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Fiscal (Un)Sustainability in Practice: Local Government Finance in Visegrad Economies

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Abstract

The objective of this study is to evaluate the fiscal sustainability of Local Government Units (LGUs) in the Visegrad Group economies (Czechia, Hungary, Poland, and Slovakia; the V4), focusing on three key hypotheses: (1) LGUs in the V4 are involved in so-called Ponzi games; (2) the adverse effects of such games intensified during the economic recession, the COVID-19 crisis, and the war in Ukraine; (3) primary budget balances of LGUs impact the stabilization of their debt levels. The study spans 2001–2022, encompassing significant economic disruptions. The analysis utilizes fiscal sustainability assessments, including the primary gap indicator and criteria for Ponzi-like behaviors. Key findings reveal varying degrees of fiscal sustainability across the V4, with notable disparities in resilience and debt management. The implications and recommendations emphasize the need for enhanced fiscal discipline, targeted policy adjustments, and transparent governance frameworks to address identified vulnerabilities. The paper offers a comprehensive examination of LGU fiscal sustainability in Central European economies, offering insights for policymakers and enriching the discourse on public finance management in post-transitional economies.

Keywords: fiscal sustainability, Visegrad economies, local government, public debt, budget deficit, Ponzi games

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Introduction

Public debt and budget deficits are common characteristics of many market economies. Public borrowing has been a preferred path for financing investment and current expenditures, and it is relevant for both central administrations and local government units (LGUs). This pattern is evident in numerous European Union (EU) member countries. Keynesians argue that both deficits and debt can positively influence economic development (Palatiello and Pilkington 2022). Conversely, neoclassical economists suggest that these factors may have negative effects on growth (Dombi and Dedák 2019; Misztal 2021). Nevertheless, forecasting public revenues and expenditures is crucial to managing deficits and debts effectively (Ewing et al. 2006). Additionally, the structure of the public debt market plays an important role for borrowers (Mataibayeva et al. 2019).

This research aims to evaluate the fiscal sustainability of LGUs in the Visegrad Group economies (Czechia, Hungary, Poland, and Slovakia), also known as the V4. This evaluation is anchored in three core hypotheses: LGUs in the V4 are involved in so-called Ponzi games; (2) the adverse effects of such games intensified during the economic recession, the COVID-19 crisis, and the war in Ukraine; (3) the values of LGUs' primary budget balances interfere with the stabilization of their debt volumes. The study period extends from 2001 to 2022, capturing significant events such as the global financial crisis, the COVID-19 pandemic, and the war in Ukraine.

This paper provides an overview of discussions on sustainable fiscal policy and investigates various methods used to assess fiscal stability. The research methodology employs two main approaches: first, we assess the primary gap indicator (a measure for short-term debt sustainability), and second, we evaluate the criteria for potential involvement in Ponzi games. The empirical portion of the paper presents the research results, with key conclusions and recommendations presented in the concluding section.

Literature review

The idea of fiscal stability has its roots in the writings of seminal economists like Adam Smith, David Hume, and David Ricardo (Rowley, Shughart, and Tollison 2002). The concept of fiscal stability in the contemporary literature encompasses various dimensions, with notable contributions from John and Kurian (2009), Adam (2015), Potrafke and Reischmann (2015), and Tsuchiya (2016), among others. Fiscal stability is crucial for government economic activities and public service delivery while being influenced by economic factors and regional economic risks (Fengze 2023). According to Kálmán (2023), no consensus has emerged in the literature, legislation, or legal enforcement regarding the substance of the concept of financial stability. Filipiak and Wyszkowska (2022) and Franek (2022) highlight the importance of fiscal stability in EU countries, and show how different factors, including financial crises and the COVID-19 pandemic, have impacted the public finance sector. They trace the evolution of fiscal stability towards public finance sustainability.

Many scholars have researched fiscal sustainability, especially in Central and Eastern European (CEE) contexts, including the V4, including Uryszek (2015; 2019), Sávai (2016), Krajewski, Mackiewicz,

and Szymańska (2016), Owusu (2021), Polat and Polat (2021), Wojtowicz and Hodzic (2021), and Grosu, Pintilescu, and Zugravu (2022), among others. While the outcomes of their research are not ambiguous, they are, to some extent, inconclusive. For example, Owusu (2021) rejected the fiscal sustainability hypothesis for ten CEE economies. By contrast, Polat and Polat (2021) state that fiscal policy is sustainable for the EU overall (excluding the PIIGS countries: Portugal, Italy, Ireland and Spain). Meanwhile, at the local government level, Wojtowicz and Hodzic (2021) observed a negative relationship between fiscal sustainability and efficiency in large Polish cities and stated there is a need for further research on the determinants of municipal financial sustainability.

The prevailing academic discourse on sustainable fiscal policy investigates the scale of public debt, intertemporal budget constraints, and levels of primary balances (Neck and Sturm 2008; Legrenzi and Milas 2012; Molendowski and Stanek 2012; Collard, Habib and Rochet 2015). A widely-held consensus among academics holds that fiscal authorities should avoid Ponzi games, suggesting that a continuous reliance on increasing debt, especially when benchmarked against metrics like GDP, is untenable (Wigger 2009; Minea and Villieu 2010; Martins-da-Rocha and Vailakis 2012).

A significant methodological challenge in discerning Ponzi-like behaviors among fiscal authorities is forecasting all future primary balances (net lending or net borrowing values), a process that is intrinsically susceptible to errors. The literature posits that genuine fiscal sustainability is not achieved merely by offsetting existing debt with new liabilities (Fan and Arghyrou 2013). A sustainable policy would necessitate that the aggregate of future discounted primary balances compensate for the initial level of debt, emphasizing the imperatives of maintaining primary budget surpluses and regulating public debt (Gevorkyan 2012). The significance of public trust, based on the assumption that authorities ardently seek and uphold fiscal sustainability, is paramount (Steger 2012).

Drawing upon the constructs of intertemporal budget constraints, McCallum (1992) argued that the rate of public debt growth should not outstrip the interest rate. Barro (1989) and Kremers (1989) further demonstrated that when economic growth lags the real interest rate, there's an attendant decline in the debt-to-GDP ratio.

Fiscal sustainability indicators provide a synthesized view of how an economy's fiscal policy deviates from the equilibrium by considering variables like public debt levels, economic growth trajectories, interest rates, and primary balances (Chalk and Hemming 2000). While these indices typically assume certainty in their calculations, Barnhill Jr. and Kopits (1998), Bohn (1995), Tanner and Samake 2008, and Hajdenberg and Romeu (2010) suggest that incorporating uncertainty would make the analyses more robust.

Statistical methods represent another significant approach to gauging fiscal sustainability (Burnside 2005). The pioneering work of Hamilton and Flavin (1986), which examined the sustainability of U.S. public debt, has sparked numerous analyses that focused on the stationarity and cointegration of macrofinancial variables, particularly public revenues and expenditures (Trehan and Walsh 1988; Baglioni and Cherubini 1993; Bohn 2007; Holmes, Otero, and Panagiotidis 2010; Westerlund and Prohl 2010; Afonso and Jalles 2016; Chen 2016).

In practice, indices for fiscal sustainability assessment at the local government level vary across nations and regions. For instance, the U.S. state of Michigan employs a set of metrics for fiscal oversight (Crosby and Robbins 2013).

Research has established links between local fiscal sustainability and multiple variables, including governance competencies (Okubo 2010; Tang et al. 2014), strategic development, intergovernmental fiscal relations (Ji, Ahn, and Chapman 2015; Szołno-Koguc 2021), spatial planning paradigms (Wójtowicz 2015; 2016), fiscal norms (Moździerz 2015), decentralization levels (Maličká 2016), as well as institutional and organizational frameworks (Nam and Parsche 2001).

Data sources and research methods

This part of the study presents the research methods for assessing fiscal sustainability. These universal methods can be easily employed for time series analysis and international comparisons.

The first step of the research was to calculate the primary gap indicator employed as proposed by Blanchard (1990). It can be expressed as follows (see Blanchard 1990; Chalk and Hemming 2000, p. 8):

$$d^* = (r_t - n_t)b_t, \tag{1}$$

where:
d^* represents the level of primary balance needed to stabilize the debt-to-GDP ratio,
r_t is the real interest rate of local government sector debt in period t,
n_t is the real economic growth rate in period t,
b_t denotes the volume of public debt relative to GDP in period t.

