND TECHNOLOGY*, *22*(3), 926–968. https://doi.org/10.1108/JEDT-12-2021-0739

Khodakarami, M., Shabani, A., Farzipoor Saen, R., & Azadi, M. (2015). Developing distinctive two-stage data envelopment analysis models: An application in evaluating the sustainability of supply chain management. *Measurement*, *70*, 62–74. https://doi.org/10.1016/j.measurement.2015.03.024

Lee, C. H., Rhee, B.-D., & Cheng, T. C. E. (2013). Quality uncertainty and quality-compensation contract for supply chain coordination. *European Journal of Operational Research*, *228*(3), 582–591. https://doi.org/10.1016/j.ejor.2013.02.027

MacCarthy, B. L., Blome, C., Olhager, J., Srai, J. S., & Zhao, X. (2016). Supply chain evolution – theory, concepts and science. *International Journal of Operations & Production Management*, *36*(12), 1696–1718. https://doi.org/10.1108/IJOPM-02-2016-0080

Moktadir, Md. A., Dwivedi, A., Khan, N. S., Paul, S. K., Khan, S. A., Ahmed, S., & Sultana, R. (2021). Analysis of risk factors in sustainable supply chain management in an emerging economy of leather industry. *Journal of Cleaner Production*, *283*, 124641. https://doi.org/10.1016/j.jclepro.2020.124641

Morais, D. O. C., & Silvestre, B. S. (2018). Advancing social sustainability in supply chain management: Lessons from multiple case studies in an emerging economy. *Journal of Cleaner Production*, *199*, 222–235. https://doi.org/10.1016/j.jclepro.2018.07.097

Narimissa, O., Kangarani-Farahani, A., & Molla-Alizadeh-Zavardehi, S. (2020). Drivers and barriers for implementation and improvement of Sustainable Supply Chain Management. *Sustainable Development*, *28*(1), 247–258. https://doi.org/10.1002/sd.1998

Pagell, M., & Shevchenko, A. (2014). Why Research in Sustainable Supply Chain Management Should Have no Future. *Journal of Supply Chain Management*, *50*(1), 44–55. https://doi.org/10.1111/jscm.12037

Pereira, M. M. O., Hendry, L. C., Silva, M. E., Bossle, M. B., & Antonialli, L. M. (2023). Sustainable supply chain management in a global context: The perspective of emerging economy suppliers. *RAUSP Management Journal*, *58*(3), 197–218. https://doi.org/10.1108/RAUSP-05-2022-0141

Roy, V., Silvestre, B. S., & Singh, S. (2020). Reactive and proactive pathways to sustainable apparel supply chains: Manufacturer's perspective on stakeholder salience and organizational learning toward responsible management. *International Journal of Production Economics*, *227*, 107672. https://doi.org/10.1016/j.ijpe.2020.107672

Seuring, S., Aman, S., Hettiarachchi, B. D., de Lima, F. A., Schilling, L., & Sudusinghe, J. I. (2022). Reflecting on theory development in sustainable supply chain management. *Cleaner Logistics and Supply Chain*, *3*, 100016. https://doi.org/10.1016/j.clscn.2021.100016

Seuring, S., & Müller, M. (2008). Core issues in sustainable supply chain management – a Delphi study. *Business Strategy and the Environment*, *17*(8), 455–466. https://doi.org/10.1002/bse.607

Sharma, M., Kamble, S., Mani, V., Sehrawat, R., Belhadi, A., & Sharma, V. (2021). Industry 4.0 adoption for sustainability in multi-tier manufacturing supply chain in emerging economies. *Journal of Cleaner Production*, *281*, 125013. https://doi.org/10.1016/j.jclepro.2020.125013

Silvestre, B. S., Monteiro, M. S., Viana, F. L. E., & de Sousa-Filho, J. M. (2018). Challenges for sustainable supply chain management: When stakeholder collaboration becomes conducive to corruption. *Journal of Cleaner Production*, *194*, 766–776. https://doi.org/10.1016/j.jclepro.2018.05.127

Singh, S., & Srivastava, S. K. (2022). Decision support framework for integrating triple bottom line (TBL) sustainability in agriculture supply chain. *Sustainability Accounting, Management and Policy Journal*, *13*(2), 387–413. https://doi.org/10.1108/SAMPJ-07-2021-0264

Wang, Y., Wallace, S. W., Shen, B., & Choi, T.-M. (2015). Service supply chain management: A review of operational models. *European Journal of Operational Research*, *247*(3), 685–698. https://doi.org/10.1016/j.ejor.2015.05.053

Zhu, C., Du, J., Shahzad, F., & Wattoo, M. U. (2022). Environment Sustainability Is a Corporate Social Responsibility: Measuring the Nexus between Sustainable Supply Chain Management, Big Data Analytics Capabilities, and Organizational Performance. *Sustainability*, *14*(6), Article 6. https://doi.org/10.3390/su14063379

The Digital Transformation of Higher Education: The Role of Artificial Intelligence and Chatbots

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Abstract: *The development of new digital resources and tools in education has catalyzed its transformation, aiming to achieve better outcomes for students and foster more fulfilling relationships in the educational process. Smart technologies have been, and continue to be, pivotal in the global transformation of the educational space. This paper examines the main trends related to the digital transformation of higher education, with a focus on the burgeoning role of artificial intelligence (AI) and its most popular application—chatbots. Based on a survey of students, this study explores new possibilities for knowledge acquisition and the further digitization of higher education. The increasing use of chatbots holds significant potential for enhancing university-level economics teaching. Despite certain risks associated with this technology, it is clear that chatbots can significantly contribute to the digitalization efforts within universities and make an additional impact on the sustainability of educational progress and development.*

1. INTRODUCTION

The rapid development of digital resources and tools in education has and will continue to change the landscape of higher education. Resources such as e-books, e-textbooks, online courses and massive online courses (MOOCs), educational websites and portals, as well as digital libraries and databases are part of modern education and tools that are used ubiquitously in the education and higher education system. Although somewhat slower than in business, digital tools are making their mark in schools and universities. These include learning management systems (LMS), interactive whiteboards, virtual classrooms, educational applications (Photomath, Duolingo, etc.) assessment tools (such as Kahoot, Socrative, etc.). Along with these systems and resources, in the last few years more and more smart technologies and the ones with Artificial Intelligence (AI) are rapidly entering both life and education. They are inevitably being integrated into educational structures and approaches, thereby accelerating the digital transformation in education. These transformations are fundamentally aimed at enhancing the effectiveness of student learning, as well as improving and facilitating access to learning materials. Expectations from new technologies are to strengthen student learning outcomes. The effects are widespread - teaching methods and learning approaches are changing, infrastructure is changing and so is the technological environment, new skills are being developed, research approaches are being developed and innovation is taking place. These transformations lead to a complex change and enrichment of the educational world, and its experience, and new directions for development are created - summarized it is a serious and complex digital transformation process (Alenezi, 2021; Teixeira et al., 2021). This paper examines some of the latest trends in digital transformation, namely the application of AI in higher education, with a special focus on chatbots.

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2. OBJECTIVES AND DIRECTIONS IN THE DIGITAL TRANSFORMATION IN EDUCATION

The digital transformation in education aims at major changes in the learning process through new digital technologies. Among the most important goals are: improving the learning experience and academic performance of learners; personalizing the learning process and education, improving teaching processes with improved efficiency, creating a more engaged and effective learning landscape, increasing the level of accessibility and equity, modernizing education in line with the realities and demands of the modern world, and creating more fulfilling learning experiences for learners (Acevedo, 2021; Bsecrets, n.d.; McCarthy et al., 2023; OECD, 2019, 2023; Pane et al., 2015; Tamim et al., 2011; UNESCO Institute for Statistics, 2018). In general, we can distinguish 5 major objectives:

1. **Enhance the learning experience and learning outcomes**. The use of digital tools and resources has the potential to greatly aid the educational experience and improve understanding and more effective retention of material. This inevitably leads to better academic outcomes (UNESCO, n.d.; UNESCO, 2020).

2. **Personalized learning and education**. New digital technologies, which include self-tuning programs and those that can provide feedback depending on the progress or lack thereof of the learners (most often artificial intelligence tools) have the potential to adapt the educational content to the individual needs of each learner, to the respective learning style of the material, and also to the optimal pace of learning the curriculum. This creates real opportunities for effective personalized learning. To this goal can be added the improvement of teaching processes with improved efficiency as a consequence of the personalization of learning and the creation of a more engaged and effective learning side. Overall, digital tools provide more interactive and engaging learning, which in many cases leads to more active participation from learners.

3. **Increasing access and equity**. Digital resources make education more accessible and efficient by removing geographical barriers (travel) that in many cases have been difficult to overcome for the vast majority of people who want to get a good, quality education, while also removing the need for learning to take place within precise time frames (as in traditional education), thus enabling learners to follow their flexible learning schedules.

4. **Modernizing education in line with the digital world** and creating more fulfilling learning experiences for learners. This process includes integrating technology, adapting teaching methods and preparing students for the rapidly evolving digital environment. This can also be the use of blended and hybrid learning, which successfully combines online and face-to-face learning and enables the application of best practices from digital and traditional methods of teaching knowledge.

5. **Digital Age competencies and skills**. The use of digital technology enables learners to perceive, learn and build important digital literacy skills to be able to solve both existing traditional problems and new ones that are typical of today's workforce that is in a digital work environment. Some studies indicate that companies and enterprises lack workers with advanced knowledge and skills to use new digital technologies, and education systems need to further update their training programs to be able to respond to the dynamically emerging needs of the labor market (Spada et al., 2022). It is also important to adopt new methods to change student mindsets, increase critical thinking and motivation and align with the real world (Kopackova et al., 2024).

Digital transformation should not be limited to the installation, adoption and use of new programs, tools, and resources, but to a serious, even in some cases - fundamental rethinking of the learning process and its methodology. In some cases, this could involve a new perspective and even approach to creating educational content to improve both learning and teaching outcomes.

Chatbots and Chatbots in Education. Advances in artificial intelligence have led to the development of powerful techniques capable of solving problems ranging from gaming to medical diagnostics. Today, artificial intelligence is deeply embedded in our everyday lives, both visible and invisible. Technologies like fingerprint and facial recognition in smartphones, voice assistants like Siri and Alexa, personalized movie and shopping recommendations, and social media algorithms are all powered by AI. In recent years, the use of chatbots (abbreviation of the words **chat** and ro**bot**) - tools built and working on the basis of AI and in particular Generative AI - has become extremely popular. Chatbots have been around since 1966 when ELIZA (Ireland, 2012) was created, but since 2016 and especially since 2022, sophisticated chatbots using advanced machine learning techniques including deep learning and natural language processing have rapidly developed. These chatbots have vastly improved communication skills and provide answers to users that in their vast majority seem to be by humans with serious levels of knowledge. It is for these reasons that the ChatGPT chatbot (an OpenAI product) reached 100 million active users just two months after being released for mass use (November 2022)! Such unprecedented rapid growth was identified in a UBS study as the fastest-growing consumer app to date. The data is taken from Similarweb and shows an average of 13 million unique visitors per day in January 2023 (Gadgets 360., 2023). Today, we know that chatbots mimic conversations with a human in natural language, provide answers to questions or perform "tasks". They can be used to retrieve information, schedule meetings, create content and get answers to questions in all sorts of areas, including financial services, customer service and marketing, planning trips, booking flights, hotels or car rentals, providing information on travel destinations and real-time updates on travel-related issues, automating the process of gathering user feedback, conducting surveys and collecting opinions on products or services, for entertainment, storytelling, etc. In recent years, chatbots have also entered the field of education. They are proving to be a serious help in the learning process for both students and their teachers. Along with this, chatbots have improved communications used for administrative tasks. Apart from the popular general-purpose chatbots such as ChatGPT, Gemini, Copilot, Claude, You.com, today we are seeing the use of many chatbots that have been created for use in the field of education.

Math chatbots can provide step-by-step explanations, practice problems, and instant feedback to help students master math concepts (ALEKS, n.d.; Mathway, n.d.; Thinkster Math, n.d.). Developing artificial intelligence is becoming a major focus for universities around the world. Many prestigious institutions such as Georgia Tech, Stanford, MIT, Oxford University and many others are actively pursuing AI-related projects, not only as research topics but also as initiatives to help make learning more efficient and easy (Georgia Institute of Technology, 2023; MIT Media Lab, n.d.; Stanford Artificial Intelligence Laboratory, n.d.; University of Oxford, 2024). Additionally, technology solutions like conversational AI tools are being deployed across so many platforms on the internet, whether it's social media or business websites and apps. Tech-literate students, parents, and teachers experience the privilege of interacting with chatbots, and institutions in turn see happy students and staff.

AI chatbots can significantly contribute to the sustainability of higher education by enhancing operational efficiency, reducing costs, and promoting environmentally conscious practices. Key areas include automating administrative tasks, creating digital learning resources, optimizing energy and resource consumption through smart campus technologies, and personalizing learning experiences to reduce dropout rates and the need for physical infrastructure. This can lead to significant financial savings for universities, enabling them to operate more sustainably. Furthermore, AI chatbots can support at-risk students, and facilitate global collaboration and knowledge sharing among students and institutions (Dempere et al., 2023).

Although chatbots have been around for a relatively short time, there are already many studies that raise questions about how they or similar tools can be used in education, including higher education (Baidoo-Anu & Owusu Ansah, 2023; Fitzpatrick et al., 2023; Ilieva et al., 2023; Labadze et al., 2023; Lo, 2023; Michel-Villarreal et al., 2023). The most frequently discussed topics are whether it is acceptable to use these tools during work (and even exams) or not, what are the best and correct ways to use them, should students and teachers develop skills to use them, what are the benefits and harms of them, etc. From these and similar perspectives, we conducted a survey at the UNWE to see what the current state of thinking of students at that university is on these issues.

3. METHODS AND DATA

This study aims to uncover the potential of chatbots in education, focusing on their applications and benefits, as well as identifying the associated challenges and issues. This understanding will contribute to better regulation of these tools, ultimately leading to more effective digitalization of the learning process.

The main research hypothesis is that in the last two years, a large proportion of students have had a small but some experience with using chatbots for a variety of purposes. At the same time, a number of them are using it for their university studies, and the use has rather been sporadic for solving a specific task and there is no regulated technology for incorporating chatbots into the learning process.