A value higher than the current primary balance level suggests that the deficit is too large (or the surplus too small) to stabilize the debt ratio, indicating that the fiscal policy is imbalanced in the short run.

In the next step of the empirical research, the Ponzi condition was examined. It can be formally presented as:

$$b_t = \sum_{j=0}^{\infty} R(t, t+j)^{-1} d_{t+j}, \tag{2}$$

where:
b_t is the outstanding public debt to be repaid in period t relative to GDP,
d_{t+j} denotes the primary balance (reduced by public debt interest) relative to GDP,
$R(t, t+j) = \prod_{k=0}^{j} R_{t+k}$ is the discount factor applied between periods t and $t + j$,
$R_{t+k} = 1 + r_{t+k}$,

r_{t+k} represents the real interest rate of public debt instruments in period $t + kt + k$, which is assumed to be the same for all assets under the assumption of perfect foresight (O'Connell and Zeldes 1988).

Equation 2 formally describes a situation where the sum of all future discounted primary balances covers the existing debt level. If this criterion is met in a particular economy, the government (fiscal agent) is not engaging in a Ponzi games, and the fiscal policy can be deemed sustainable.

The empirical formula for studying fiscal sustainability was slightly modified. To avoid ex ante estimation errors, historical data were used (22 annual observations from 2001–2022). This period seems sufficiently long given the average maturities of public borrowing instruments (see: Eurostat 2017). The following formula was used:

$$\sum_{j=0}^{22} R(t, t+j)^{-1} d_{t+j} \geq 0. \tag{3}$$

Since debt volumes are large, initial requirements for the examined economies were relaxed. The objective was to verify whether the sum of discounted primary net lending/borrowing values at the local level during the observed period was at least positive. If so, it could be concluded that the local government sector in a particular economy was at least capable of undertaking a repayment path for the existing debt level.

Subsequently, the final condition for avoiding Ponzi games was checked. This involved examining whether the sum of primary net lending/borrowing values during a given period was capable of covering the initial debt level. This can be formally written as:

$$\sum_{j=0}^{22} R(t, t+j)^{-1} d_{t+j} \geq b_0, \tag{4}$$

where:
b_0 is the initial level of local government sector debt,
other symbols are as defined in equation 2.

The study did not apply formal stationarity and cointegration tests. Most popular tests like Dickey-Fuller or Phillips-Perron could not be used due to their significant issues with test power and finite sample size (see DeJong et al. 1992). The data series seemed too short even for the DF-GLS test, which is characterized by the best overall performance in small samples (see Elliott, Rothenberg, and Stock 1996).

The empirical data were sourced from Eurostat, covering 16 annual observations from 2001 to 2021. Additionally, data regarding the debt level of local governments in 2000 was used as the initial debt level for testing involvement in the Ponzi games. Data denominated in EUR and in percentages of GDP were utilized.

Empirical results

The starting point for the empirical research was the general analysis of the main aggregates related to the fiscal sustainability of the local government sector: the fiscal balance, primary balance, and debt. For clarity, the fiscal balance (FB) represents the local government sector's net borrowing or net lending as defined by ESA 2010. The primary balance (PB) refers to the primary net borrowing or net lending, which excludes the cost of public borrowing. Lastly, 'D' denotes debt borne by the local government sector. Table 1 presents the relevant data from 2001 to 2022 for the V4 countries.

Table 1. Fiscal balance, primary balance, and debt of local government units in the V4 economies (% of GDP)

Year	Czechia			Hungary			Poland			Slovakia		
	FB*	PB**	D***	FB*	PB**	D***	FB*	PB**	D***	FB*	PB**	D***
2001	−0.4	−0.4	1.6	0.1	0.2	1.1	−0.1	−0.1	1.3	0.0	−0.1	1.3
2002	−0.4	−0.4	1.8	−0.9	−0.8	1.5	−0.3	−0.3	1.7	0.3	0.4	1.3
2003	−0.4	−0.3	2.0	−0.2	−0.1	1.5	−0.4	−0.3	1.8	0.0	0.0	1.3
2004	0.0	0.1	2.3	−0.3	−0.2	1.6	0.2	0.3	1.8	0.5	0.5	1.2
2005	−0.1	0.1	2.4	−0.5	−0.4	1.8	−0.1	0.0	2.1	0.2	0.1	1.4
2006	−0.3	−0.1	2.5	−0.8	−0.8	2.3	−0.3	−0.2	2.4	−0.1	0.0	1.6
2007	0.3	0.4	2.4	−0.1	−0.2	3.0	0.0	0.1	2.2	0.1	0.1	1.7
2008	−0.2	−0.1	2.3	0.1	0.1	3.8	−0.2	−0.1	2.3	0.1	0.0	1.7
2009	−0.6	−0.7	2.3	−0.4	−0.9	4.1	−1.1	−1.1	3.0	−0.6	−0.8	2.1
2010	−0.4	−0.4	2.5	−0.8	−1.0	4.6	−1.3	−1.2	3.8	−0.8	−0.9	2.4
2011	−0.3	−0.3	2.5	0.6	0.4	4.3	−0.9	−0.6	4.2	0.0	0.0	2.6
2012	−0.1	−0.2	2.6	0.5	0.2	3.7	−0.4	−0.2	4.2	0.3	0.1	2.4
2013	0.3	0.2	2.8	2.5	2.5	1.5	−0.2	−0.1	4.3	0.3	0.2	2.2
2014	0.2	0.2	2.7	1.3	1.4	0.1	−0.3	−0.1	4.3	−0.1	−0.1	2.2
2015	0.6	0.7	2.4	0.2	0.2	0.2	−0.1	0.1	4.2	0.1	0.3	2.3
2016	1.0	1.0	1.9	0.3	0.3	0.2	0.3	0.4	3.9	0.5	0.7	2.2
2017	0.8	0.1	1.7	0.1	0.0	0.3	0.1	0.1	3.9	0.0	0.0	2.1
2018	0.4	0.0	1.6	0.1	0.0	0.5	−0.3	0.1	3.9	0.1	0.1	2.1
2019	0.6	0.0	1.5	−0.1	0.0	0.6	−0.2	0.1	3.9	0.2	0.0	2.1
2020	0.5	−0.1	1.5	0.1	−0.1	0.6	0.2	−0.1	4.2	0.2	−0.1	2.3
2021	0.9	0.0	1.4	0.2	0.0	0.6	0.6	0.2	3.9	0.0	0.1	2.3
2022	0.8	0.8	1.3	−0.3	−0.3	0.5	−0.4	−0.2	3.3	−0.4	−0.4	2.2
Aver.	0.1	0.0	2.1	0.1	0.0	1.7	−0.2	−0.1	3.2	0.0	0.0	1.9
Std. Dev.	0.5	0.4	0.5	0.7	0.8	1.5	0.4	0.4	1.0	0.3	0.4	0.4

* FB – fiscal balance of the local government sector (net borrowing/net lending according to ESA 2010).

** PB – primary balance of the local government sector (primary net borrowing/net lending according to ESA 2010); primary balance is a fiscal balance that excludes the cost of public borrowing.

*** D – debt of the local government sector.

Source: own elaboration based on Eurostat 2024.

Czechia managed to maintain a marginally positive fiscal balance over the observed period, with an average of 0.1 and a nearly neutral primary balance of 0.0. The debt for its local government sector hovered around an average of 2.1, with fluctuations denoted by a standard deviation of 0.5. This signifies moderate variations in local government debt levels throughout the years.

In contrast, Hungary's financial metrics showed average fiscal and primary balances of 0.1 and 0.0, respectively. Local government debt averaged 1.7. However, Hungary exhibited the greatest variability among the V4, with a standard deviation of 1.5. This sizable standard deviation suggests potential fiscal challenges or greater fiscal adjustments over the specified years.

Poland's fiscal landscape demonstrated a marginally negative tendency, with average fiscal and primary balances of –0.2 and –0.1, respectively. Notably, the country's local government debt was comparatively higher, averaging 3.2, indicating a relatively greater reliance on borrowing at the local government level.