In order to accomplish the aim of the study, an author's instrument (questionnaire) was developed and disseminated via email to 200 undergraduate and graduate students at the UNWE in May 2024. 106 responses were received. Although the sample is with 53% response rate and is not completely balanced by key characteristics, the results have the potential to highlight an under-studied issue and reveal the main, attitudes of students at UNWE towards the use of chatbots in their studies. The distribution of students by key characteristics is presented in Table 1. The results reveal interesting trends among students regarding their general use of chatbots, their application in education, and the challenges associated with them, and their perspectives on the potential opportunities they offer in their studies.

Table 1. Distribution of the Respondents in the Sample by Variables of Interest

Variables of Interest	Share %
Gender	
Female	60.0
Male	39.0
Age	
up to 22	76.2
23 and more	21.9
Specialty	
Business Informatics or Data Analytics	40.0
Economics, Business and Management	60.0
Level and Year of Study	
Bachelors first and second year	57.1
Bachelors third and fourth year	31.4
Master	11.4

Source: Own calculations

Non-parametric hypothesis testing methods - Chi-Square Test, Independent-Samples Mann-Whitney U Test and Independent-Samples Kruskal-Wallis Test - were used to explore the presence of statistically significant relationships between variables and the presence of statistically significant differences between relative proportions in subgroups formed by the categories of variables of interest.

4. RESULTS

According to respondents' answers to the question "Since when do you know about the possibility of using chatbots for any reason?" the largest share (about 40%) is "From about one year". Approximately one in five indicated that they had known about this possibility "For about two years" and another 20% indicated "Since a few months". Around 14% have known about the possibility of using chatbots for more than two years and just under 7% have not heard of this possibility. Meanwhile, 72% use chatbots for any purpose and 28% do not (Table 2). Differences in usage by categories of variables of interest stand out, with a higher proportion of men and students under 23 using chatbots. As expected, the proportion of student users from "Business Informatics or Data Analytics" majors is higher compared to those from "Economics, Business and Management" majors. By testing hypotheses for a relationship between the listed characteristics and chatbot usage Chi-Square Test results confirm a statistically significant relationship between Specialty and Chatbot usage (p=0.003).

Of those using chatbots, 70% indicated that they use them to find information related to their studies. Between 30 and 45% indicated using chatbots for problem-solving, finding information related to their hobbies and entertainment, finding information related to daily activities, translating texts, writing homework, finding information related to their job and getting help with their job duties.

Table 2. Usage of Chatbots for any Purposes - Total and by Subgroups

Variables of Interest	Users	Non-users
Gender		
Female	68.3%	31.7%
Male	78.0%	22.0%
Age		
up to 22	73.8%	26.3%
23 and more	65.2%	34.8%
Specialty		
Business Informatics or Data Analytics	88.1%	11.9%
Economics, Business and Management	61.9%	38.1%
Level and Year of Study		
Bachelors first and second year	65.0%	35.0%
Bachelors third and fourth year	84.8%	15.2%
Master	75.0%	25.0%
Total sample	72.4%	27.6%

Source: Own calculations

Chatbot users were asked if they use this tool for their studies. Interestingly, just over ¼ declared that they use chatbots frequently for their learning purposes, while over half use them rarely (55%) and 17% do not use them. This fact may suggest that there is a need for a broad discussion about the possibilities of chatbots for the educational process at the UNWE, as well as the definition of rules

and procedures for their use in specific activities within the training. Moreover, of the 76 students who used chatbots at all, only 18 indicated that lecturers/professors had recommended them to use chatbots concerning their studies. Chi-Square Test results confirm a statistically significant relationship between the frequency of usage and Gender ($p < 0.001$), Specialty ($p < 0.001$), and Level and Year of Study ($p < 0.001$). The trends observed in line with the general usage of chatbots.

Figure 1 presents the specific training-related activities for which respondents indicated they use chatbots. The most common use is for obtaining additional information related to their study material. Students also use chatbots extensively for writing homework, preparing for exams, and developing course assignments or projects. About one in three students indicate that they use chatbots to solve assignments during class, suggesting that in some form or other lecturers have started to encourage students to use this tool in class. Interestingly, less than 10% indicated that they use chatbots during exams, suggesting that such use is not yet popular and is not regulated for assessing student knowledge.

Sixty-three students responded to the question of how satisfied they were with using chatbots for their learning purposes. More than half (36 students) stated "Partly help to complete the tasks", 14 answered "Yes, it helped me a lot to complete the tasks" and 13 - "It helped me very little to complete the tasks". The variety in responses is likely due to the different skills of the students in using chatbots as well as the variety in the tasks they used them for. Of those using chatbots in their studies, 21 students indicated that they had also experienced problems. Twenty students experienced inaccurate answers, 13 –could not find the information they were looking for and the same number had the wrong answer to the problem. In addition, among the problems mentioned were "Could not solve the problem" (9 answers), "Communication was difficult and could not understand what I wanted" (6 answers) and "Lack of security" (6 answers). These problems also outline potential challenges that will seek solutions as chatbots become more prevalent in the learning process - how to find the right information and check for its correctness, how to ask clear, precise and unambiguous questions so that we get unambiguous answers, and how to be sure of the accuracy of the information received.
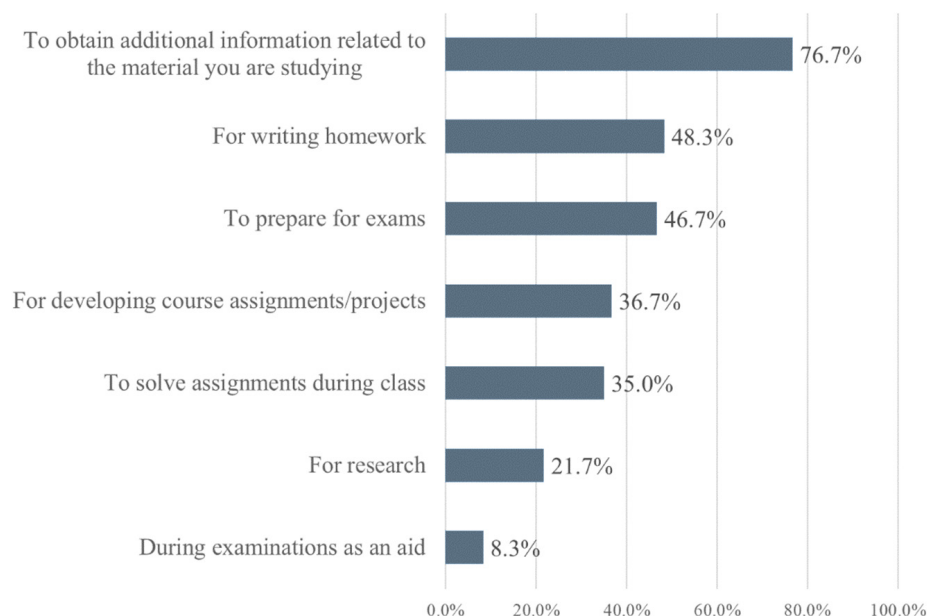

Figure 1. Chatbots Usage in Training-Related Activities for University Studies
Source: Own calculations

All survey participants were asked, "Would you like to have specialized training on working with chatbots in connection with your studies at the university?" (Table 3). About ¼ of the respondents claimed that they did not need such training. Interestingly, students who do not use chatbots in their studies are more likely to declare a lack of need for training (38%). At the same time, only 14% of those who frequently use chatbots in their training do not need specialized training and about 50% of them think it would be very useful. This leads to the conclusion that those who already have experience realize the need for targeted instruction and comprehensive training on the use of chatbots in training.

Table 3. Interest in Specialized Chatbots Training Related to University Studies: Usefulness and Learning Potential vs. Current Usage in University Studies

Do you use chatbots in your studies at UNWE	Would you like to have specialised training on working with chatbots in connection with your studies at the university?		
	Yes, it would be very useful	**Rather yes, I can learn something new**	**No, I don't see what more I can learn**
Yes, often	47.6%	38.1%	14.3%
Yes, rarely	30.0%	45.0%	25.0%
No, I do not use	15.4%	46.2%	38.5%
Total sample	32.4%	43.2%	24.3%

Source: Own calculations

To the question "Would you like to have a regulated possibility to use chatbots in your studies at the university" only six participants answered negatively. Table 4 presents the relative proportions of respondents (overall and by subgroup) who responded positively to the need for regulated use of chatbots for study activities. The highest proportion of those who wanted a regulated opportunity to use chatbots during class (53%) and the lowest proportion of those who indicated during exams (20%). The latter result may be due to students associating exams mainly with the reproduction of material rather than creative tasks. Another reason for this low proportion could be the lack of confidence in the facts and information received.

Table 4. Proportion of Respondents Supporting Regulated Use of Chatbots for Various Study Purposes by Subgroup

Variables of Interest	For homework help	For help with coursework/ projects	During class to solve assignments, case studies, etc.	During exams
Gender				
Female	34.9%*	36.5%*	50.8%	20.6%
Male	53.7%*	53.7%*	56.1%	19.5%
Age				
up to 22	45.0%	42.5%	52.5%	23.8%
23 and more	30.4%	43.5%	52.2%	8.7%
Specialty				
Business Informatics or Data Analytics	50.0%	57.1%**	54.8%	16.7%
Economics, Business and Management	36.5%	33.3%**	50.8%	22.2%
Level and Year of Study				
Bachelors first and second year	36.7%*	35.0%	50.0%	23.3%
Bachelors third and forth year	57.6%*	57.6%	63.6%	18.2%
Master	25%*	41.7%	33.3%	8.3%
Total sample	41.9%	43.3%	52.9%	20.2%

* $p<0.10$, ** $p<0.05$

Source: Own calculations

The Independent-Samples Mann-Whitney U Test and Independent-Samples Kruskal-Wallis Test were used to test hypotheses about differences in proportions of positive responses by subgroups. Men indicated "For help with coursework/projects" and "For homework help" at significantly higher rates. The proportion of students in "Business Informatics or Data Analytics" who wanted to regulate use of chatbots in coursework/projects was significantly higher than that of students in "Economics, Business and Management". This may be due to both the greater experience of using chatbots and the greater number of coursework/projects they prepare during their studies. Undergraduates, especially those in their third and fourth years, are more likely to want regulated use of chatbots for homework. This is probably also related to the larger number of homework assigned in this period of study.

5. CONCLUSION

As a relatively new technology, chatbots are still an important topic for consideration in their use in Higher education. In line with this, we surveyed students at UNWE. There is a need for a broader discussion on the potential educational applications of chatbots and the establishment of guidelines for their use in specific training activities. The fact that only about 1/4th of students declared that they use chatbots frequently for their learning purposes may suggest that there is a need to look closely at the possibilities of chatbots for the purposes of the educational process. There is also a need for the definition of rules and procedures for chatbot use in specific activities within the training. Another interesting fact is the low percentage of lecturers/professors who have recommended the use of chatbots by students concerning their studies. This can be considered as an indicator that educators must also be educated in the use of chatbots and how and when they can help (or not) students.

Universities can use chatbots to personalize the educational process by recommending appropriate courses, learning materials, and extracurricular activities based on individual preferences and achievements. This technology can be used to collect feedback, and assessing the quality of teaching, course content, and overall satisfaction of both students and faculty. The implementation and integration of AI chatbots will boost the efficiency of delivering learning material and enhance the overall educational experience by making it more personalized, accessible, and interactive. This points to the sustainability of the process and is supported by other research as well (Mekić et al., 2024).

Chatbots are not yet able to replace lecturers in higher education institutions. However, they offer many advantages and opportunities to improve and enhance the learning process, the student experience and their attitude. The implementation of chatbots in higher education has the potential to foster the development of more sustainable knowledge, aligning educational outcomes with the ever-evolving demands of the job market and present and emerging industry trends.

Acknowledgment

References

Acevedo, A. L. (2021). Gaming in Education. *Advances in Educational Technologies and Instructional Design*, 85-101. https://doi.org/10.4018/978-1-7998-6480-6.ch006

ALEKS. (n.d.). Adaptive Learning & Assessment for Math, Chemistry, Statistics & More. McGraw Hill ALEKS. Retrieved January 31, 2024, from https://www.aleks.com

Alenezi, M. (2021). Deep Dive into Digital Transformation in Higher Education Institutions. *Education Sciences, 11*(12), 770. https://doi.org/10.3390/educsci11120770

Baidoo-Anu, D., & Owusu Ansah, L. (2023). Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4337484

Bsecrets. (n.d.). Objectives of digital transformation in education. Bsecrets. https://bsecrets.sa/en/blogs/objectives-of-digital-transformation-in-education

Dempere, J., Modugu, K., Hesham, A., & Ramasamy, L. K. (2023). The impact of ChatGPT on higher education. *Frontiers in Education, 8*. https://doi.org/10.3389/feduc.2023.1206936

Fitzpatrick, D., Fox, A., & Weinstein, B. (2023). The AI classroom: The ultimate guide to artificial intelligence in education. TeacherGoals Publishing.

Gadgets 360. (2023, February 2). ChatGPT to become fastest-growing app, estimated to have gained 100 million monthly active users in January: Study. Gadgets 360. https://www.gadgets360.com/internet/news/chatgpt-openai-fastest-growing-app-estimated-gain-100-million-monthly-users-january-ubs-study-3748007

Georgia Institute of Technology. (2023, June 6). AI Hub at Georgia Tech to unite campus artificial intelligence R&D and commercialization. Georgia Tech News Center. https://news.gatech.edu/news/2023/06/06/ai-hub-georgia-tech-unite-campus-artificial-intelligence-rd-and-commercialization

Ilieva, G., Yankova, T., Klisarova-Belcheva, S., Dimitrov, A., Bratkov, M., & Angelov, D. (2023). Effects of Generative Chatbots in Higher Education. *Information, 14*(9), 492. https://doi.org/10.3390/info14090492

Ireland, C. (2012, September 13). Alan Turing at 100. Harvard Gazette. https://news.harvard.edu/gazette/story/2012/09/alan-turing-at-100/

Kopackova, H., Simonova, S., & Reimannova, I. (2024). Digital transformation leaders wanted: How to prepare students for the ever-changing demands of the labor market. The International *Journal of Management Education, 22*(1), 100943. https://doi.org/10.1016/j.ijme.2024.100943

Labadze, L., Grigolia, M., & Machaidze, L. (2023). Role of AI chatbots in education: systematic literature review. *International Journal of Educational Technology in Higher Education, 20*(1). https://doi.org/10.1186/s41239-023-00426-1

Lo, C. K. (2023). What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature. *Education Sciences, 13*(4), 410. https://doi.org/10.3390/educsci13040410

Mathway. (n.d.). Algebra. Mathway. https://www.mathway.com/Algebra

McCarthy, A. M., Maor, D., McConney, A., & Cavanaugh, C. (2023). Digital transformation in education: Critical components for leaders of system change. *Social Sciences & Humanities Open, 8*(1), 100479. https://doi.org/10.1016/j.ssaho.2023.100479

Mekić, E. S., Jovanović, M. N., Kuk, K. V., Prlinčević, B. P., & Savić, A. M. (2024). Enhancing educational efficiency: Generative AI chatbots and DevOps in Education 4.0. *Computer Applications in Engineering Education, 32*(6). https://doi.org/10.1002/cae.22804

Michel-Villarreal, R., Vilalta-Perdomo, E., Salinas-Navarro, D. E., Thierry-Aguilera, R., & Gerardou, F. S. (2023). Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT. *Education Sciences, 13*(9), 856. https://doi.org/10.3390/educsci13090856

MIT Media Lab. (n.d.). Projects. MIT Media Lab. Retrieved July 3, 2024, from https://www.media. mit.edu/groups/media-lab-research-theme-life-with-ai/projects/

OECD. (2019). Measuring the Digital Transformation: A Roadmap for the Future. Organisation for Economic Co-operation and Development. https://www.oecd-ilibrary.org/science-and-technology/ measuring-the-digital-transformation_9789264311992-en

OECD. (2023). OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem. OECD. https://doi.org/10.1787/c74f03de-en

Pane, J., Steiner, E., Baird, M., & Hamilton, L. (2015). Continued Progress: Promising Evidence on Personalized Learning. https://doi.org/10.7249/rr1365

Spada, I., Chiarello, F., Barandoni, S., Ruggi, G., Martini, A., & Fantoni, G. (2022). Are universities ready to deliver digital skills and competences? A text mining-based case study of marketing courses in Italy. *Technological Forecasting and Social Change, 182*, 121869. https://doi. org/10.1016/j.techfore.2022.121869

Stanford Artificial Intelligence Laboratory. (n.d.). Stanford AI Lab. Stanford University. https:// ai.stanford.edu/

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What Forty Years of Research Says About the Impact of Technology on Learning: A Second-Order Meta-Analysis and Validation Study. *Review of Educational Research, 81*(1), 4-28. https:// doi.org/10.3102/0034654310393361

Teixeira, A. F., Gonçalves, M. J. A., & Taylor, M. de L. M. (2021). How Higher Education Institutions Are Driving to Digital Transformation: A Case Study. *Education Sciences, 11*(10), 636. https://doi.org/10.3390/educsci11100636

Thinkster Math. (n.d.). Thinkster Math: Online math tutoring with guaranteed results. Thinkster Math. https://hellothinkster.com/

UNESCO. (n.d.). Higher education. UNESCO. https://www.unesco.org/en/higher-education

UNESCO. (2020, March 4). Education: From disruption to recovery. UNESCO. https://en.unesco. org/covid19/educationresponse

UNESCO Institute for Statistics. (2018). Handbook on Measuring Equity in Education. https://uis. unesco.org/sites/default/files/documents/handbook-measuring-equity-education-2018-en.pdf

University of Oxford. (2024). Artificial Intelligence and Machine Learning. https://www.cs.ox. ac.uk/research/ai_ml/index.html

The Validation of Sustainable Clothing Measurement Scale in Romania

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Abstract: *This study endeavors to provide empirical support for the validity and reliability of the Sustainable Clothing Measurement Scale (SCMS). The scale, which comprises general sustainability and sustainable clothing, encompasses two sub-domains within the sustainable clothing domain, namely knowledge and attitudes towards sustainability and sustainable clothing consumption. The study engaged a sample of 1,250 Romanian participants. To assess reliability, Cronbach's alpha coefficients were computed for the thirteen-item scale, the general sustainability and sustainable clothing domains, and their respective subdomains. Furthermore, to investigate construct validity, both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were employed, utilizing commonly applied indices such as the Chi-square, comparative fit index (CFI), Tucker-Lewis Index (TLI), root mean square error of approximation (RMSEA), and other well-known indicators. Findings exhibit strong reliability and validity of the scale, with high internal consistency and significant correlations between the identified dimensions. This research offers a tool for assessing sustainability and sustainable clothing knowledge and attitudes, in the context of consumer behavior studies, and industry practices.*

1. INTRODUCTION

The concept of sustainability has emerged as a significant concern on a global scale in the last two decades. An official definition was given in 1987 when the Brundtland Report "Our Common Future"(World Commission on Environment and Development, 1987) brought to life the concept of sustainability, also referred to as sustainable development, through the following statement "Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". Many scholars have criticized the Brundtland Report for its vague conceptualization of sustainability and extensive research has been conducted on diverse approaches to understand and predict this broad field (Balderjahn et al., 2013; Costanza & Patten, 1995).

Numerous efforts have been made to establish a more specific interpretation of sustainability within the business context and amidst this extensive field of investigation, there has been a growing emphasis on sustainable consumption, embracing practices like green consumption (Peattie, 2010), political consumption (Halkier, 2004), and ethical consumption (Devinney et al., 2010; Newholm & Shaw, 2007). Nevertheless, these approaches frequently concentrate on specific facets or determinants of sustainable behavior, resulting in deficiencies in comprehending the broader scope of sustainable consumption (Balderjahn et al., 2013).

Several measurement instruments have been devised to assess the various dimensions of sustainability (Balderjahn et al., 2013; Gilg et al., 2005; Iwata, 2006; Pepper et al., 2009). Many initiatives have led to the designing of scales that measure sustainable consumption behavior (Fischer et al.,

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2017; Geiger et al., 2018) as well as awareness of the same topic (Balderjahn et al., 2013). There most known measurement tools are: the Sustainable Apparel Consumption Scales which comprise different dimensions of sustainable clothing consumption, such as eco-fashion consumption, post-acquisition consumption, and environmental consciousness (Zhang, 2014), the Sustainable Clothing Consumption Scale focuses on measuring the cognitive, affective, and behavioral dimensions of sustainable clothing consumption (Park & Lee, 2021), and the Sustainable Fashion Awareness Scale that evaluates consumers' awareness and knowledge about sustainable fashion practices and products (Shen et al., 2013).

Although substantial progress has been made, there remains a gap in one's ability to evaluate individuals' comprehension and perspectives on sustainability and sustainable clothing choices. This study intends to address the identified lack of theoretical frameworks that measure both the notion of sustainability as a broad concept and sustainable clothing consumption. To complete this objective, we developed a reliable and valid measurement scale, the Sustainable Clothing Measurement Scale (SCMS), that evaluates respondents' attitudes and knowledge towards sustainability and sustainable clothing consumption. Contrary to other sustainability measures, this proposed scale does not specify particular behaviors or situations. It instead concentrates on individuals' general views of sustainability and perceptions of sustainable clothing consumption. Moreover, this instrument aims to measure respondents' core understanding and attitudes toward sustainability in the fashion industry, avoiding specific topics and focusing only on elements that are beneficial to the measurement tool.

Regarding the Romanian context, there is a significant research gap concerning the existence of a comprehensive assessment instrument designed to evaluate Romanian consumers' knowledge and attitudes towards sustainability and sustainable clothing consumption. Based on prevailing literature on sustainability, sustainable consumption, and measurement tools, the present study proposes to address this void through the development of a scale specific to the Romanian context.

The present tool goes in contrast with prevailing scales that evaluate attitudes towards corporate, governmental, or educational actions (Michalos et al., 2011), while other scenarios concentrate on personal behaviors that are correlated to particular lifestyles (Milfont & Duckitt, 2004), since it outlines participants' personal views on sustainability in the context of fashion, without prescribing a particular path.

The findings of this study contribute to our understanding of sustainability and sustainable clothing consumption and propose practical interventions that could be implemented in Romania to encourage the consumption of sustainable clothes.

This study has the following structure: the following section outlines the research methodology, the key findings are summarized in the third section, the fourth section opens a discussion based on the results while highlighting the key implications, and the conclusion, limitations, and future research directions of the study are presented in the final section.

2. RESEARCH METHODOLOGY

The data collection process occurred in Romania from November to December 2023. An online self-administered questionnaire was shared on several platforms like Facebook, LinkedIn, WhatsApp, and other social media networks where respondents could have accessed the designated form. The

sample consists of responses from 1,250 participants who voluntarily and anonymously engaged in this study's survey. They consented to participate in the study and were informed of its objective. The questionnaire employed a combination of convenience sampling (Baltar & Brunet, 2012) and snowball sampling methods (Browne, 2005; Heckathorn, 2011).

2.1. Data Collection Tool

For this study on sustainable clothing consumption, we first conducted a thorough review of relevant literature on the concept of sustainability, sustainable clothing, and the development of measurement scales for sustainable clothing consumption. Based on these findings, we created a thirteen-item scale to measure respondents' understanding of sustainability from a general perspective, and sustainable clothing specifically. The Sustainable Clothing Measurement Scale (SCMS) assesses dimensions such as the definition of sustainability, attitudes towards sustainability in the context of clothing, and knowledge about sustainable clothing practices.

Table 1. Sustainable Clothing Measurement Scale Constructs

Dimension	Items	Abbreviation
Sustainable Clothing Measurement Scale	Sustainability means carrying out activities in a qualitative way that doesn't damage the environment or deplete resources	SCMS1
	Sustainability means finding a balance between economic growth and environmental protection.	SCMS2
	Sustainability means finding alternative resources while still being able to provide for future generations.	SCMS3
	The principles of sustainability are reduction, reusing, and recycling.	SCMS4
	A sustainable attitude means taking into account the need to preserve the planet for present and future generations, while also considering economic, environmental, and social factors.	SCMS5
	Sustainable fashion means not changing our clothes based on the ongoing trend, but adapting fashion to protect the ecological footprint.	SCMS6
	Sustainable clothing uses fabrics derived from environmentally friendly resources, like sustainably grown fiber crops, or recycled materials.	SCMS7
	Sustainable clothing is special since it is processed in a way that is less harmful to the environment.	SCMS8
	Sustainable clothing reduces the harmful effects of agrochemicals on the environment.	SCMS9
	Using sustainable clothes can help reduce the amount of clothing discarded in landfills.	SCMS10
	Having a sustainable attitude towards clothing often includes buying second-hand clothes.	SCMS11
	Having a sustainable attitude towards clothing means donating or recycling clothes so they can be reused or resold.	SCMS12
	Having a sustainable attitude means owning fewer items but ensuring they are of high quality.	SCMS13

Source: Own research

The elements used in this suggested scale seek to capture the essential concepts for understanding sustainability, such as the need for environmental preservation and resource conservation. We included items that reflect the general concept of sustainability, for example, "Sustainability means finding a balance between economic growth and environmental protection". We also incorporated items that addressed attitudes towards sustainability and sustainable clothing, such as the statement "A sustainable attitude means considering the need to protect the planet for current and future generations, while also taking into account economic, environmental, and social factors".

Furthermore, the SCMS aims to measure individuals' familiarity with sustainable clothing by evaluating their understanding of topics such as reducing the environmental impact of agrochemicals and sourcing materials in an environmentally responsible way.

The items of the scale were included as an introductory component in a more complex study that aimed to explore the consumption of sustainable clothes in Romania. Thus, all statements were written in Romanian to guarantee cultural relevance and accessibility for our participants. The main purpose of the measurement tool is to assist in identifying respondents' views and attitudes towards sustainable clothing practices.

All responses were measured on a seven-point Likert scale, where 1 is for complete disagreement and 7 for complete agreement. Table 1, offers a detailed description of the specific wording of the scale items, facilitating transparency and reproducibility in our methodology.

2.2. Research Methods

The statistical procedure was conducted using the R software, version 4.3.0 (R, 2024). We began our analysis by first focusing on the reliability of the measurement scale, as well as the correlation matrix and the adequacy test. Afterward, to identify potential underlying factors within the SCMS dimension, we assessed through an exploratory factor analysis (EFA) the construct validity of the scale. For the present study, we used the 'psych' package in R that provides the functions necessary for performing EFA. Thus, we used the "varimax" rotation and the principal axis as an extraction method. Based on the literature, exploratory factor analysis is a valuable tool for developing a model before validating it with confirmatory factor analysis (Gerbing & Hamilton, 1996). Following the extraction of factors, we conducted a confirmatory factor analysis (CFA) to examine the model's performance (Schreiber et al., 2006). The functions for this procedure can be found in R's 'lavaan' package (R, 2024).

3. RESULTS

Our final sample comprises 1,250 participants (77.2% female), aged 14 to 77, with an average age of 35.73 (median =35, SD = 12.44). The majority of the respondents reported a monthly income exceeding 5,000 RON (35.6%), and 77.4% had completed higher studies. We organized the results section into three subsections: the first one focuses on the reliability and consistency of the instrument, followed by the one detailing the exploratory factor analysis findings, and then the confirmatory factor analysis. We chose this approach for a more comprehensive summary of the data.

3.1. Exploratory Factor Analysis

We initiated the analysis by checking the reliability and homogeneity of our instrument. The tools we used are the Cronbach's Alpha reliability index, the Kaiser-Meyer-Olkin (KMO) coefficient, and the Bartlett test for controlling if the data is appropriate for further analysis. A KMO coefficient exceeding the threshold of 0.60, combined with a significant Bartlett's test result, suggests that data is suitable for factor analysis (Çelikler & Aksan, 2016). Moreover, Cronbach's alpha showed satisfactory results, exceeding the 0.7 threshold (Cortina, 1993).

The Bartlett's test, which evaluated the data stability for factor analysis on our thirteen-item scale, the significant statistic chi-square, the KMO coefficient, and Cronbach's alpha, provide sufficient evidence to support the data's suitability for factor analysis. The findings are summarized in Table 2.

Table 2. The results of the reliability and homogeneity tests

Measurement index	Value	
Cronbach's alpha	0.88	
KMO measure of sample adequacy	0.93	
Bralette's test approximate Chi-square value	1099.1	Df = 12, p-value <2.2e-16

Source: Own research (Software: R)

After conducting the exploratory factor analysis (EFA), three factors were extracted with a cut-off point of 0.4. The cumulative variance registered by them was 51%, and for each factor, the variance calculated was 21%, 17%, and 13%. The EFA standard methodology states that item factor loading should be 0.30 or greater. Meanwhile, studies on scale development and adaptation suggest a threshold of 0.30 for acceptable item factor loadings in this field of interest. Our estimations concluded that all thirteen items met the required limit. Thus, the primary criterion for assessing factor analysis results is factor loading, which in essence is represented through the correlation between variables and factors (Çelikler & Aksan, 2016).