Finally, Slovakia maintained a fiscal balanced, with both its fiscal and primary balances remaining relatively neutral. Local government debt averaged 1.9, demonstrating a moderate level of indebtedness.

In summary, while Czechia and Slovakia demonstrated fiscal resilience with mild to neutral averages in their respective balances, Poland's financial metrics leaned slightly negative. Hungary's highly variable debt levels suggest potential fiscal intricacies or significant fiscal adjustments during the 2001–2022 period.

Table 2 presents the primary gap indicator for local government units within the V4. This metric provides insights into fiscal sustainability in the short run, with a negative value indicating an imbalance in fiscal policy, suggesting the fiscal deficit is too large (or the surplus too small) to stabilize the debt ratio.

Table 2. The primary gap indicator for local government in the V4 (% of GDP)

	Czechia	Hungary	Poland	Slovakia
2001	–0.35	0.17	–0.12	0.04
2002	–0.36	–0.83	–0.29	0.37
2003	–0.31	–0.13	–0.34	0.11
2004	0.10	–0.24	0.27	0.60
2005	0.07	–0.43	–0.03	0.25
2006	–0.12	–0.77	–0.18	0.06
2007	0.43	–0.16	0.13	0.30
2008	–0.14	0.06	–0.14	0.22
2009	–0.73	–0.82	–1.08	–0.71
2010	–0.44	–0.99	–1.27	–0.77
2011	–0.35	0.45	–0.74	0.06
2012	–0.19	0.24	–0.34	0.32

	Czechia	Hungary	Poland	Slovakia
2013	0.24	2.51	–0.13	0.24
2014	0.22	1.30	–0.19	–0.09
2015	0.72	0.20	0.07	0.20
2016	1.04	0.30	0.40	0.53
2017	0.87	0.10	0.27	0.04
2018	0.42	0.11	–0.09	0.17
2019	0.62	–0.09	–0.02	0.25
2020	0.40	0.06	0.15	0.13
2021	0.92	0.22	0.79	0.11
2022	0.77	–0.31	–0.22	–0.41
Average	0.17	0.04	–0.14	0.09
Std. Dev.	0.51	0.75	0.46	0.34

Source: own calculations based on Eurostat n.d.

Analysis of the data reveals distinct patterns across the V4 countries. Czechia maintained a slightly positive average of 0.17 and a standard deviation of 0.51, suggesting relatively stable fiscal sustainability with moderate fluctuations. Slovakia follows closely with an average of 0.09, demonstrating a marginally balanced fiscal stance. Its standard deviation of 0.34 is the lowest among the V4, highlighting its consistency over the years. By contrast, Poland's average of –0.14 suggests a tendency towards short-term fiscal imbalance in the short run, with observable variations in fiscal measures across the years (standard deviation of 0.46). Hungary's near-neutral average of 0.04 hides pronounced volatility in fiscal sustainability (standard deviation of 0.75; the highest among the V4).

To summarize, Czechia and Slovakia exhibit relatively healthier fiscal sustainability, with Slovakia demonstrating the most consistent approach. In contrast, Poland's metrics lean towards fiscal imbalance. Hungary, while hovering around neutrality, exhibits the most significant variability, indicating potential challenges or pronounced fiscal adjustments across the years.

Table 3 presents the initial condition of the Ponzi-like behaviors of LGUs in the V4. The values provided are particularly insightful as they gauge the fiscal path's sustainability at the local government level. Specifically, positive figures suggest that the sum of discounted primary net lending/borrowing values for the local government sector exceeds zero, indicating the potential for that particular country to embark on a sustainable fiscal path. This analysis examined whether local government sectors in these nations could begin repaying their existing debt.

Table 3. Outcomes for the initial condition of the Ponzi-like behaviors of the local government sector in the V4 economies

	EUR	
	million	EUR per capita
Czechia	5,540.13	524.63
Hungary	814.90	83.00
Poland	– 4,491.73	– 118.36
Slovakia	788.40	145.22

Source: own calculations based on Eurostat n.d.

In terms of the initial condition of the Ponzi-like behaviors of the local government sector, Czechia and Hungary exhibit positive values, implying that their local government sectors are on a potentially sustainable fiscal path. Czechia reached a value of 5.54 bn EUR (and 524.63 EUR per capita), whereas Hungary's figures stand at 0.81 bn EUR (and 83.00 EUR per capita), respectively. Conversely, Poland's negative values (–4.49 bn EUR and –118.36 EUR per capita) suggest potential challenges in achieving fiscal sustainability at the local level. Slovakia, with a modest positive of 0.79 bn EUR (and 145.22 EUR per capita), seems to be in a relatively stable position.

In summary, while Czechia, Hungary, and Slovakia show promising figures suggesting potentially sustainable fiscal paths at the local government level, Poland's data raise concerns regarding its achieving similar sustainability.

Table 4 presents the final condition of the fiscal (un)sustainability scheme (Ponzi-like behaviors) for local government sectors within the V4. An assessment of long-term fiscal sustainability hinges on the values displayed, with positive figures indicating a sum of discounted primary net lending/borrowing values that exceed the initial debt volume. Essentially, these values determine whether a country's local government sector can be deemed fiscally sustainable over the long term.

Table 4. Final condition of the Ponzi-like behaviors of the local government sector in the V4 economies

	EUR	
	million	EUR per capita
Czechia	4,526.55	428.65
Hungary	451.80	46.02
Poland	– 6,179.23	– 162.83
Slovakia	495.35	91.24

Source: own calculations based on Eurostat n.d.

Czechia and Hungary appear to be on a fiscally sustainable path. Czechia's figures are robust, with a total of 4.53 bn EUR (and 428.65 EUR per capita). Hungary, meanwhile, stands at 0.45 bn EUR (and 46.02 EUR per capita). In contrast, Poland's values (–6.18 bn EUR and –162.83 EUR per capita) raise concerns about the long-term fiscal sustainability of its local

government sector. Slovakia, while showing modest figures, also leans toward the positive side, with values of 0.50 bn EUR (and 91.24 EUR per capita).

In essence, while Czechia, Hungary, and Slovakia exhibit data suggesting potential long-term fiscal sustainability for their local government sectors, Poland's indicators are more cautionary, hinting at potential fiscal challenges in the long term.

Conclusion

The empirical findings reveal varying levels of fiscal sustainability among the V4 nations. Czechia and Slovakia consistently demonstrated fiscal resilience, maintaining positive averages and exhibiting potential for sustainable fiscal pathways in both the short and long term. Hungary's variability in its fiscal sustainability metrics indicates the possibility of fiscal adjustments or challenges over the years. Poland's indicators are the most concerning, pointing towards fiscal imbalances and potential long-term unsustainability.

The results directly address the research objectives, which aimed to evaluate whether LGUs in the V4 engage in Ponzi-like public debt practices, assess the impact of economic disruptions like the COVID-19 pandemic and the war in Ukraine on fiscal sustainability, and investigate the role of primary budget balances in stabilizing debt levels. By focusing on the research hypotheses, the study provides a structured understanding of the fiscal dynamics across the V4, grounding its conclusions in empirical evidence.

The added value of this research lies in its application of a comprehensive methodological framework for assessing both short-term and long-term fiscal sustainability. Utilizing the primary gap indicator and Ponzi games criteria, the study provides a framework for evaluating fiscal sustainability at the local government level – a critical aspect of public finance. By offering a comparative analysis of the V4, it provides actionable insights for policymakers and enriches the ongoing debate on fiscal management in transitional economies.

The literature review indicated an academic consensus against the perpetuation of Ponzi schemes and emphasized genuine fiscal sustainability. The primary gap indicator, a measure of short-term fiscal stability, and the conditions of the Ponzi games involvement, which gauged long-term sustainability, provided essential frameworks for the empirical evaluation. The review also highlighted the significance of public trust and the need for authorities to actively seek and uphold fiscal sustainability.