Table 3. Sustainable Clothing Measurement Scale Constructs

Dimension	Items	Factor 1 0.21	Factor 2 0.17	Factor 3 0.13
General Sustainability 0.85	SCMS1: Sustainability means carrying out activities in a qualitative way that doesn't damage the environment or deplete resources	0.65		
	SCMS2: Sustainability means finding a balance between economic growth and environmental protection.	0.64		
	SCMS3: Sustainability means finding alternative resources while still being able to provide for future generations.	0.66		
	SCMS4: The principles of sustainability are reduction, reusing, and recycling.	0.63		
	SCMS5: A sustainable attitude means taking into account the need to preserve the planet for present and future generations, while also considering economic, environmental, and social factors.	0.64		
Sustainable clothing 0.84	SCMS6: Sustainable fashion means not changing our clothes based on the ongoing trend, but adapting fashion to protect the ecological footprint.		0.40	
	SCMS7: Sustainable clothing uses fabrics derived from environmentally friendly resources, like sustainably grown fiber crops, or recycled materials.		0.60	
	SCMS8: Sustainable clothing is special since it is processed in a way that is less harmful to the environment.		0.75	
	SCMS9: Sustainable clothing reduces the harmful effects of agrochemicals on the environment.		0.66	
	SCMS10: Using sustainable clothes can help reduce the amount of clothing discarded in landfills.		0.50	
Sustainable attitude 0.66	SCMS11: Having a sustainable attitude towards clothing often includes buying second-hand clothes.			0.68
	SCMS12: Having a sustainable attitude towards clothing means donating or recycling clothes so they can be reused or resold.			0.63
	SCMS13: Having a sustainable attitude means owning fewer items but ensuring they are of high quality.			0.44

Source: Own research (Software: R)

To distribute the items across three distinct factors, the "varimax" rotation technique was used (R, 2024). Factor loading values ranged from 0.40 to 0.75. An evaluation of the content showed that the items were clustered into good predictors with good internal consistency, which allowed us to name them according to the latent variable they represented. Furthermore, we analyzed Cronbach's Alpha to assess the reliability of each new dimension. The results for the first, second, and third factors were computed as 0.85, 0.84, and 0.66. Thus, the determined values for these factors demonstrated their reliability for further statistical procedures. The identified values for the SCMS items, their latent variable name, and reliability index are found in Table 3.

3.2. Confirmatory Factor Analysis

We continued the statistical procedure with the Confirmatory factor analysis (CFA) to evaluate the structural validity of the model obtained during the EFA stage. In this part of the analysis, we employed as model fit indices the Root Mean Square Error Approximation (RMSEA), the Standardized Root Mean Square Residuals (SRMR), the Comparative Fit Index (CFI), and the Tucker-Lewis Index (TLI). We compared the values of these indices to the guidelines found in the literature. Universally accepted cut-offs are RMSEA below 0.06, SRMR below 0.08, CFI above 0.9, and TLI above 0.9. In our case indices were registered: RMSEA = 0.058, SRMR = 0.038, CFI = 0.961, and TLI = 0.950. Given the satisfactory results, we then investigated a second-order model with a four-factor solution. In this case, we used two different statistical methods to assess the goodness-of-fit indicators. First, we employed the "marker" method within the "lavaan" package (R, 2024) that yielded the following results: RMSEA = 0.059, SRMR = 0.046, CFI = 0.959 and TLI = 0.950. For the second method, we used from the same library, the "var std" procedure to evaluate the discussed model, and in return, we found the following values: RMSEA = 0.058, SRMR = 0.031, CFI = 0.961, and TLI = 0.951. All of the results for the CFA are presented in Table 4.

Table 4. Confirmatory Factor Analysis Goodness of Fit Indices

	RMSEA (*< 0.06)	SRMR (* < 0.08)	CFI (* > 0.9)	TLI (* > 0.9)
Three-factor model	0.058	0.038	0.961	0.950
Second-order model 1	0.059	0.046	0.959	0.950
Second-order model 2	0.058	0.031	0.961	0.951

Source: Own research (Software: R)

The confirmatory factor analysis indicates that the three-factor and four-factor models are well-performing, suggesting they measure the same concept. Moreover, in the cases of the second-order models, both hint at an overarching construct, namely the fundamental concept of sustainability.

4. DISCUSSION AND FUTURE RESEARCH DIRECTIONS

The Sustainable Clothing Measurement Scale (SCMS) is a thirteen-item scale that broadly evaluates various aspects of sustainable clothing consumption. The scale was developed aligned with the core principles of sustainability; thus, it incorporates dimensions such as one's understanding of sustainability, attitudes towards sustainable clothing, and knowledge of sustainable clothing practices.

Both the exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA) supported the SCMS's reliability and validity. The EFA revealed three distinct factors for the scale developed in this study: general sustainability, sustainable clothing, and sustainable attitude. For these

predictors, Cronbach's alpha values exhibited strong internal consistency. Furthermore, the structural validity of the scale was supported by the CFA, since the three-factor and four-factor models showed good fit indices.

During the statistical procedures, a potential overarching latent construct was discovered, namely the fundamental concept of sustainability. Through the scale's holistic perspective on sustainability, we can transcend its specific dimensions and emphasize the complementary nature of economic, environmental, and social predictors in driving sustainable behaviors.

Through this study, we offer significant implications for both academic research and practical efforts to advocate for sustainable clothing consumption practices in Romania. The development of the SCMS adds to the academic literature by providing a new instrument that can measure individuals' understanding and attitudes toward sustainable clothing consumption and enable future empirical investigations in this research area. Moreover, based on this study's findings, several programs and policies could be designed to foster sustainable behavior among Romanian consumers. On this note, the fashion industry is one of the key actors that can significantly benefit from the SCMS findings. Using the scale to identify and understand consumers' perceptions and preferences could be valuable in addressing the group of interest's offerings to meet the needs of sustainable fashion. Also, this tool can provide businesses with helpful insights that can be used to improve their marketing strategies and product offerings to align with their consumers' needs and values. These actions will ultimately benefit the advancement of the sustainable fashion ecosystem.

5. CONCLUSION

This study successfully developed and validated the Sustainable Clothing Measurement Scale (SCMS) to address the identified research gap in measuring consumers' understanding and attitudes toward sustainable clothing consumption, especially in the context of Romania. We created a comprehensive tool specifically designed and tested for Romanian consumers, by integrating the found notions from existing literature with the well-discussed principles of sustainability.

The SCMS is a thirteen-item instrument and serves as a comprehensive tool for evaluating multiple dimensions of sustainable clothing consumption. The newly developed instrument was measured using a seven-point Likert scale. We ensured the scale was culturally appropriate and accessible to our 1,250 Romanian respondents who have evaluated it. All thirteen items were validated with different statistical procedures as EFA and CFA, and took part in the formation of the three predictors: general sustainability, sustainable clothing, and sustainable attitude. The same statistical methods were employed to test the validity and reliability of the instrument, both returning great results that encourage future research in the fields of tool development and sustainable clothing consumption.

As for the limits of this research, one limitation is the potential for different biases that can occur due to using an online survey method and relying on self-reported data. These biases could limit the generalizability of our findings. Another limitation is the demographic characteristic of having a large percentage of female respondents. This specific part of the sample could bias our results in favor of a particular characteristic of understanding sustainability. Future research could overcome this limitation and employ different methods of data collection that would increase the study's generalizability and include a demographically balanced group. Additionally, the design and conceptualization of the scale were based especially on the existing literature and no other

specialized perspective was given on the final version that was used. Thus, there is a high possibility that during their crafting process, the instrument's items may not have fully covered all of the relevant aspects of sustainability and sustainable clothing. Moreover, the statistical procedures that have been employed may have limited the exploration process in identifying the tool's statistical characteristics. Future studies should be carried out to identify and rectify these shortcomings and enhance the scale's effectiveness. Recognizing these limitations serves as a foundation for future research directions aimed at contributing to sustainable clothing consumption.

To conclude, the development and validation of the Sustainable Clothing Measurement Scale seeks to be a pioneering effort in understanding sustainability and sustainable clothing consumption in Romania. Also, we consider this study to be a step towards fostering a more sustainable future for fashion and other industries. The value of the research stands in the importance of the analyzed sector and the novelty it brings in addressing the identified gap within the specialized literature, especially in the Romanian context.

References

Balderjahn, I., Buerke, A., Kirchgeorg, M., Peyer, M., Seegebarth, B., & Wiedmann, K.-P. (2013). Consciousness for sustainable consumption: Scale development and new insights in the economic dimension of consumers' sustainability. *AMS Review*, *3*(4), 181–192. https://doi.org/10.1007/s13162-013-0057-6

Baltar, F., & Brunet, I. (2012). Social research 2.0: Virtual snowball sampling method using Facebook. *Internet Research*, *22*(1), 57–74. https://doi.org/10.1108/10662241211199960

Browne, K. (2005). Snowball sampling: Using social networks to research non-heterosexual women. *International Journal of Social Research Methodology*, *8*(1), 47–60. https://doi.org/10.1080/1364557032000081663

Çelikler, D., & Aksan, Z. (2016). The development of an attitude scale to assess the attitudes of high school students towards renewable energy sources. *Renewable and Sustainable Energy Reviews*, *54*, 1092–1098. https://doi.org/10.1016/j.rser.2015.10.049

Cortina, J. M. (1993). What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, *78*(1), 98–104. https://doi.org/10.1037/0021-9010.78.1.98

Costanza, R., & Patten, B. C. (1995). Defining and predicting sustainability. *Ecological Economics*, *15*(3), 193–196. https://doi.org/10.1016/0921-8009(95)00048-8

Devinney, T. M., Auger, P., & Eckhardt, G. M. (2010). *The Myth of the Ethical Consumer Hardback with DVD*. Cambridge University Press.

Fischer, D., Böhme, T., & Geiger, S. M. (2017). Measuring young consumers' sustainable consumption behavior: Development and validation of the YCSCB scale. *Young Consumers*, *18*(3), 312–326. https://doi.org/10.1108/YC-03-2017-00671

Geiger, S. M., Fischer, D., & Schrader, U. (2018). Measuring What Matters in Sustainable Consumption: An Integrative Framework for the Selection of Relevant Behaviors. *Sustainable Development*, *26*(1), 18–33. https://doi.org/10.1002/sd.1688

Gerbing, D. W., & Hamilton, J. G. (1996). Viability of exploratory factor analysis as a precursor to confirmatory factor analysis. *Structural Equation Modeling: A Multidisciplinary Journal*, *3*(1), 62–72. https://doi.org/10.1080/10705519609540030

Gilg, A., Barr, S., & Ford, N. (2005). Green consumption or sustainable lifestyles? Identifying the sustainable consumer. *Futures*, *37*(6), 481–504. https://doi.org/10.1016/j.futures.2004.10.016

Halkier, B. (2004). Political Virtue and Shopping: Individuals, Consumerism and Collective Action. *Perspectives on Politics*, *2*(3), 575–576. https://doi.org/10.1017/S1537592704310376

Heckathorn, D. D. (2011). SNOWBALL VERSUS RESPONDENT-DRIVEN SAMPLING. *Sociological Methodology*, *41*(1), 355–366. https://doi.org/10.1111/j.1467-9531.2011.01244.x

Iwata, O. (2006). An Evaluation of Consumerism and Lifestyle as Correlates of a Voluntary Simplicity Lifestyle. *Social Behavior and Personality: An International Journal*, *34*, 557–568. https://doi.org/10.2224/sbp.2006.34.5.557

Michalos, A. C., Creech, H., McDonald, C., & Kahlke, P. M. H. (2011). Knowledge, Attitudes and Behaviours. Concerning Education for Sustainable Development: Two Exploratory Studies. *Social Indicators Research*, *100*(3), 391–413. https://doi.org/10.1007/s11205-010-9620-9

Milfont, T. L., & Duckitt, J. (2004). The structure of environmental attitudes: A first- and second-order confirmatory factor analysis. *Journal of Environmental Psychology*, *24*(3), 289–303. https://doi.org/10.1016/j.jenvp.2004.09.001

Newholm, T., & Shaw, D. (2007). Studying the ethical consumer: A review of research. *Journal of Consumer Behaviour*, *6*(5), 253–270. https://doi.org/10.1002/cb.225

Park, S., & Lee, Y. (2021). Scale Development of Sustainable Consumption of Clothing Products. *Sustainability*, *13*(1), Article 1. https://doi.org/10.3390/su13010115

Peattie, K. (2010). Green Consumption: Behavior and Norms. *Annual Review of Environment and Resources*, *35*(1), 195–228. https://doi.org/10.1146/annurev-environ-032609-094328

Pepper, M., Jackson, T., & Uzzell, D. (2009). An examination of the values that motivate socially conscious and frugal consumer behaviors. *International Journal of Consumer Studies*, *33*, 126–136. https://doi.org/10.1111/j.1470-6431.2009.00753.x

R. (2024). *R: The R Project for Statistical Computing*. https://www.r-project.org/

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting Structural Equation Modeling and Confirmatory Factor Analysis Results: A Review. *The Journal of Educational Research*, *99*(6), 323–338. https://doi.org/10.3200/JOER.99.6.323-338

Shen, D., Richards, & Liu, F. (2013). Shen, D., Richards, J., & Liu, F. (2013). Consumers' awareness of sustainable fashion. Marketing Management Journal, *23*(2), 134-147. *Marketing Management Journal*, *23*, 134–147.

World Commission on Environment and Development. (1987). *Our common future*. Oxford University Press.

Zhang, R. (2014). *Sustainable apparel consumption: Scale development and validation*. Oregon State University.

Exploring the Impact of Business Travel on Employee Well-Being: A Focus on Leisure Opportunities

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Abstract: *For the modern business traveler, the idea of working most of the time and not having fun is changing and more emphasis is given to the balance between business and leisure. Companies are recognizing the importance of relaxation during working trips, whereas technology is helping travelers find leisure opportunities easily. The theme in travel and tourism research has been largely focused on leisure tourism, neglecting the changing landscape of business travel. The aim of this research is to explore the relationship between business trips and leisure activities while explaining the role of travel satisfaction on well-being. The term 'bleisure' is frequently used these days to describe professionals traveling domestically and internationally for work while taking time to enjoy leisure activities. Motivated by the desire to maximize travel opportunities and enhance work-life balance, bleisure travelers seamlessly integrate leisure activities into their business trips. The findings of the study highlight that 68% of domestic business travelers on their business trips incorporate some leisure activities, while 83% of international business travelers add leisure activities to their business trips. This hybrid, new form of travel, where travelers integrate work-related activities with leisure pursuits offers the opportunity to achieve higher levels of satisfaction. Travel satisfaction and well-being intertwine as individuals embark on journeys to new destinations, seeking new experiences and a chance for personal growth. This study highlights how integrating leisure activities into business travel aligns with sustainable tourism practices by fostering cultural exchange, boosting local economies, and reducing travel redundancy. By recognizing the value of travel satisfaction and well-being, businesses can enhance employee satisfaction while contributing to sustainable tourism and promoting long-term success and growth.*

1. INTRODUCTION

Business tourism is the type of tourism that is concerned with people whose travelling purposes are related to their work (Davidson, 1994). As such, business tourism represents one of the oldest forms of tourism, where people have travelled to trade goods since ancient times.

International business tourism in particular involves individuals travelling abroad for work-related purposes. As companies increasingly expand across borders to explore new opportunities, international business and tourism are becoming key issues for most of them, where network facilitating, market expansion and fostering collaborations globally are crucial components for achieving long-term success in the global marketplace (Lichy & McLeay, 2018).

Therefore, it is important to distinguish between business travel and business tourism concepts. Business travel focuses particularly on the movement of individuals from place A to place B for work purposes. In that case, they are not true tourists in the conventional meaning of the term,

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while business tourism is the broader term that encompasses all aspects of the experience of the business traveler (Swarbrooke & Horner, 2001).

Business travel, once primarily seen as a tool to meet organizational goals, is now experiencing a significant shift. It is increasingly recognized as an opportunity for travelers to combine work with personal leisure, allowing them to spend part of their trip on business activities and part on recreational pursuits like sightseeing, shopping, or relaxation (Çulfaqı et al., 2024; Leiper et al., 2008). This evolving trend has led to the emergence of "bleisure" travel, where travelers balance business commitments with the exploration of the destination they visit (Bhudke & Athnikar, 2024).

Bleisure travel can be considered as a sustainable activity as well, since bleisure travelers can be transformational knowledge transmitters by sharing their knowledge with others (Hovhannisyan & Keller, 2015). Despite several disadvantages like the absence from home, unstable sleeping and eating habits, and emotional problems from cultural differences (Espino et al., 2002; Unger et al., 2016), bleisure travel offers several advantages such as career promotion, higher cross-cultural understanding, promotes an open-minded approach and enhances professional status (Cohen & Gössling, 2015; Gustafson, 2014).

Despite the growing size of bleiusre travel market, academic research has been largely focused on leisure tourism failing to address the changing nature of business travel (Lichy & McLeay, 2018). With this in mind, this study aims to explore the relationship between travel satisfaction and overall well-being among individuals engaging in bleisure travel and to examine how this relationship impacts their overall life satisfaction.

2. LITERATURE REVIEW

2.1. Business Travel vs. Leisure Travel

The business traveler usually becomes a leisure traveler once the working day is over (Swarbrooke & Horner, 2001). There are several differences between business travel and leisure travel. The main difference is the purpose of the travel. Business travel is a trip related to work (Davidson, 1994), whereas leisure travel is a trip related to pleasure, with the motivation to rest and relax, spend time with friends and family, shopping, attending sports events, visiting historical and cultural sites, sightseeing, etc. (Murphy et al., 2007; Radojevic et al., 2018). Other important differences are travel destination and who pays for the travel. In leisure travel, the tourist is typically responsible for both paying for the trip and choosing the destination. However, in the context of business travel, the employer generally covers the costs, while a third party or event organizers determine the travel destination (Swarbrooke & Horner, 2001). Another important difference, according to Leiper et al. (2008) is the focus of the experience, in which the experiences of business travelers are focused on the agenda of the meetings they have travelled to attend or the business-related phenomena they have travelled to observe or interact with, while the experiences of leisure travelers are tourists' attractions of the city.

Leisure trips take place during holidays or weekends and are planned in advance, while business trips take place all year round and are planned at very short notice. The latter are also known differences (Swarbrooke & Horner, 2001) among leisure travel and business travel. Furthermore, leisure and business guests perceive value for money and service quality differently (Rajaguru & Hassanli, 2018). For leisure travelers value for money is a priority, while business travelers value service quality more, since their company covers their holiday expenses (Batala & Slevitch, 2024).

Several studies have discussed the differences between these two tourism forms, but only a few studies have discussed the mixture of work and travel as a new tourism trend (Lichy & McLeay, 2018; Voll et al., 2023).

2.2. Bleisure Travel Experience

Bleisure travel has gained momentum due to the flexibility of the modern workplace and the desire for work-life balance (Bhudke & Athnikar, 2024; Park et al., 2024). Bleisure can be considered as the freedom of time and space to perform your work-related duties and also indulging in relaxing and exploring related activities (Walia et al., 2023). Bleisure travelers are working vacationers who actively seek to take advantage of the opportunity to combine work and pleasure, while still respecting their professional obligations (Lichy & McLeay, 2018).

The key feature of bleisure travel is the opportunity to take some personal time to relax while working abroad. For the modern business traveler, the idea of working all day is no longer optional. These travelers are seeking destinations that can help them achieve personal growth and relaxation. Companies are recognizing the necessity to adapt some relaxation and some fun time during their employee working trips, while technology is helping these travelers find leisure opportunities faster. Respondents of the study agree (80%) that they are more productive when they incorporate leisure activities into their business trips (The Economist, 2019). In addition, in a study conducted by Expedia Group, 60% of respondents revealed that they turned their business trips in America into bleisure trips (Expedia, 2018).

The experiences of travelers who move for meetings, conferences and other work-related trips explained that leisure can be a part of business travel, particularly when people travel with their co-workers or partners to enhance the quality of travel (Shaheer et al., 2021). While business trips are often conducted solo, family members may occasionally accompany travelers, especially if the destination is attractive or the stay is extended. On the other hand, bleisure tourists who travel alone can interact with both colleagues and residents, enriching their experience. This interaction prevents loneliness and offers a chance to immerse in different cultures. By combining professional responsibilities with personal exploration, bleisure travelers gain both business insights and valuable leisure experiences, turning their trips into enjoyable, educational journeys (Ünal & Özgürel, 2021).

Hybrid travel modes, such as bleisure, not only enhance individual well-being but also contribute to sustainable tourism by providing benefits to local economies (Gustafson, 2014; Wang, 2017). By integrating work and leisure, travelers are more likely to extend their stays and engage deeply with the host communities. This approach reduces the environmental impact associated with multiple separate trips while contributing to the socio-economic development of destinations. Hovhann-isyan and Keller (2015) highlight that business travelers often serve as knowledge transmitters, spreading innovative ideas and fostering cultural exchange within host communities. Similarly, Cohen and Gössling (2015) emphasize how combining work and leisure fosters more meaningful and responsible interactions with local cultures and economies.

2.3. Travel Satisfaction, Well-Being and Life Satisfaction

Satisfaction is defined as a state of contentment that arises when an individual's desires or needs are fulfilled, reflecting the degree to which experiences or products meet or exceed expectations (Oliver, 2014). Satisfaction in regards to expectations is the comparison between an individual's

expectations and their experience. Expectations are individuals' beliefs about what will happen during an experience, and these expectations can be influenced by several factors such as previous experience, word-of-mouth, and marketing messages. According to the expectation-disconfirmation model, when the experience meets or surpasses its expectations, the individual feels satisfied (Oliver, 1980). On the other hand, if the experience falls short of expectations, dissatisfaction occurs. The same is true with travel satisfaction, if individuals' travel experience surpasses their expectations individuals feel satisfied.

Research indicates that there is a strong relationship between travel satisfaction and an individual's well-being, as positive travel experiences significantly impact mental and emotional health. Dhanabhakyam and Sarath (2023) explain that well-being encompasses emotional health and overall functioning, suggesting that satisfying travel experiences can enhance these aspects of a person's life. Engaging in travel can provide a break from daily stressors, offering a chance for relaxation and rejuvenation which can be the case in bleisure travel too. Business trips offer the opportunity for personal growth (Cohen & Gössling, 2015; Gustafson, 2014) which can enrich individuals' well-being. Business travelers who blend work with leisure during business trips tend to achieve a better work-life balance, leading to improved job performance, reduced stress, and greater life satisfaction (Bhudke & Athnikar, 2024; Ramgade, 2023). Their satisfaction is further enhanced by the fact that their organization covers travel expenses, and by the opportunity to immerse themselves in different cultural and institutional settings (Çulfaqı et al., 2024; Ünal & Özgürel, 2021). Additionally, bleisure travel, especially for young professionals, offers the chance to expand both professional and personal networks, benefiting both the individual and their company (Lichy & McLeay, 2018; Ramgade, 2023). Several research studies highlight the positive relationship between travel satisfaction and individuals' well-being (De Vos et al., 2013; Ettema et al., 2011; Friman et al., 2017; Y. Wang & Gao, 2022; Zins & Ponocny, 2022).

As awareness of the importance of quality of life grows, academic research on life satisfaction has increased as well. Diener (1984) defines life satisfaction as "an overall assessment of feelings and attitudes about one's life at a particular point in time ranging from negative to positive", while Wang (2017) defines it as "the extent to which individuals assess the overall quality of their lives". The latter also emphasizes that leisure travel plays a significant role in enhancing life satisfaction by offering opportunities for relaxation, cultural enrichment, and social interaction. These travel experiences contribute to both immediate and long-term well-being, supporting personal development and creating meaningful memories that further improve life satisfaction. In a study conducted in China, with 509 elderly tourists, respondents revealed that travel satisfaction positively influences overall life satisfaction (Pan et al., 2020). Other research studies have revealed similar results (Wang, 2017; Zarabi et al., 2019).
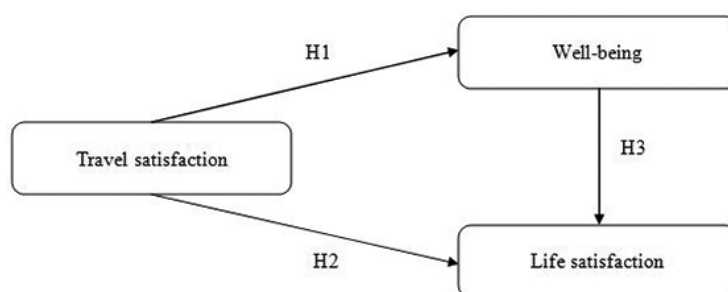

Figure 1. Proposed research model
Source: Own processing

Research also confirms a positive relationship between an individual's well-being and his/her life satisfaction (Dhanabhakyam & Sarath, 2023; Diener et al., 2023; Huppert, 2023; Maddux, 2017; Martyr et al., 2018; Ryff & Keyes, 2023). These works explore how psychological well-being, including emotional and mental health, influences in enhancement of life satisfaction. The authors emphasize that individuals with higher levels of psychological well-being are more likely to experience greater life satisfaction and overall happiness, therefore attempts to improve emotional health can lead to sustained improvements in overall life satisfaction.

Based on the above-mentioned arguments, we propose the following research model (Figure 1) and develop the following hypotheses:

H1. There is a significant influence of travel satisfaction on individuals' well-being.

H2. There is a significant influence of travel satisfaction on individuals' life satisfaction.

H3. There is a positive relationship between individuals' well being and life satisfaction.

3. RESEARCH METHODOLOGY

3.1. Sample and Data Collection

This empirical study was conducted in 2024 using the data collected from Montenegrin respondents by self-administered questionnaires. The target population consists of Montenegrin employees engaged in bleisure travel in the last three years. Each respondent prior to fulfilling the questionnaire was asked if they had engaged on a business trip in the last three years and if at the same travel have taken some personal time for fun, relaxation or rejuvenation. Only those who have taken part in bleisure travel received the questionnaire. If participants had more than one occasion of bleisure travel, they were asked to refer to their most recent experience. The purpose of the study was kindly explained to each participant and we explained that the data will be used for statistical purposes only.

Data were collected from the authors with the help of two assistants throughout January, February, and March 2024. Potential respondents were approached at the entrance of their work and were asked whether they would be willing to participate in a survey dealing with bleisure travel. In total, 150 questionnaires were distributed. Eight incomplete questionnaires were eliminated from the analysis, leaving 142 valid questionnaires for further analysis.

3.2. Demographic Profile

The characteristics of the respondents are summarized in Table 1. A majority of the respondents (56.3 percent) were male. In terms of age, 12.0 percent are in the age group 18-27, 27.5 percent in the group 28-37, the majority of the respondents (33.10 percent) are in the group 38-47, 11.9 percent are in the age group 48-57 and 15.5 percent are in the age group 58-67. In terms of education, the majority of respondents report having a high level of education, (40.8 percent have a bachelor's degree, 40.1 percent report having a master's degree, 1.4 percent report having a doctorate or a higher level of education), 2.1 percent have a professional degree, 6.3 percent have a high school diploma or equivalent, 9.2 percent report that they attended college/university but not finished. As per their job title or rank, 3.5 percent declare they are CEOs/Entrepreneurs/Owners or Presidents,

9.2 percent are executive managers, 9.9 percent belong to the middle level of management, 9.9 percent to the low level, 5.6 percent are professors/academics/researchers, 4.9 percent are technical staff, 22.5 percent are professional workers, 16.9 percent are administrative staff, and 17.6 percent have other profession. More than 66 percent of the respondents report traveling for work more than once a year. The data were coded and processed using SPSS.

Table 1. Profile of the respondents (n = 142)

Variable	Frequency (n = 142)	(%)
Gender		
Male	80	56.3
Female	62	43.7
Age		
18-27	17	12.0
28-37	39	27.5
38-47	47	33.1
48-57	17	11.9
58-67	22	15.5
Educational background		
High school or equivalent	9	6.3
Attended College/University	13	9.2
Bachelor's degree	58	40.8
Master's degree	57	40.1
Doctorate or higher degree	2	1.4
Professional degree	3	2.1
Job title		
CEO/Entrepreneur/Owner/President	5	3.5
Executive management (eg, CFO, CIO, CMO)	13	9.2
Middle management (eg, group director, department manager, supervisor)	14	9.9
Lower management	14	9.9
Professor/Academic/Researcher	8	5.6
Technical staff (eg, non-manager, IT, scientific, engineering)	7	4.9
Professional (eg, accountant, architect, lawyer)	32	22.5
Administrative staff	24	16.9
Other	25	17.6
Travel for work		
Less than once a year	14	9.9
Once a year	33	23.2
Two, three times a year	48	33.8
Four, five times a year	22	15.5
Six or more times a year	25	17.6

Source: Own calculations

3.3. Measures

Travel satisfaction. Travel satisfaction was operationalized as a multidimensional construct using a modified version of the scale developed by Kwon and Lee (2020). Items used to measure this dimension are as follows: Overall, I am satisfied with this trip, I am more satisfied than I expected to be with this trip, I am satisfied with my decision, I am satisfied with the experiences of the trip, and this trip fully met my expectations. A five-point Likert scale (1 = "strongly disagree"; 5 = "strongly agree") was used to measure all these five items.