Given the pivotal role that LGUs play in public borrowing and the current fiscal trajectory of the V4 nations, several policy implications emerge:

1. Emphasis on fiscal resilience: countries displaying fiscal resilience, such as Czechia and Slovakia, should continue to uphold and strengthen their fiscal policies, ensuring that they remain adaptable to future economic uncertainties.
2. Addressing variability: Hungary's pronounced variability signals the need for a more stable fiscal policy approach, potentially involving recalibrations or adjustments to address the fiscal challenges or fluctuations observed.

3. Intervention for fiscal imbalance: Poland's indicators, which lean towards fiscal imbalances, require immediate policy interventions. The country must reassess its fiscal strategies at the local government level to correct course and move towards a more sustainable path.

4. Reinforcing public trust: all V4 countries should prioritize maintaining and enhancing public trust, ensuring transparent communication regarding fiscal policies, and taking actions that affirm their commitment to fiscal sustainability.

In conclusion, this study underscores the multifaceted nature of fiscal sustainability across the V4 nations, emphasizing the need for tailored policy interventions and a unified commitment to achieving long-term fiscal stability.

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(Nie)zrównoważenie fiskalne w praktyce: finanse samorządowe w gospodarkach Grupy Wyszehradzkiej

Celem artykułu jest ocena stabilności fiskalnej jednostek samorządu terytorialnego (JST) w gospodarkach Grupy Wyszehradzkiej (krajach V4) z uwzględnieniem trzech kluczowych hipotez: (1) JST w krajach V4 realizują tzw. gry/schematy Ponziego; (2) negatywne skutki korzystania z tego schematu nasiliły się w czasie recesji gospodarczej, kryzysu COVID-19 i wojny w Ukrainie; (3) poziomy pierwotnego salda budżetowego JST wpływają na stabilizację poziomów ich zadłużenia. Badanie obejmuje lata 2001–2022, uwzględniając najważniejsze zakłócenia w gospodarce. Do analiz wykorzystano metody oceny stabilności fiskalnej, w tym wskaźnik luki pierwotnej i kryteria realizacji schematu Ponziego. Kluczowe wyniki ujawniają zróżnicowany poziom stabilności fiskalnej w Czechach, na Węgrzech, w Polsce i na Słowacji, z zauważalnymi różnicami w odporności fiskalnej i zarządzaniu długiem. Implikuje to konieczność wzmocnienia dyscypliny budżetowej, korekt prowadzonej polityki oraz przejrzystych ram zarządzania publicznego w celu zaradzenia zidentyfikowanym słabościom. Artykuł stanowi kompleksową analizę stabilności fiskalnej JST w krajach Europy Środkowej, oferując istotne wnioski dla decydentów politycznych i wzbogacając dyskusję na temat zarządzania finansami publicznymi w gospodarkach po transformacji.

Słowa kluczowe: zrównoważenie fiskalne, gospodarki Grupy Wyszehradzkiej, jednostki samorządu terytorialnego, dług publiczny, deficyt budżetowy, gry/schematy Ponziego

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Organic Animal Products in the EU to Support Sustainable Consumption

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Abstract

A critical analysis of the research discourse on the development of organic farming is imperative if it is to contribute to the spread of sustainable consumption patterns, as indicated in the European Green Deal (EGD). However, there is a notable dearth of research from a macroeconomic perspective. What and how much we consume affects human health and the environment. Therefore, there is a need to increase consumer awareness of the consequences of food choices, as organic animal products can contribute to sustainable consumption and production. The study aims to determine the level of development of the production of organic animal products in European Union (EU) countries. Synthetic indicators of the development level of EU countries in 2016 and 2020 were constructed based on the Principal Components Approach (PCA) using Eurostat data. A survey and literature review shows that countries at the top of the ranking, such as Denmark, Sweden, Finland and Austria, have active policies to support the development of organic agriculture on both the supply and demand sides. On the other hand, a divergence in the factors that influence the development of organic agriculture was also observed in the top-ranked countries. Therefore, the development of organic agricultural production, including organic animal products, requires the diffusion of experiences across the EU to support the multifaceted OAFR (organic agriculture and food research) paradigm and the Sustainable Development Goals.

Keywords: organic animal products, organic farming, OAFR, level of development, sustainable consumption, European Green Deal, sustainable development goals

JEL: O11, O13, Q5, Q13, Q18

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Introduction

Organic agriculture is a tool to support sustainable food systems, including the 12th Sustainable Development Goal[1]. Achieving this goal requires the implementation of sustainable consumption and production programmes, the sustainable management and efficient use of natural resources, the reduction of food waste, and the raising of consumer awareness of the possibilities of a lifestyle compatible with nature (UN 2022). Food consumption and production patterns are still unsustainable from both human health and environmental perspectives (Komisja Europejska 2020). Therefore, an informed consumer is an important link in creating a sustainable agri-food system that aligns with the development of organic agriculture and the achievement of the Sustainable Development Goals (SDGs) (Talwar et al. 2021).

The European Green Deal (EGD) strategy is designed to combat climate change and environmental degradation. Its overarching goal is to achieve a zero-emissions economy by 2050, and within that, at least 25% of agricultural land in the EU should be devoted to organic farming by 2030. Within the three priorities of the strategy, the development of organic farming has been identified as a key objective. A number of courses of action have been identified to stimulate demand for organic food products, nurture consumer confidence, and stimulate conversion along the entire agri-food system chain. Furthermore, specific actions and the importance of sustainable consumption have been outlined in the Farm to Fork strategy (European Commission 2022). The EC defines organic production as farm management that ensures best environmental practices, the maintenance of a high level of biodiversity, the maintenance of high animal welfare, the protection of natural resources, and respect for consumer preferences (COM 2014). This broad definition of organic agricultural production outlines the three basic functions that organic farming is expected to perform: to protect the environment, to meet food demand and to protect animal welfare. While it seems that these functions should work together, from the perspective of achieving SDGs, without ensuring stability in the social area – including the eradication of poverty – environmental issues will often be downplayed (Rawort 2021).

The challenge for organic farming is to ensure that the global population has access to sufficient food ("feeding the world"). In 2022, nearly 30 per cent of the world's population lacked consistent access to food, with 900 million experiencing severe food insecurity while about two billion people suffer from obesity (The Intergovernmental Panel on Climate Change 2022). Approximately one-third of the food produced annually (1.3 billion tonnes) is wasted in households, shops, transport, and as a consequence of suboptimal harvesting practices (United Nations n.d.). These statistics illustrate the unsustainability of the global agri-food system. Organic farming development could increase the availability of food locally and thus shorten supply chains, which would have a positive impact on reducing food waste. Nonetheless, this aspect needs to be analysed further. Studies show that, on the one hand, an increase in the availability of organic food products in supermarkets has a positive impact on the demand for organic food products. On the other hand, consumers are not interested in buying organic food products due to higher

1 The twelfth sustainable development objective refers to responsible consumption and production, and the article will use the nomenclature of sustainable consumption and production for the sake of uniformity.

prices or a lack of trust in certification methods (Gutkowska and Batóg 2016; Kaczorowska, Rejman, and Nosarzewska 2018; Bialik and Śmieja 2019; Maciejewski 2020; Talwar et al 2021; Malissiova et al. 2022).

Furthermore, the role of livestock in "feeding the world" context is of particular significance. On the one hand, animal husbandry is crucial for generating food, while on the other hand it has a negative impact on the environment and thus climate change. Livestock represents an important link in sustainable land use, and livestock production is an essential part of the entire agri-food system chain. The challenge of "feeding the world" requires a multidimensional approach that acknowledges the role of organic agriculture in food security. Research should focus on reducing the yield discrepancy between conventional and organic agriculture while simultaneously promoting sustainable consumption and production (Rahmann et al. 2017). Enhanced productivity in organic farming is contingent upon the provision of effective investment support and the development of requisite skills (Mei et al. 2022).

The discourse surrounding research into the development of organic agriculture requires a critical analysis of its characteristics, considering both its potential diffusion and an understanding of its limitations. An issue frequently encountered in the analysis of organic farming research is its diffuse nature, particularly its micro-economic aspect. Research is often based on a case study, which leads to a proposal for a systemic solution, and the conclusions relate to a specific farm or group of stakeholders. Therefore, it is not possible to generalise the results to the entire OAFR (organic agriculture and food research) system, as they are determined by the specific conditions of the farming system on a particular farm or in a particular region, for example (Freyer, Bingen, and Fiala 2019).