Well-being. Well-being was operationalized as a multidimensional construct using a modified version of the scale developed by Kang (2020). Items used to measure this dimension are as follows: this trip played a very important role in my social well-being, this trip played an important

role in my travel well-being, and this trip played an important role in enhancing my quality of life. A five-point Likert scale (1 = "strongly disagree"; 5 = "strongly agree") was used to measure all these three items.

Life satisfaction. Life satisfaction was operationalized as a multidimensional construct using the satisfaction with life scale developed by Diener et al. (1985). Items used to measure this dimension are as follows: In most ways my life is close to my ideal, the conditions of my life are excellent, I am satisfied with my life, so far I have gotten the important things I want in life, if I could live life over, I would change almost nothing. A five-point Likert scale (1 = "strongly disagree"; 5 = "strongly agree") was used to measure all these five items (Pavot & Diener, 1993, 2008).

4.   RESULTS

4.1. Factor Analysis & Reliability

Factor analysis is a statistical technique used to identify underlying relationships between measured variables by grouping them into latent constructs or factors (Meyers et al., 2013). This method provides a means to consolidate scattered information from multiple variables into a smaller, more manageable number of factors. This study used factor analysis with Varimax rotation. When performing such an analysis, importance should be paid to the factorial weights of each item. Each item had a factor loading higher than 0.70.

Table 2. Summary of measurement scales

Constructs	Items	α	Factor loading
Travel satisfaction	TS1. Overall, I am satisfied with this trip	0.786	0.722
	TS2. I am more satisfied than I expected to be with this trip		0.702
	TS3. I am satisfied with my decision		0.751
	TS4. I am satisfied with the experience of the trip		0.731
	TS5. This trip fully met my expectation		0.771
Well-being	WB1. This trip played a very important role in my social well-being	0.710	0.782
	WB2. This trip played an important role in my travel well-being		0.823
	WB3. This trip played an important role in enhancing my quality of life		0.782
Life satisfaction	LS1. In most ways my life is close to my ideal	0.768	0.714
	LS2. The conditions of my life are excellent		0.715
	LS3. I am satisfied with my life		0.713
	LS4. So far I have gotten the important things I want in life		0.707
	LS5. If I could live life over, I would change almost nothing		0.765

Source: Own processing

In order to measure reliability we used the coefficient Cronbach Alpha. The measure "Travel satisfaction" reported the highest level of Cronbach alpha (0.786). On the other hand Cronbach's alpha for the measure "well-being" was 0.710, and for the measure "life satisfaction" was 0.768. All of these levels indicate adequate reliability (Hair et al., 2010).

4.2. Regression Analysis

To test whether or not there is a significant relationship between travel satisfaction and well-being, we performed a simple regression analysis, using *travel satisfaction* as the independent variable and *well-being* as the dependent variable. The results of the simple regression analysis indicated

that there was a significant relationship between travel satisfaction and well-being (F (1, 140) = 247.526, p = 0.000). Furthermore, the regression slope coefficient was positive and highly significant (b = +0.942). Lastly, the coefficient of correlation was 0.799, indicating a relatively strong correlation between the two variables. Consequently, hypothesis H1 was supported. There is a significant influence of travel satisfaction on individuals' well-being.

To test whether or not there is a significant relationship between travel satisfaction and life satisfaction, we performed a simple regression analysis, using *travel satisfaction* as the independent variable and *life satisfaction* as the dependent variable. The results of the simple regression analysis indicated that there was a significant relationship between travel satisfaction and life satisfaction (F (1, 140) = 241.498, p = 0.000). Furthermore, the regression slope coefficient was positive and highly significant (b = +0.730). Lastly, the coefficient of correlation was 0.796, indicating a relatively strong correlation between the two variables. Consequently, hypothesis H2 was supported. There is a significant influence of travel satisfaction on individuals' life satisfaction.

To test whether or not there is a significant relationship between well-being and life satisfaction, we performed a simple regression analysis, using *well-being* as the independent variable and *life satisfaction* as the dependent variable. The results of the simple regression analysis indicated that there was a significant relationship between well-being and life satisfaction (F (1, 140) = 203.485, p = 0.000). Furthermore, the regression slope coefficient was positive and highly significant (b = +0.600). Lastly, the coefficient of correlation was 0.770, indicating a relatively strong correlation between the two variables. Consequently, hypothesis H3 was supported. There is a positive relationship between individuals' well-being and life satisfaction.

The results indicate that incorporating leisure into business travel has implications beyond individual well-being, fostering sustainable tourism practices. By encouraging longer stays and deeper engagement with local communities, bleisure travel enhances cultural exchange and drives local economic growth. These findings suggest that companies have an opportunity to align their travel policies with broader sustainability goals while improving employee satisfaction.

5. FUTURE RESEARCH DIRECTIONS

Despite its contribution to existing literature, this study is subject to certain limitations. The sample size used is small (n = 142), limiting therefore the generalization of the findings. Additionally, the study offers only a snapshot of employees' perceptions from only three cities in Montenegro: Ulcinj, Bar and Budva. As a result, the findings may not accurately represent the perceptions of business travellers in other regions of Montenegro or other countries, particularly since the study is focused solely on Montenegro and does not include cross-border comparisons. Furthermore, the data collected do not reflect changes in behaviour over time. Based on these limitations, future research should extend the study to other countries and across different periods to enable valuable comparisons between countries and specific travel periods.

Despite these limitations, the study offers valuable insights into the relationship between business travel and/or bleisure with individuals' well-being and overall life satisfaction, serving as a foundation for more detailed research in this area. Future research could explore which specific types of leisure activities have the most significant impact on travel satisfaction and well-being. It would also be beneficial to investigate how different demographics—such as age, gender, and cultural background—experience the relationship between business travel, leisure opportunities,

and well-being. Additionally, examining the effects of business travel on well-being across various industries would provide further depth to this field of study.

6. CONCLUSION

The objective of this study was to test a conceptual model on the relationship among the constructs of "travel satisfaction", individuals' "well-being", and their "life satisfaction". The conceptual model proposed in the study postulated that travel satisfaction impacts both individuals' well-being and their life satisfaction, in the case of bleisure travelers. The model also postulated that there is a positive relationship between well-being and overall life satisfaction. All of these raised hypotheses were supported. The findings of this study resulted to be quite in line with the previous studies (Bhudke & Athnikar, 2024; Cohen & Gössling, 2015; Çulfaqı et al., 2024; De Vos et al., 2013; Dhanabhakyam & Sarath, 2023; Diener et al., 2023; Ettema et al., 2011; Friman et al., 2017; Gustafson, 2014; Huppert, 2023; Maddux, 2017; Martyr et al., 2018; Pan et al., 2020; Ramgade, 2023; Ryff & Keyes, 2023; Ünal & Özgürel, 2021; Y. Wang & Gao, 2022; Zins & Ponocny, 2022) regarding the relationship among these constructs.

The findings of the study highlighted a significant positive relationship between travel satisfaction and overall well-being. Employees who reported higher satisfaction with their business travel experiences also exhibited higher levels of life satisfaction. In addition, the positive relationship between travel satisfaction and life satisfaction is mediated by well-being, implying that improved well-being due to satisfying travel experiences enhances life satisfaction. Incorporating leisure opportunities during business travel significantly boosts travel satisfaction, highlighting the need for companies to facilitate enjoyable activities for their travelling employees. Employers/managers should consider implementing policies that promote leisure and relaxation during business trips to enhance employee well-being and satisfaction, ultimately benefiting the organization through improved employee performance.

This study positions bleisure travel as a key strategy for promoting sustainable tourism, offering benefits to employees, employers, and local communities alike. The integration of leisure into business travel not only enhances employee well-being and productivity but also contributes to sustainable tourism by increasing cultural and economic engagement with local destinations. Aligning business travel policies with global sustainability objectives allows companies to foster sustainable tourism practices while gaining long-term benefits from a healthier and more satisfied workforce. These findings highlight the potential of bleisure travel to play a transformative role in the intersection of business, leisure and sustainability.

References

Batala, B., & Slevitch, L. (2024). Keeping two balls in the air: The bleisure travel experience. *Annals of Tourism Research Empirical Insights*, *5*(1), 100115. https://doi.org/10.1016/j.annale.2023.100115

Bhudke, S., & Athnikar, A. (2024). Rise of bleisure travel in India: Understanding the needs of business travelers with leisure interests. *Journal of Travel Research in India*, *18*(3), 45-58.

Cohen, S. A., & Gössling, S. (2015). A darker side of hypermobility. Environment and Planning A: *Economy and Space*, *47*(8), 166–1679. https://doi.org/10.1177/0308518X15597124

Çulfaqı, G., Onursoy, F. M., & Akın, M. H. (2024). Business Travel and Bleisure Tourism A Study on The Travel Motivations of Academics. *GSI Journals Serie A: Advancements in Tourism, Recreation and Sports Sciences (ATRSS),7*(2): 406-423. https://doi.org/10.53353/atrss.1403738

Davidson, R. (1994). Business Travel. London, Great Britain: Pitman Publishing.

De Vos, J., Schwanen, T., Van Acker, V., & Witlox, F. (2013). Travel and Subjective Well-Being: A Focus on Findings, Methods and Future Research Needs. *Transport Reviews*, *33*(4), 421–442. https://doi.org/10.1080/01441647.2013.815665

Dhanabhakyam, M., & Sarath, M. (2023). Psychological Wellbeing: A systematic literature review. *International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), 3*(1), 603. https://doi.org/10.48175/IJARSCT-8345

Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, *95*(3), 542-575. https://doi.org/10.1037//0033-2909.95.3.542

Diener, E., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The Satisfaction With Life Scale. *Journal of Personality Assessment*, *49*(1), 71–75. https://doi.org/10.1207/s15327752jpa4901_13

Diener, E., Oishi, S., & Tay, L. (2023). The role of subjective well-being in psychological research. *Annual Review of Psychology, 74*, 325-348. https://doi.org/10.1146/annurev-psych-032022-005509

The Economist. (2019). The 2019 bleisure barometer: Asia's best cities for work and recreation. *The Economist Intelligence Unit Limited*.

Espino, C. M., Sundstrom, S. M., Frick, H. L., Jacobs, M., & Peters, M. (2002). International business travel: Impact on families and travellers. *Occupational and Environmental Medicine*, *59*(5), 309–322. https://doi.org/10.1136/oem.59.5.309

Ettema, D., Gärling, T., Eriksson, L., Friman, M., Olsson, L. E., & Fujii, S. (2011). Satisfaction with travel and subjective well-being: Development and test of a measurement tool. *Transportation Research Part F: Traffic Psychology and Behaviour, 14*(3), 167–175. https://doi.org/10.1016/j.trf.2010.11.002

Expedia. (2018). *Unpacking Bleisure Traveler Trends*.

Friman, M., Gärling, T., Ettema, D., & Olsson, L. E. (2017). How does travel affect emotional well-being and life satisfaction? *Transportation Research Part A: Policy and Practice, 106*, 170–180. https://doi.org/10.1016/j.tra.2017.09.024

Gustafson, P. (2014). Business travel from the traveller's perspective: Stress, stimulation and normalization. *Mobilities, 9*(1), 63–83. https://doi.org/10.1080/17450101.2013.784539

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). *Multivariate data analysis*. Upper Saddle River, NJ: Prentice Hall.

Hovhannisyan, N., & Keller, W. (2015). International business travel: An engine of innovation? *Journal of Economic Growth, 20*(1), 75–104. https://doi.org/10.1007/s10887-014-9107-7

Huppert, F. A. (2023). Well-being and mental health: Current perspectives. *Journal of Mental Health and Well-being*, *10*(2), 85-102.

Kang, J. (2020). Identifying antecedents and consequences of well-being: The case of cruise passengers. *Tourism Management Perspectives, 33*, 100609. https://doi.org/10.1016/j.tmp.2019.100609

Kwon, J., & Lee, H. (2020). Why travel prolongs happiness: Longitudinal analysis using a latent growth model. *Tourism Management, 76*, 103944. https://doi.org/10.1016/j.tourman.2019.06.019

Leiper, N., Witsel, M., & Hobson, J. S. P. (2008). Leisure travel and business travel: A comparative analysis. *Leisure Travel and Business Travel, 2*(1), 1–10.

Lichy, J., & McLeay, F. (2018). Bleisure: Motivations and typologies. *Journal of Travel & Tourism Marketing, 35*(4), 517–530. https://doi.org/10.1080/10548408.2017.1364206

Maddux, J. E. (2017). Subjective Well-Being and Life Satisfaction. *Subjective Well-Being and Life Satisfaction*, 3-31. https://doi.org/10.4324/9781351231879-1

Martyr, A., Nelis, S. M., Quinn, C., Wu, Y.-T., Lamont, R. A., Henderson, C., Clarke, R., Hindle, J. V., Thom, J. M., Jones, I. R., Morris, R. G., Rusted, J. M., Victor, C. R., & Clare, L. (2018). Living well with dementia: a systematic review and correlational meta-analysis of factors associated with quality of life, well-being and life satisfaction in people with dementia. *Psychological Medicine, 48*(13), 2130-2139. https://doi.org/10.1017/s0033291718000405

Meyers, L. S., Gamst, G. C., & Guarino, A. J. (2013). *Performing Data Analysis Using IBM SPSS*. New Jersey: Wiley.