A macroeconomic analysis is required to determine the level of development of organic animal product production in the EU. This analysis is part of the process of satisfying consumer demand for food, including the challenge of "feeding the world". However, this study represents only a preliminary investigation into the potential for organic farming to contribute to the development of a sustainable food system. It aims to provide insights into the opportunities for organic farming to support sustainable consumption and production within the context of the SDGs.

Organic food products in the light of sustainable consumption

Achieving both the EDG and SDG goals necessitates the implementation of sustainable, responsible consumption practices. Thus, there is a continued need to educate consumers about the consequences of their purchasing choices, including food products, as the quantity and type of food consumed affects human health and the environment (Szubska-Włodarczyk 2022).

The demand for organic food products is strongly influenced by a number of factors. Wheeler (2006) demonstrated that the availability of organic products in supermarkets is a significant factor. Ladwein and Sánchez Romero (2021) highlighted the role of public institutions in financing activities for sustainable consumption and production, which is crucial for building trust between consumers and actors along the supply chain. Furthermore, Verburg, Verberne, and Negro

(2022) emphasised the need to support the demand side by promoting consumer awareness of organic farming.

Diagourtas, Kounetas, and Simaki (2022) analysed the purchasing motives of organic food consumers from two different European markets, Greece (a developing market) and Sweden (a developed market), were analysed. They found that consumer awareness was an important factor that influences the development of the organic food market. Swedish consumers were characterised by high environmental awareness and a demonstrated interest in sustainability. In contrast, Greek consumers were characterised by low environmental awareness and a lack of concern for animal welfare. However, they observed that health concerns play a significant role for them.

Stoica (2021) noted that low consumer awareness in Romania represents a significant barrier to the development of organic farming. However, there has been an increased interest in organic products due to the COVID-19 pandemic.

Table 1. Demand for organic food products in EU countries in 2016 and 2020

Country	2016			2020			2023		
	Organic consumption per capita [€/person]	Organic retail sales [€ million]	Organic retail sales share [%]	Organic consumption per capita [€/person]	Organic retail sales [€ million]	Organic retail sales share [%]	Organic consumption per capita [€/person]	Organic retail sales [€ million]	Organic retail sales share [%]
Austria	177.39	1541.6	8.2	253.63	2265	11.3	292.00	2657	11.00
Belgium	53	600	2.39	77.24	892	3.2	101.00	1153.00	4.0
Bulgaria	3.91	28.01	0.47	5	33.27	1	5.85	37.77	1
Croatia	23.5	99.3	2.2	24.18	99.3	2.2	24.18	99.3	2.2
Czech Republic	9.15	93.56	0.9	21.91	225.97	1.77	25.14	274.11	1.70
Denmark	243.9	1392	10.5	383.58	2240	13	362.00	2159	11.80
Estonia				57	76.5	4.3	81.27	111.00	4.60
Finland	49.75	273	2	73.9	409	2.6	63.26	352.00	1.90
France	100.89	6736	3.8	190.12	12831	6.57	176.00	12081	5.60
Germany	116.4	9478	4.97	180.25	14990	6.8	190.61	16080	6.30
Greece	5.6	66	0.32	5.6	66	0.31	5.92	60.00	–
Hungary	3.04	30	0.3	3.04	30	0.3	3.04	30	0.3
Ireland	33.85	160	1.94	47.33	235	2.73	32.65	165.15	2.73
Italy	43.58	2644	3	64.14	3872	3.5	65.80	3882	3.5
Latvia	2	4	0.2	6.32	51	1.5	6.32	51	1.5
Lithuania	2	6	0.2	17.8	50.5	1	17.8	50.5	1
Luxembourg	188	108	6.2	284.6	170.87	9.11	227.65	151.39	7.20
Netherlands	62.77	1070.9		78.19	1361.13	3.26	90.65	1614.60	4.59

Country	2016			2020			2023		
	Organic consumption per capita [€/person]	Organic retail sales [€ million]	Organic retail sales share [%]	Organic consumption per capita [€/person]	Organic retail sales [€ million]	Organic retail sales share [%]	Organic consumption per capita [€/person]	Organic retail sales [€ million]	Organic retail sales share [%]
Poland	4.39	167	0.39	8.28	314.12	0.62	8.23	310.00	0.57
Romania	2.06	40.65	0.15	2.06	40.65	0.15	2.06	40.65	0.15
Slovenia	26.6	48.6	1.8	26.6	48.6	1.8	26.6	48.6	1.8
Spain	36.33	1 641	1.69	53.4	2 528	2.48	57.14	2 747.80	2.53
Sweden	224	2 207	7.9	212.32	2 192.8	8.7	219.55	2 310.00	7.80

Source: FiBL Statistics n.d.

The largest market for organic food products in the EU is in Austria, Denmark, France, Germany, Italy, Portugal, and Sweden. The statistical consumer spends the most on organic food in Denmark, with an average expenditure of €362. This is followed by Austria (€292), Sweden (€219.55), France (€176), and Germany (€190.61). A comparison of the rate of retail sales of organic food products in both 2016 and 2020 reveals that Austria, Denmark, Finland, France, and Germany exhibited the highest levels of sales. Austria, Denmark, France, Germany, Luxembourg, and Sweden had the highest share of spending on organic food in general, with consumers spending between 6.57% and 13% of their expenditure on organic food in general. Comparing the data reveals that, in most leading countries, there was a decline in the rate of retail sales of organic products in 2016, 2020 and 2023, although the amount grew in absolute terms.

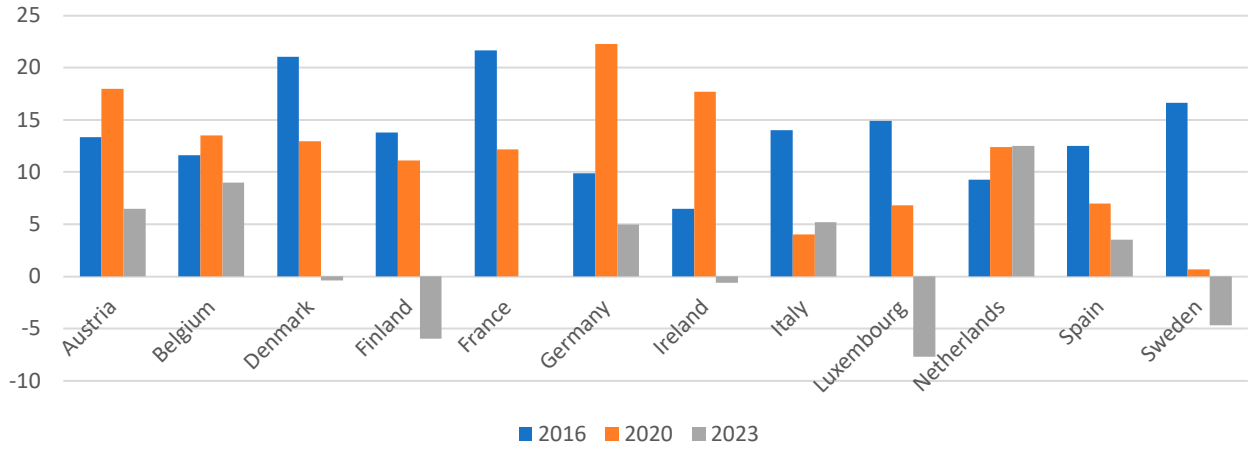

Figure 1. Organic retail sales growth (1 year) [%]

Source: FiBL Statistics n.d.

The following countries were also included in the study: Belgium, Croatia, Estonia, Finland, Ireland, Italy, the Netherlands, and Spain. In these countries, the share of organic food in total food expenditure was between 2% and 5%. The last group comprises the Czech Republic, Greece, Hungary, Lithuania, Latvia, Poland, Romania, and Slovenia, where the share of organic food expenditure ranged between 0.15% and 2%. In 2023 there was an overall decrease in the share

of organic food products in total food expenditure, excluding Belgium, Estonia, Netherlands and Spain, compared to 2020.

Organic farming alone cannot achieve both the SDGs and the EU's goal of a zero-emissions economy. Research shows that only a drastic change in diet, which would involve a 54–71% reduction in meat consumption and a 62–78% increase in local food consumption, would reduce EU greenhouse gas emissions by almost half. Without such changes, it will not be possible to achieve the SDGs and mitigate climate change. It has also been shown that to make changes in dietary patterns more realistic, it would be necessary to introduce a consumption tax on meat of over 70%, together with import duties and production taxes (Röös 2022). However, this is a highly contentious issue taking into account the goal of "feeding the word" and the widening of social inequalities in view of income disparities. Thus, organic farming could be one of the solutions to help achieve environmental SDG and climate change targets. For example, total energy consumption per unit of product is, on average, 15% lower in organic farming than in conventional farming (Rahmann et al. 2017). On the other hand, research shows that the benefits of developing additional/larger areas for organic crops would be offset by the greenhouse gas emissions generated by converting them (Purnhagen et al. 2021).

Furthermore, increasing the share of organic agricultural land may not always have positive results when considering the challenge of "feeding the world". Rasche and Steinhauser (2022) showed that increasing the share of organic land in Germany to 30% by 2030 could result in a calorie deficit of 7–80 kcal per capita per day, compared to the absence of 1,000–5,000 km^2 of arable land. It was estimated that the deficit would disappear by 2045, taking into account demographic and technological developments. However, the emergence of a calorie deficit would undoubtedly have a negative impact on the global food system and agri-food supply chains.

On the other hand, if crop productivity increases, there would be no need for additional agricultural land. Increasing the share of organic farming will only be possible if technological advances are made to minimise the unsustainable food system that could result. Kuosmanen et al. (2021) confirmed that the production efficiency of organic farms in Finland is lower than that of conventional farms. With the same amount of resources, organic farms produce less. However, they found that this difference is decreasing over the years.

Methodology

In the literature, most of studies analysed the level of development in regional terms while looking at the microeconomic aspects of organic farms (Jeločnik et al. 2015; Czyżewski, Matuszczak, and Muntean 2018; Antczak 2019; 2021; Smoluk-Sikorska, Malinowski, and Łuczak, 2020; Pépin, Morel, and van der Werf 2021; Smoluk-Sikorska and Malinowski 2021). The conducted research used the Hellwig method, TOPSIS, zeroed unitarisation, Factor Analysis of Mixed Data and agglomerative hierarchical clustering (AHC). Therefore, there is a need for a macroeconomic analysis of how organic agriculture is developing in the EU.

Synthetic indicators of organic animal products for EU countries were constructed using the Principal Component Analysis (PCA) method. The PCA method makes it possible to reduce the diagnostic

characteristics to several main components, facilitating interpretation. The principal components do not lose their informative value (Panek 2009). The values of the eigenvectors are interpreted as correlation coefficients of individual principal components with the variables considered (Kwiatkowski and Roszkowska 2008). Using the value of the first principal component, it is possible to determine which diagnostic variable has a greater influence on the phenomenon under study (Kolasa-Więcek 2012). A detailed description of the principal component method can be found in, among others, Radhakrishna (1964), Morrison (1990), Ostasiewicz (1998), Aczel (2000), Krzyśko (2000), and Jolliffe (2002). This method can be found in Hellwig (1968), while Pluta (1974, p. 197; 1976) used the analysis of variance to construct a synthetic indicator. The PCA method was used by Kociszewski and Szubska-Włodarczyk (2023) to construct a synthetic indicator of the efficiency of ecological plant and livestock production[2]. This study is a continuation and extension of that work.

Synthetic indicators for organic animal products have been compiled for as many EU Member States as possible using data from Eurostat. However, the statistics on organic farming that were selected for the construction of the indicators are not complete for all EU countries such as Belgium, Finland, Germany, Greece, Portugal, Slovenia. Therefore, these countries have been omitted from further analysis. Considering the amount spent on organic food products per capita and the amount of animal products consumed per capita, the availability of data for Germany and Belgium might influence the ranking results. Synthetic indicators have been constructed for 2016 and 2020. The choice of years was determined by data availability. Where no data were available for a particular diagnostic variable in a given year, the average of two values from the previous and the following year was used where possible, or the previous year was used. This was done to keep as many countries as possible for further analysis.

The selection of variables was largely limited by the availability of data for individual countries, as well as focusing on variables that fit into animal products (mainly dairy products). The production of these types of food products has a significant impact on the environment. For example, the production of 1 kg of cheese consumes on average 5,605 litres of water and emits 23.88 kg of greenhouse gases (Ritchie, Rosado, and Roser 2022). The synthetic indicator for organic animal products was constructed with the following diagnostic variables:

- x_1 – raw milk (tonnes/dairy cows (head)),
- x_2 – cream (tonnes/dairy cows (head)),
- x_3 – butter (tonnes/dairy cows (head)),
- x_4 – cheese (tonnes/dairy cows (head)),
- x_5 – eggs for human consumption (thousand/hens),
- x_6 – acidified milk (yoghurts and others) (tonnes/dairy cows (head)).

Due to large amounts of missing data for individual EU countries for selected diagnostic variables, the study included several versions of indicators with different sets of diagnostic variables.

2 In this paper, we focused on determining synthetic indicators of organic animal products was undertaken. Consequently, organic food products such as meat were omitted from the selection of variables. This approach is similar to that used by Kociszewski and Szubska-Włodarczyk (2023), who also developed similar indicators.

In Variant I from 2016 and 2020, the synthetic indicator includes variables x_1, x_2, x_3, x_4, x_5, and x_6. Variant II included x_1, x_2, x_3, x_4, and x_6.

Results

Table 2 shows the vectors of eigenvalues of the first principal component for the variables analysed in each variant. When analysing Variants I and II for 2016, variables x_1 and x_2 had the greatest impact on the value of the first principal component, followed by variable x_3. The situation is different for 2020. In Variant I, variables x_1 and x_3 had the greatest influence on the value of the first principal component in this period. In Variant II, on the other hand, variables x_2, x_3 and x_4 had the greatest influence. Variable x_5 can be said to have quite a significant impact on the value of the first component. However, it has been removed from the construction of the synthetic indicator for Variant II in order to include Hungary in 2016 and Hungary, Greece, Italy and Slovakia in Variant II from 2020 onwards.

Table 2. Vectors of eigenvalues of the first principal component for diagnostic variables analysed

Variable	Eigenvalues of the first principal component			
	I 2016	II 2016	I 2020	II 2020
x_1	0.4938	0.5585	0.4942	0.3280
x_2	0.4642	0.5173	0.4377	0.5375
x_3	0.4434	0.4980	0.4749	0.5442
x_4	0.2169	0.2629	0.3211	0.5278
x_5	0.4193	–	0.4190	–
x_6	0.3482	0.3215	0.2449	0.1696

Source: own elaboration.

The average yield of organic animal[3] products included in the synthetic indicator increased between 2016 and 2020. The average production of organic milk increased from 4.9 tonnes/head –5.0 tonnes/head in the 2016 variants to 5.5 tonnes/head in 2020. Other products also show an increase in average production, although productivity remained low. For example, the average production of organic butter increased from 0.02 tonnes/head to 0.03 tonnes/head – 0.04 tonnes/head in 2020, depending on the variant. Elsewhere, the average production of organic eggs increased from 0.17 thousand/hens in 2016 to 0.20 thousand/hens in 2020. For Variant I, the average production of organic cheese decreased slightly from 0.23 tonnes/head in 2016 to 0.13 tonnes/head in 2020. For Variant II, the decrease is negligible. The average production of organic cheese was 0.22 tonnes/head in 2016 and 0.21 tonnes/head in 2020. Looking at organic acidified milk, it is also difficult to see an increase in the average efficiency. In 2016, it was 0.25 tonnes/head or 0.26 tonnes/head, depending on the variant. In 2020, however, it was

3 Tables with the average production efficiency of the individual organic animal products included in the synthetic indicators for each EU country are in the Appendix.

0.31 tonnes/head or 0.35 tonnes/head. The efficiency of organic cream production did not change and remained at 0.02 tonnes/head.

Below is the ranking of EU countries based on the value of the designated synthetic indicator for organic animal products.