Murphy, L., Benckendorff, P., & Moscardo, G. (2007). Linking travel motivation, tourist self-image and destination brand personality. *Journal of Travel & Tourism Marketing, 22*(2), 45–59. https://doi.org/10.1300/J073v22n02_04

Oliver, R. L. (1980). A cognitive model of the antecedents and consequences of satisfaction decisions. *Journal of Marketing Research, 17*(4), 460–469. https://doi.org/10.1177/002224378001700405

Oliver, R. L. (2014). Satisfaction: A Behavioral Perspective on the Consumer. https://doi.org/10.4324/9781315700892

Pan, Y., Fu, X., & Wang, Y. (2020). How does travel link to life satisfaction for senior tourists? *Journal of Hospitality and Tourism Management, 45*, 234–244. https://doi.org/10.1016/j.jhtm.2020.07.013

Park, S., Lehto, X., & Kang, J. (2024). Balancing work and leisure: Unraveling constraints on work-leisure integration in bleisure travel. *International Journal of Hospitality & Tourism Administration, 1*–27. https://doi.org/10.1080/15256480.2024.2344226

Pavot, W., & Diener, E. (1993). The affective and cognitive context of self-reported measures of subjective well-being. *Social Indicators Research, 28*, 1–20. https://doi.org/10.1007/bf01086714

Pavot, W., & Diener, E. (2008). The Satisfaction With Life Scale and the emerging construct of life satisfaction. *The Journal of Positive Psychology, 3*(2), 137–152. https://doi.org/10.1080/17439760701756946

Radojevic, T., Stanisic, N., Stanic, N., & Davidson, R. (2018). The effects of traveling for business on customer satisfaction with hotel services. *Tourism Management, 67*, 326–341. https://doi.org/10.1016/j.tourman.2018.02.007

Rajaguru, R., & Hassanli, N. (2018). The role of trip purpose and hotel star rating on guests' satisfaction and WOM. *International Journal of Contemporary Hospitality Management, 30*(5), 2268–2286. https://doi.org/10.1108/ijchm-01-2017-0044

Ramgade, A. (2023). A study on the growth and popularity of bleisure tourism amongst corporate employees. *NIU International Journal of Human Rights*, 8(XVII), 88-91.

Ryff, C. D., & Keyes, C. L. M. (2023). *The structure of well-being and its measurement. In C. L. M. Keyes & C. D. Ryff (Eds.), The Oxford Handbook of Well-Being and Quality of Life* (pp. 55-78). Oxford University Press.

Shaheer, I., Lee, C., & Carr, N. (2021). Factors motivating working holiday travel: The case of Latin American visitors to New Zealand. *Tourism and Hospitality Research, 21*(3), 330–343. https://doi.org/10.1177/14673584211003630

Swarbrooke, J., & Horner, S. (2001). *Business Travel and Tourism* (1st ed.). Butterworth-Heinemann.

Ünal, A., & Özgürel, G. (2021). A research on determining the destination quality perceptions and intentions to revisit of bleisure tourists: İstanbul case. *Tourism and Recreation, 3*(1), 45-60.

Unger, O., Uriely, N., & Fuchs, G. (2016). The business travel experience. *Annals of Tourism Research, 61*, 142–156. https://doi.org/10.1016/j.annals.2016.10.003

Voll, K., Gauger, F., & Pfnür, A. (2023). Work from anywhere: Traditional workation, coworkation and workation retreats: a conceptual review. *World Leisure Journal, 65*(2), 150–174. https://doi.org/10.1080/16078055.2022.2134199

Walia, S., Kour, P., Choudhary, P., & Jasrotia, A. (2023). COVID-19 and the bleisure travellers: An investigation on the aftermaths and future implications. *Tourism Recreation Research, 48*(5), 657–667. https://doi.org/10.1080/02508281.2021.1946653

Wang, S. (2017). Leisure travel outcomes and life satisfaction: An integrative look. *Annals of Tourism Research, 63*, 169–182. https://doi.org/10.1016/j.annals.2017.01.009.

Wang, Y., & Gao, Y. (2022). Travel satisfaction and travel well-being: Which is more related to travel choice behaviour in the post COVID-19 pandemic? Evidence from public transport travellers in Xi'an, China. *Transportation Research Part A: Policy and Practice, 166*, 218-233. https://doi.org/10.1016/j.tra.2022.10.003

Zarabi, Z., Gerber, P., & Lord, S. (2019). Travel satisfaction vs. life satisfaction: A weighted decision-making approach. *Sustainability, 11*(19), 5309. https://doi.org/10.3390/su11195309

Zins, A. H., & Ponocny, I. (2022). On the importance of leisure travel for psychosocial wellbeing. *Annals of Tourism Research, 93*, 103378. https://doi.org/10.1016/j.annals.2022.103378

Travel Trends Among Generation Z: A Focus on Knowledge-Based Sustainable Development

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Abstract: *In recent years, the impact of tourism on environmental degradation has intensified the focus on knowledge-based sustainable development, as research increasingly identifies tourism as a major contributor to environmental pollution and damage. This study explores Generation Z's preference for nature-based tourism, a group known for their environmental consciousness. The present study aims to identify the travel trends of Generation Z youth in the context of sustainable knowledge-based development. Questionnaires were administered to students and masters from tourism-specialized higher education institutions, and structured interviews were conducted with representatives of institutions and organizations in the tourism sector. The research area is the North-East Region of Romania. Findings indicate a relationship between the travel preferences of young people towards natural settings and their awareness of environmental quality. Therefore, there is an increase in the awareness of natural values among young tourists of this generation and a growing involvement from institutions and organizations in the tourism sector. The study contributes to existing literature by identifying sustainable travel trends among Generation Z, analyzed from both the perspectives of young people, and representatives of institutions and organizations within the tourism sector.*

1. INTRODUCTION

The World Tourism Organization (UNTWO, 2019) has published consumer trends in tourism services, among which the most relevant is the trend towards a healthy lifestyle, reflected in the tourism industry through wellness tourism, sports tourism, and nature walking tourism. The tourism sector has grown significantly, and tourists' preferences are changing. They are becoming increasingly interested in protecting the environment (Brînză & Butnaru, 2020), and raising awareness about sustainable tourism (Melinte et al., 2023). Therefore, as shown by researchers, the ecological aspect of studying tourism as a system has great relevance (Baloch et al., 2023).

Tourism is also a knowledge-based industry that provides, manages, and shares a large amount of information, generating new knowledge (Fan, 2024). In this context, knowledge-based management can help tourism organizations face various challenges by promoting sustainable tourism development. The behavior of tourists during their travel experiences is a process of creating and sharing knowledge. Thus, increased attention is being paid to sustainable development based on knowledge, especially since studies have shown that tourism is one of the main contributors to environmental pollution and damage (Butnaru et al., 2022; Ștefănică et al., 2021). The challenge of managing tourism lies in determining the threshold of tolerability, which is defined as the maximum number of tourists that can visit an area without causing harm to the natural environment. A high frequency

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of tourism can lead to the degradation of the natural environment, potentially causing irreversible damage (Jarolímková & MIENAT project team, 2023). Thus, tourism development actions in certain regions should be implemented with consideration for the future of tourism and the local conditions and particularities that determine its current and potential state (Ianioglo & Rissanen, 2020).

Moreover, it has been observed that tourists are increasingly interested in the concept of nature-based tourism; they tend to travel to quiet, natural places where they can have new experiences and emotions (Niță et al., 2023). At the same time, specialists in sustainable development have analyzed the impact of tourist activities that adopt responsible behavior towards the natural environment, thus promoting forms of travel with reduced environmental impact (Chenoweth, 2009; Otero & Ringertz, 2022). Related to this concern, studies conducted globally have also shown a good understanding and receptivity regarding sustainable travel among young tourists (Buffa, 2015; Cavagnaro et al., 2021; Melinte et al., 2023).

The objectives are the analysis of Generation Z's preferences for nature-based tourism and the study of gender differences in relation to tourist destinations. The novelty of this study lies in its use of both quantitative and qualitative research methods to identify the travel trends of the young Generation Z in the context of knowledge-based sustainable development.

The article is organised into the following sections: introduction, analysis of the literature, research methodology, results, discussions, and conclusion. The results obtained are of particular interest regarding nature-based tourism, especially because a study of this research subject has not yet been conducted in the context of Romania.

2. LITERATURE REVIEW

Sustainable tourism has been an increasingly popular field of research since the 1980s (Liu, 2003). Streimikiene et al. (2021) showed that the management of sustainable tourism development must focus on meeting tourists' needs at the highest possible level. Therefore, it is essential to ensure a unique experience for tourists, aiming to raise their awareness of sustainability issues and promote sustainable tourism practices.

It is also important to recognize that sustainable development is a process aimed at envisioning a favorable future for human societies. This involves creating living conditions and managing resource use in a way that meets human needs while preserving the integrity, beauty, and stability of vital ecological systems (Darvishi et al., 2023). Sustainable development involves the relationship between humans and the environment and the responsibilities of the current generation toward future generations, with tourism being a system that has social, environmental, and economic impacts on a global scale (Çalışkan, 2021). Therefore, the role of sustainable tourism is defined by the adoption of sustainable practices in the tourism industry.

Nature-based tourism has emerged as a key component of sustainable tourism. Peter (1992) shows that most tourism activities can be described as nature-based, as nature plays a major role in attracting tourists to holiday destinations. Nature-based tourism has undergone tremendous growth (Balmford et al., 2009; Coghlan & Buckley, 2012; Kuenzi & McNeely, 2008). In recent decades, there has been a growing interest from researchers and international institutions in the sustainable development of natural and cultural tourism resources. This trend underscores the critical need for comprehensive sustainable tourism development plans in natural areas (Niță et al., 2023). According

to Kim et al. (2015), over the last decade, there has been a significant increase in the number of tourists visiting national parks and protected areas. This trend is largely due to the growing global popularity of nature-based tourism. Niță et al. (2023) argue that for many emerging countries, the natural resources that can be leveraged through tourism are extremely valuable. These countries can be positioned to successfully participate in the highly competitive international tourism market, which has traditionally been dominated by developed countries. Developed countries attract the majority of tourists and revenues due to their well-established infrastructure, skilled workforce, and continuous innovations in tourism-related activities. Therefore, nature-based tourism offers a unique travel niche, driven by the desire to enjoy wildlife, explore remote natural areas, or discover places untouched by civilization (World Bank, 2017).

Kim et al. (2015) have shown that nature-based tourism motivation is related to the need to appreciate nature and escape from daily life, explore the unknown and pursue new types of travel, and enjoy new experiences. Considering that, in recent years, the impact of tourism on environmental degradation has intensified the focus on knowledge-based sustainable development, research increasingly identifies tourism as a major contributor to environmental pollution and damage. In this context, it is important to understand what knowledge-based development and knowledge-based sustainable development represent.

Knowledge-based development is a potent strategy for economic growth, enabling nations to actively participate in and benefit from the global knowledge economy (Lever, 2002, cited in Laszlo & Laszlo, 2007). It highlights the intent to enhance the skills and knowledge of individuals, thereby fostering both personal and societal development (Gonzalez, et. al., 2005, cited in Laszlo & Laszlo, 2007). Knowledge-based sustainable development, on the other hand, emphasizes the use of knowledge to promote environmental protection (Mbaiwa et al., 2008).

Therefore, knowledge is essential for the sustainable use and development of tourism resources provided by nature. Considering that, in the coming years, Generation Z will become the main target market of tourism (Setiawan et al., 2018), it is important to understand how young people will use their knowledge about protecting the environment while engaging in nature-based tourism. As young people accumulate their savings, they will have the ability to purchase tourism products and services independently. The social behavior of this generation is relatively different from that of its predecessors, and it must be considered that Generation Z grew up and developed in an era of new technologies.

3. RESEARCH METHODOLOGY

The present study aims to identify the travel trends of Generation Z youth in the context of knowledge-based sustainable development. We use two research methods: quantitative and qualitative. The questionnaires were administered to a sample of 388 Generation Z students from tourism-specialized higher education institutions. The qualitative method involved using interviews. For the present study, 11 interviews were conducted with representatives from 11 institutions in the field of tourism. These institutions have been coded, using codes R1 to R11, to protect their data and identity.

The research area is the North-East Region (NE) of Romania. The NE Region of Romania, with a resident population of 3,157,192 inhabitants as of January 1, 2021, is the largest of Romania's eight development regions. It has significant tourist potential, comparable to other international tourist regions (ADR Nord-Est, 2022).

4. RESULTS

4.1. The Results of the Sample Statistical Analysis

The quantitative method involved administering questionnaires to a sample of 388 Generation Z students from tourism-specialized higher education institutions. The sample is structured by the gender of the respondents as follows: 61% are young female tourists, and 39% are young male tourists.

To test the reliability (internal consistency) of the research tool, Cronbach's Alpha coefficient was calculated. The values of the Cronbach's Alpha coefficient for the three analyzed questions range from 0.70 to 0.796, indicating that these questions have been validated.

Research hypothesis 1 (H1) was formulated starting from the idea that the importance of choosing a natural tourist attraction depends on each tourist. The Gamma coefficient was used to test hypothesis H1.

H1: There is a relationship between the importance of tourist attractions and the gender of the respondents

Table 1. Relationship between the importance of tourist attractions
and the gender of the respondents

Items - Tourist attractions	Gamma Coefficient	Sig.
Tradition	0.243	0.003
Culture	0.162	0.061
Nature	0.226	0.047
Churches	0.319	< 0.0001
Castles	0.174	0.036
Muzeums	0.101	0.212
Citadels	0.076	0.360
Sports activities	-0.075	0.332

Source: Own calculations

The gamma coefficient has positive values for 7 of the 8 analyzed items, and sig. < 0.05 for four out of the 8 analyzed items (Table 1). Based on the results, we can conclude that there is a direct and significant relationship between gender and preferences for the following tourist attractions: tradition, nature, churches, and castles. Therefore, hypothesis H1 is validated for 4 out of the 8 analyzed items.

We assumed that there is a relationship between the attractiveness of a nature-based tourist destination and the gender of the respondents, leading to the formulation of research hypothesis 2. The Gamma coefficient was used to test hypothesis H2.

H2: There is a relationship between the attractiveness of tourist destinations and the gender of the respondents.

Gamma coefficient has negative values for all 8 analyzed items and sig. < 0.05 for four out of the 8 analyzed items (Table 2). The results show that there is an inverse and significant relationship between the attractiveness of natural tourist destinations and the gender of Generation Z respondents,

indicating that male individuals are more focused on sports activities while on vacation. Therefore, hypothesis H2 is validated for 4 out of the 8 analyzed items.

Table 2 The relationship between the attractiveness of natural tourist destinations and the gender of the respondents

Items - the attractiveness of natural tourist destinations	Gamma Coefficient	Sig.
Tradition	-0.265	0.002
Culture	-0.185	0.040
Nature	-0.146	0.220
Churches	-0.283	< 0.0001
Castles	-0.179	0.039
Muzeums	-0.085	0.310
Citadels	-0.132	0.128
Sports activities	-0.111	0.164

Source: Own calculations

We also aimed to identify the link between the factors influencing the choice of a nature-based tourist destination and the gender of the respondents, leading to the formulation of research hypothesis 3. The Gamma coefficient was used to test hypothesis H3.