Table 3. Ranking of EU countries according to designated synthetic indicators for organic animal products

I 2016		II 2016		I 2020		II 2020	
Country	Ranking	Country	Ranking	Country	Ranking	Country	Ranking
DK	1	DK	1	DK	1	IT	1
SE	2	EL	2	FR	2	DK	2
NL	3	SE	3	NL	3	FR	3
EL	4	NL	4	SE	4	CY	4
FR	5	FR	5	CY	5	NL	5
AT	6	AT	6	AT	6	AT	6
CY	7	CY	7	LT	7	SE	7
IE	8	IE	8	IE	8	EL	8
IT	9	EE	9	ES	9	IE	9
LT	10	LT	10	EE	10	LT	10
CZ	11	IT	11	BG	11	ES	11
EE	12	ES	12	CZ	12	EE	12
ES	13	HU	13	RO	13	HU	13
RO	14	CZ	14	LV	14	BG	14
LV	15	LV	15	HR	15	LV	15
HR	16	BG	16	PL	16	SK	16
PL	17	RO	17			CZ	17
BG	18	SK	18			HR	18
SK	19	HR	19			RO	19
		PL	20			PL	20

Source: own elaboration.

When analysing the ranking, Denmark was in first place in all variants, except for Variant II in 2020. In that case, Italy took first place due to its high production of organic cheese compared to Denmark (IT – 1.56 tonnes/head, DK – 0.2 tonnes/head). Italy also had the highest production of organic butter (0.4 tonnes/head) and organic cream (0.33 tonnes/head). In comparison, Denmark produced, on average, 0.1 tonnes/head organic cream and 0.16 tonnes/head organic butter. When analysing the average yields for this variant, Denmark produced the most organic milk (9.2 tonnes/head), followed by Sweden (8.4 tonnes/head), Cyprus (8.2 tonnes/head), the Netherlands (7.9 tonnes/head), France (7.2 tonnes/head) and Austria (5.6 tonnes/head). The lowest efficiency of organic milk production was found in Poland (2.4 tonnes/head).

Comparing the statistics above with Variant II from 2016, in which organic eggs were removed from the set of variables to keep as many countries as possible in the ranking, Denmark is also in first place, followed by Greece, Sweden, the Netherlands, France and Austria. Poland came last. Comparing the ranking with the average production efficiency of the individual variables, the most organic milk was produced by Greece (10.4 tonnes/head), Denmark (8.9 tonnes/head), the Netherlands (7.7 tonnes/head), and Sweden (7.6 tonnes/head). This was followed by Italy (5.2 tonnes/head), Austria (5.2 tonnes/head), and France (5.0 tonnes/head). The highest average production of organic cream was recorded in Sweden and Denmark (0.1 tonnes/head each). Denmark (0.1 tonnes/head), the Netherlands (0.09 tonnes/head), and France (0.08 tonnes/head) are among the leaders in the efficiency of organic butter production. Greece leads in the average efficiency of organic cheese production (2.0 tonnes/head), followed by Cyprus (0.4 tonnes/head) and Austria (0.3 tonnes/head). The highest average production of acidified milk was in Ireland (1.0 tonnes/head), the Netherlands (0.7 tonnes/head), Cyprus (0.6 tonnes/head), and Sweden (0.5 tonnes/head). In Variant I of 2016 and 2020, all variables were used to construct the indicator. The average efficiency of organic egg production was 0.17 thousand/hens in 2016 and 0.20 thousand/hens in 2020. In 2016, the leading countries in terms of efficient organic egg production were Sweden, France, the Netherlands, Italy and Ireland. In 2020, it was Denmark, Sweden, the Netherlands, Ireland, and France.

The development of organic animal production in the context of promoting sustainable consumption

The article attempts to determine the level of development of organic animal production in the EU. Organic animal products have been treated as "the lesser of two evils" on the way to sustainable, responsible consumption due to the lower energy consumption per unit of product and the concept of organic agricultural production itself. However, scientific research confirms that it will be impossible to achieve the EU's environmental targets and the SDGs without reducing the consumption of meat and animal products (Rahmann et al. 2017; Purnhagen et al. 2021; Talwar et al. 2021; Röös 2022).

The implementation of SDG 12 through organic farming seems justified, considering the principles of this type of production. Organic agricultural production means avoiding the use of artificial fertilisers, pesticides, antibiotics, animal growth hormones and GMOs while maintaining biodiversity and natural biological cycles and ensuring a high standard of animal welfare (European Union 2007; 2008). Additionally, organic food is less harmful to health (Taghikhah et al. 2020). For example, organic milk is richer in omega-3 polyunsaturated fatty acids, carotenoids, and vitamins E, B2, and B9 than conventionally produced milk, while organic meat contains more bioactive compounds than meat produced using conventional methods (Duru et al. 2017).

Organic farming in the EU is developing at different rates in different countries, taking into account, for example, the share of organic land in the total agricultural area. For example, it is 25.7% in Austria, 22.4% in Estonia, 20.3% in Sweden, 16% in Italy, 15.3% in the Czech Republic, 14.8% in Latvia, 13.9% in Finland, 11.7% in Slovakia, 11.45% in Denmark, 10.1% in Greece,

8.7% in France, 7.25% in Belgium and 3.9% in the Netherlands. Analysing the results of the study, it can be concluded that the level of development is not solely dependent on the share of organic agricultural area. The countries at the top of the ranking, such as Denmark, the Netherlands, and France, do not exhibit a unique share of organic agricultural area in the EU. On the other hand, Sweden, which is at the top of the ranking, has the third highest share of organic agricultural area. A similar example is Italy, which moved from ninth and eleventh place in the 2016 variants of the indicator to first place in Variant II in 2020. Austria, which has the highest share of organic agricultural area, ranks sixth in each variant.

Therefore, it seems that the level of development of organic farming should be identified with more than just the share of organic agricultural area in general. Going a step further, Purnhagen et al. (2021) raised concerns about the EU's targets for organic farming, which shows an increase in carbon dioxide emissions as a result of additional land conversions.

What then influences the level of organic farming development in the EU? Daugbjerg (2023) showed that the introduction of public procurement programmes for organic food in public institutions in Denmark and Sweden helped the organic food and agriculture sector expand. Palšová et al. (2014) showed that after the introduction of policy changes in Slovakia, the development of organic agriculture was noticed through the obligation to increase the area of organic crops in Slovakia and the possibility for farmers to receive subsidies for establishing organic agricultural production. However, organic livestock production dominated organic crop production.

On the other hand, when analysing Slovakia's ranking, which was in 19th or 18th place in 2016, depending on the variant, and in 16th place in 2020 in Variant II, it is evident that the policy contributed to the development of organic agriculture, which is visible in the ranking classification and in the share of organic agricultural area (11.7%). However, it also confirms the observation that the increased share of organic agricultural area should not be the only measure/determinant of organic agriculture development in terms of the implementation of sustainable consumption. Countries with a lower share of organic areas, such as the Netherlands, Denmark, France, and Belgium, were higher in the ranking.

Kujala, Hakala, and Viitaharju (2022) demonstrated that many factors contribute to regional differences in the share of organic land in Finland. However, the key factor for areas with the highest shares is the long tradition of organic heritage. In some Finnish regions, initiatives to support the development of organic farming were established as early as the 1980s, such as extension services (the Mikkeli eco-county and the Partala Rural Development Centre for research on organic farming).

In Sweden, policies to limit the use of pesticides and artificial fertilisers in agriculture began to be implemented as early as the 1980s, and the main Swedish certification body for organic products (KRAV) was established. In addition, a tax was levied on the prices of pesticides and fertilisers, with the revenues used for research into eliminating the use of chemicals in agriculture and to spread awareness and education in this area (Lohr and Salomonsson 2000). In addition to production targets (i.e., increasing the area under organic farming to 30% by 2030), Sweden also set consumption targets to increase demand for organic food, introducing a law that requires a 60% share of organic food in public procurement (Basnet et al. 2023).

The current food system includes large amounts of animal products and processed foods. Increasing food self-sufficiency and reducing the negative impact of consumption on the natural environment can be achieved by reducing consumption of mainly animal products while increasing domestic production of cereals, pulses, and potatoes (Basnet et al. 2023).