H3: There is a relationship between the factors influencing the choice of a tourist destination and the gender of the respondents.

Table 3. The relationship between the factors influencing the choice of a tourist destination and the gender of the respondents

Items – factors influencing the choice of a young tourist destination	Gamma Coefficient	Sig.
Family	0.208	0.008
Friends	0.111	0.186
Co-workers	0.003	0.966
Mass-media	0.377	< 0.0001
Social networks	0.230	0.002
Travel agencies	0.245	0.001

Source: Own calculations

The gamma coefficient has positive values for all 6 analyzed items and sig. < 0.05 for four out of the 6 analyzed items (Table 3). The results show that there is a direct and significant relationship between the gender and the following factors influencing the choice of a tourist destination by young people: family, mass-media, social networks, and travel agencies. Therefore, hypothesis H3 is validated for 4 out of the 6 analyzed items.

Based on our quantitative analysis, we've identified a significant relationship between gender and tourism preferences among Generation Z in the analyzed region. This demographic shows distinct preferences for traditional, natural, and historical attractions, such as churches and castles. Their vacation choices are primarily influenced by family, mass media, social networks, and travel agencies. Moreover, there's a strong awareness of the need for sustainable tourism development; students recognize that tourism must be developed in harmony with nature. Overall, there is a marked preference for ecological tourism among the students, with natural destinations considered particularly appealing for their travel choices.

4.2. The Results of the Qualitative Method

As a result of the interviews conducted, we summarize the responses obtained from the 11 participants. Regarding the involvement of institutions in environmental protection activities, some measures were taken into account concerning the importance of tourism in the North East Region of Romania. The respondents agreed that tourism in the North East Region is very important, especially since this area has underutilized natural and human potential (R1, R6, R7, R9). Tourism is seen as an activity through which European funds can be attracted for the rehabilitation of tourist attractions in the region (R11). The North East Region is rich in history, traditions, natural beauty, and cultural and spiritual monuments (R8). These aspects indicate that the North East Region is attractive to both locals and tourists visiting this area.

The positive aspects of tourism in the North East Region of Romania were identified. Respondents R1 and R4 emphasized the creation of new jobs, the potential to capitalize on products from local farms, and the increase in income for residents through the sale of local products.

The interviews also identified the negative effects of tourism in the North East Region of Romania. Respondent R2 believes that inadequate tourism development, especially in communities adjacent to protected areas and beyond, can pose a potential threat to the quality of the landscape and the preservation of natural quality. Emphasis was also placed on issues such as increased environmental pollution, rising waste levels, damage caused by tourists, changes to rural landscapes, and congestion in the area and on the roads (R1, R4, R7, R11). Respondent R10 noted a growing demand for visiting natural protected areas by people who lack a strong connection to or understanding of the mountain as a natural asset.

Next, the travel trends of Generation Z tourists were analyzed. A trend among young people towards sustainable development practices was observed; they are concerned with ecological practices and knowledge-based sustainable development through awareness of the value of these practices. Young people are involved in waste recycling efforts, exhibit caring behavior towards nature, voluntarily participate in clean-up actions in tourist areas, and advocate for keeping the environment as clean as possible (R1-R11). There is an increasing number of young "eco-tourists" (R2).

Respondents R3, R5, and R7 noticed that Generation Z is more interested in ecological practices, as young people are more environmentally responsible. They use mobile applications instead of paper maps and scan virtual codes for transportation. However, the R11 representative believes that many young tourists lack early education in the spirit of respecting nature, which still prevents most of them from fully appreciating the importance and beauty of practicing nature-based tourism.

The attitude of young tourists towards the environment indicates that those who engaged in mountain tourism were more environmentally conscious (R1). Respondents R4 and R10 observed that tourists no longer leave waste in nature, as they prefer to practice nature-based tourism in an environment that is as clean as possible.

However, there are different opinions regarding the behavior of tourists toward the environment. Respondents R2, R8, and R11 did not notice significant improvements or major changes in the behavior of tourists. They believe that, for many tourists, comfort at the destination is more important than spending time in nature.

There is a growing trend of nature-based travel (R3, R5, R7), particularly if, in the future, influencers promote tourism that is practiced as much as possible in natural settings, if comfortable conditions are provided at tourist destinations, and if these destinations are well-advertised. There is also a tendency for young tourists, especially those living in big cities, to seek out nature-based tourism experiences (R8). The development of nature-based tourism in the North East Region of Romania will provide development opportunities for the local population (R9). However, to achieve this, the foundations of education in this area must be established (R10).

Young tourists are eager for knowledge and appreciate traditions, crafts, folk wear and costumes, and traditional culinary products (R1-R8). There is a noticeable inclination among young people towards local culinary authenticity. Young tourists are also interested in activities specific to the area, enjoy spending time in adventure parks, and are willing to stay in tents (R3).

Based on the 11 interviews conducted with representatives of tourism institutions and organizations from the North East Region of Romania, we identified several opinions of specialists regarding the connection between the travel trends of the young generation and the focus on knowledge-based sustainable development in this region:

- There is a nexus between the travel trends of the young generation and knowledge-based sustainable development in the North East Region of Romania.
- Even though the literature does not provide a standard typology for the profile of sustainable tourists (Butnaru et al., 2022), the results of this study indicate that tourists from the younger generation tend to prioritize options for engaging in ecotourism and protecting the environment.
- Young tourists show a growing tendency to engage in tourism that reflects a responsible attitude toward the natural values of the area. Additionally, there is an increasing trend among them to purchase ecological services and products.

5. CONCLUSION

The present study provided an overview of Generation Z tourists' opinions towards nature and their motivation to travel to nature tourism areas. Generation Z's preference for nature-based tourism was analyzed using both quantitative and qualitative research methods.

The analysis of gender differences in relation to tourist destinations - specifically regarding the importance of tourist attractions (H1), the attractiveness of tourist destinations (H2), and the factors influencing the choice of a tourist destination (H3) - was conducted using statistical methods. The research hypotheses were partially validated.

The results indicate that there is a direct and significant relationship between gender and the preferences of Generation Z from the North East region for the following tourist attractions: tradition, nature, churches, and castles. Conversely, there is an inverse and significant relationship between the attractiveness of natural tourist destinations and the gender of Generation Z respondents. Additionally, there is a significant relationship between gender and the following factors influencing the choice of a tourist destination among young people: family, mass media, social networks, and travel agencies.

Findings indicate a relationship between young people's travel preferences for natural settings and their awareness of environmental quality. Therefore, there is an increase in the awareness of

natural values among young tourists of this generation and a growing involvement from institutions and organizations in the tourism sector.

Achieving sustainability in tourism necessitates the development of tourism models that contribute to preserving the natural environment and biodiversity, vital for both present and future generations. It is crucial to promote sustainable and responsible tourism practices that prevent environmental degradation. This trend towards sustainability is also becoming increasingly evident on a global scale.

The study contributes to the existing literature by identifying sustainable travel trends among Generation Z, analyzed from the perspectives of both young people and representatives of institutions and organizations within the tourism sector.

References

ADR Nord-Est. (2022). Localizare istorică și geografică. Retrieved from https://www.adrnordest.ro/regiunea-nord-est/localizare-istorica-si-geografica/

Balmford, A., Beresford, J., Green, J., Naidoo, R., Walpole, M., & Manica, A. (2009). A Global Perspective on Trends in Nature-Based Tourism. *PLoS Biology*, 7(6), e1000144. https://doi.org/10.1371/journal.pbio.1000144

Baloch, Q. B., Shah, S. N., Iqbal, N., Sheeraz, M., Asadullah, M., Mahar, S., & Khan, A. U. (2023). Impact of tourism development upon environmental sustainability: a suggested framework for sustainable ecotourism. *Environmental Science and Pollution Research, 30*(3), 5917-5930. https://doi.org/10.1007/s11356-022-22496-w

Brînză, G., & Butnaru, G., I. (2020). Aspects regarding tourism business development in the European Union, *CES Working Papers*, 11(4), p. 350-364.

Buffa, F. (2015). Young Tourists and Sustainability. Profiles, Attitudes, and Implications for Destination Strategies. *Sustainability, 7*(10), 14042-14062. https://doi.org/10.3390/su71014042

Butnaru, G. I., Niţă, V., Melinte, C., Anichiti, A., & Brînză, G. (2022). The Nexus Between Sustainable Behaviour of Tourists from Generation Z and the Factors That Influence the Protection of Environmental Quality. *Sustainability, 14*(19), 12103. https://doi.org/10.3390/su141912103

Çalışkan, C. (2021). Sustainable tourism: Gen Z? *Journal of multidisciplinary academic tourism*. 6(2): 107-115. https://doi.org/10.31822/jomat.2021-6-2-107

Cavagnaro, E., Staffieri, S., Carrieri, A., Burns, K., Chen, N., & Fermani, A. (2021). Profiling for sustainable tourism: young travellers' self-transcendence values and motivations. European *Journal of Tourism Research, 28*, 2810. https://doi.org/10.54055/ejtr.v28i.2261

Chenoweth, J. (2009). Is tourism with a low impact on climate possible?. *Worldwide Hospitality and Tourism Themes*, 1(3), 274-287. https://doi.org/10.1108/17554210910980611

Coghlan, A., & Buckley, R. (2012). Nature-based tourism. In A. Holden & D. Fennell (Eds.), The Routledge Handbook of Tourism and the Environment (pp. xx-xx). Routledge. https://doi.org/10.4324/9780203121108

Darvishi, Y., Karami, H., & Goodarzian, F. (2023). Sustainable development in oxygenated fuels. Advancement in Oxygenated Fuels for Sustainable Development, 315-330. https://doi.org/10.1016/b978-0-323-90875-7.00013-7

Fan, S. (2024). Knowledge management in tourism. Retrieved from https://realkm.com/2024/07/16/knowledge-management-in-tourism/

Ianioglo, A., & Rissanen, M. (2020). Global trends and tourism development in peripheral areas. *Scandinavian Journal of Hospitality and Tourism, 20*(5), 520-539. https://doi.org/10.1080/15022250.2020.1848620

Jarolímková, L., & MIENAT project team. (2023). Guidelines. Interpretation of European Nature Heritage in Tourism. Oeconomica Publishing House – Prague 2023. ISBN 978-80-245-2494-8. URL: https://oeconomica.vse.cz/wp-content/uploads/publication/23227/Jarolimkova_EBOOK_2023_MIENAT.pdf

Kim, H., Lee, S., Uysal, M., Kim, J., & Ahn, K. (2015). Nature-Based Tourism: Motivation and Subjective Well-Being. *Journal of Travel & Tourism Marketing, 32*(sup1), S76-S96. https://doi.org/10.1080/10548408.2014.997958

Kuenzi, C., & McNeely, J. (2008). Nature-Based Tourism. International Risk Governance Council Bookseries, 155-178. https://doi.org/10.1007/978-1-4020-6799-0_8

Laszlo, K. C., & Laszlo, A. (2007). Fostering a sustainable learning society through knowledge-based development. *Systems Research and Behavioral Science: The Official Journal of the International Federation for Systems Research, 24*(5), 493-503. https://doi.org/10.1002/sres.850

Liu, Z. (2003). Sustainable Tourism Development: A Critique. *Journal of Sustainable Tourism.* 11(6), 459–475. https://doi.org/10.1080/09669580308667216

Mbaiwa, J. E., Thakadu, O. T., & Darkoh, M. B. K. (2008). Indigenous Knowledge and Ecotourism-based Livelihoods in the Okavango Delta in Botswana. *Botswana Notes and Records, 39*, 62–74. http://www.jstor.org/stable/41236634

Melinte, C., Butnaru, G. I., & Niță, V. (2023). The Nexus Between the Travel Trends of the Young Generation and Ecotourism Development in the North East Region of Romania. In: R. Pamfilie, V. Dinu, C. Vasiliu, D. Pleșea, L. Tăchiciu eds. 2023. 9th BASIQ International Conference on New Trends in Sustainable Business and Consumption. Constanța, Romania, 8-10 June 2023. Bucharest: ASE, pp. 311-318. https://doi.org/10.24818/basiq/2023/09/010

Niță, V., Tătărușanu, M., Butnaru, G. I., Ștefănică, M., Iațu, C., & Ciortescu, R. E. (2023). Nature heritage in tourism. In L. Jarolímková & MIENAT project team (Eds.), Guidelines. Interpretation of European Nature Heritage in Tourism (pp. 1-15). Oeconomica Publishing House. https://oeconomica.vse.cz/wp-content/uploads/publication/23227/Jarolimkova_EBOOK_2023_MIENAT.pdf

Otero, E., & Ringertz, U. (2022). Case study on the environmental impact and efficiency of travel. *CEAS Aeronautical Journal, 13*(1), 163-180. https://doi.org/10.1007/s13272-021-00547-1

Peter, V. (1992). Review: Nature-based tourism. In B. Weiler & C. M. Hall (Eds.), *Special interest tourism* (pp. 105–127). Belhaven Press. Retrieved from https://eprints.jcu.edu.au/1632/

Setiawan, B., Trisdyani, N. L. P., Adnyana, P. P., Adnyana, I. N., Wiweka, K., & Wulandani, H. R. (2018). The Profile and Behaviour of ‚Digital Tourists' When Making Decisions Concerning Travelling Case Study: Generation Z in South Jakarta. *Advances in Research, 17*(2), 1-13. https://doi.org/10.9734/air/2018/43872

Ștefănică, M., Sandu, C. B., Butnaru, G. I., & Haller, A.-P. (2021). The Nexus between Tourism Activities and Environmental Degradation: Romanian Tourists' Opinions. Sustainability, 13(16), 9210. https://doi.org/10.3390/su13169210

Streimikiene, D., Svagzdiene, B., Jasinskas, E., & Simanavicius, A. (2021). Sustainable tourism development and competitiveness: The systematic literature review. *Sustainable Development, 29*(1), 259-271. https://doi.org/10.1002/sd.2133

UNTWO. (2019). International Tourism Highlights. Retrieved from https://www.e-unwto.org/doi/pdf/10.18111/9789284421152

World Bank. (2017). Tourism for Development. 20 Reasons Sustainable Tourism Counts for Development, World Bank Group. Retrieved from http://documents1.worldbank.org/curated/en/558121506324624240/pdf/119954-WP-PUBLIC-SustainableTourismDevelopment.pdf