Table 4. Total per capita consumption of selected animal products in the EU

	Per capita milk consumption [kg]			Per capita egg consumption [kg]		
	2016	2020	Relative change [%]	2016	2020	Relative change [%]
Austria	185.65	188.23	1	13.95	13.99	0
Belgium	107.64	133.38	24	7.42	13.84	86
Bulgaria	140.03	127.06	– 9	8.19	4.98	– 39
Croatia	211.95	161.04	– 24	9.62	8.32	– 14
Cyprus	116.86	157.01	34	7.62	6.49	– 15
Czech Republic	143.75	157.14	9	8.94	10.27	15
Denmark	234.57	241.16	3	15.95	15.02	– 6
Estonia	270.62	279.54	3	12.94	12.41	– 4
Finland	358.18	258.80	– 28	10.74	11.37	6
France	183.19	200.90	10	11.64	14.11	21
Germany	164.54	209.63	27	13.02	15.38	18
Greece	224.95	200.32	– 11	8.75	8.67	– 1
Hungary	165.69	175.05	6	13.70	14.55	6
Ireland	203.66	238.47	17	8.77	9.06	3
Italy	181.32	184.09	2	11.76	11.49	– 2
Latvia	165.71	197.29	19	11.21	13.41	20
Lithuania	102.65	223.99	118	15.46	11.83	– 23
Luxembourg	102.53	93.84	– 8	15.38	16.26	6
Malta	98.42	93.03	– 5	10.14	9.61	– 5
Netherlands	311.44	256.24	– 18	22.24	21.86	– 2
Poland	164.81	173.06	5	7.25	8.63	19
Portugal	133.51	138.99	4	9.04	10.09	12
Romania	234.12	211.04	– 10	14.15	12.84	– 9
Slovakia	172.99	144.82	– 16	11.88	9.46	– 20
Slovenia	135.03	168.61	25	9.63	9.52	– 1
Spain	160.80	154.56	– 4	14.74	14.65	– 1
Sweden	176.59	210.76	19	13.83	13.27	– 4

Source: own elaboration based on Ritchie, Rosado, and Roser 2017.

Milk and egg consumption varies between EU countries. The highest per capita consumption of milk, of 200 kg or more, is found in Sweden, Romania, the Netherlands, Lithuania, Ireland, Greece, Germany, France, Finland, Estonia, and Denmark. The per capita consumption of eggs is highest in the Netherlands, with an average of 21.86 kg per inhabitant in 2020. Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Luxembourg, Portugal and Romania also have egg consumption per capita ranging from 10 to more than 16 kg.

In 2020, 154 million tonnes of milk was produced in the EU. The largest milk producers are Germany (32.5 million tonnes), France (24.8 million tonnes), Poland (14.9 million tonnes), the Netherlands (14.2 million tonnes) and Italy (13.2 million tonnes). In the EU alone, 10.3 million tonnes of cheese were produced in 2021. The largest producers were Germany (2.4 million tonnes), France (1.9 million tonnes), Italy (1.4 million tonnes), Poland (993,000 tonnes) and the Netherlands (984,000 tonnes) (Krajowy Ośrodek Wsparcia Rolnictwa 2023, pp. 5–12). For example, research conducted in France shows that dairy farmers believe that organic farming increases their adaptability to changing market conditions. It can increase their adaptability by reducing risk, stimulating learning, increasing job satisfaction and allowing them to maintain a family farm. This is due to the belief that organic milk prices are higher, prices are more stable, and feed autonomy is increased, thus limiting the risk of increasing production costs (Bouttes, Darnhofer, and Martin 2019).

The differences in organic milk production methods across the EU are the result of topography, land availability and legislation. The development of this form of organic farming requires the exchange of knowledge, experience and advice between farms across the continent. Research in seven EU countries showed that the lowest levels of organic milk production and the smallest herd sizes were found on Polish and Austrian farms, while the highest levels were found in Denmark, Sweden, and northern Germany. Farms in the Netherlands, Germany, Denmark, and Sweden were characterised by high intensity.

The greatest diversity was observed in Austria and Germany due to the different dairy systems, i.e., lowland and mountain. The diversity included the size of the herd and the area of arable land used for fodder production and pastures. The automated milking system was predominant in Germany, Denmark and Sweden, i.e., countries where the culture of automated milking systems also prevails in conventional production. There were also differences in the proportion of animals slaughtered due to, among other things, differences between breeds. A lower rate of organic milk production was found in Lithuania. However, the rate is higher on highly efficient dairy farms in Sweden and Germany. High production intensity is associated with shorter animal life and reduced fertility (Wallenbeck et al. 2019).

Looking at the top countries in the ranking, strong growth in organic dairy cattle can be seen in Austria and Denmark. In the Netherlands, however, this type of production has developed more slowly due to the lack of government support in the early 1990s. The focus was on supporting conventional agriculture to increase the competitiveness of the sector and develop exports of conventional agricultural products. Additionally, organic farms were not considered when it came to reducing emissions from natural fertilisers. Organic farmers produce animal products

at lower densities, but the rules have not been relaxed for them. In addition, the belief that organic farming should develop through market mechanisms, the non-application of CAP (Common Agricultural Policy) payments and the high price of agricultural land were identified as barriers to the development of organic farming in the Netherlands. As research has shown, the different pace of development is the result of inappropriate support, or a lack thereof, at the very beginning of formal guidelines for organic farming.

By comparison, Denmark and Austria have long supported organic dairy farming. In Denmark, the use of pesticides was taxed, and the revenue from these taxes was used to support organic farming. In addition, in both countries, the large distribution of organic dairy products in supermarkets is a very important factor in the popularisation of organic food products, helping to reduce the differences in retail prices between these products. These countries have also implemented health and marketing campaigns to promote the consumption of regional products (Verburg Verberne, and Negro 2022).

Taking into account the applied policies to develop organic farming in different EU countries, as well as the results of the ranking, it seems that demand-stimulating instruments can have a positive impact on organic farming development, e.g., the implementation of public procurement programmes in Denmark and Sweden. Such solutions seem crucial for increasing interest in organic food consumption in EU countries such as Bulgaria, Greece, Hungary, Lithuania, Poland, and Romania, where consumption of these products is relatively low (see Tables 1). Positive confirmation can be found in the campaigns promoting the health benefits of consuming regional organic food products, carried out in Denmark and Austria, where organic consumption per capita is high (see Tables 1). The use of only supply-side instruments aimed at increasing organic agricultural land may not have a satisfactory effect in terms of promoting organic farming supporting sustainable consumption, as exemplified by Slovakia, which is at the bottom of the ranking.

Conclusion

When trying to outline a unified framework for systemic solutions for organic farming, it remains difficult to clearly state what influences its development in the EU. However, there is no doubt that organic farming, based on its principles and guidelines, is a tool that can support the implementation of SDG 12. The issues outlined in the article point to an area of research that requires the identification and definition of opportunities and threats and, perhaps most importantly, barriers to development from a macroeconomic perspective. The study examined the complex interplay between organic farming, the promotion of sustainable consumption, and the EU's environmental objectives based on the EGD.

However, there remains a need to thoroughly examine the validity of the subsequent conversion of agricultural land to organic use from the perspective of greenhouse gas emissions. Research shows that environmental goals do not always go hand in hand with the goals of sustainable consumption development of organic food. Thus, more research is needed on the balance of greenhouse gas emissions, as well as the benefits and costs for the entire food system from a global perspective in light

of the mission to "feed the world" (Rahmann et al. 2017; Rasche and Steinhauser 2017; Purnhagen et al. 2021; Röös et al. 2022; Basnet et al. 2023).

When analysing the results of the study and the literature presented, a similarity can be observed between the position of a country's position in the ranking and the observations presented in the literature on the subject. Countries at the top of the ranking, such as Denmark, Sweden, Finland, and Austria, had active policies to support the development of organic agriculture from both the supply and demand sides. Their policy included public procurement aimed at purchasing organic food, early support for organic farming as far back as the 1980s, revenues from the taxation of pesticides and fertilisers were allocated to support organic farming, and consumers were given easier access to organic animal products through supermarket distribution (Wallenbeck et al. 2019; Lohr and Salomonsson 2000; Kujala, Hakala, and Viitaharju 2022; Verburg, Verberne, and Negro 2022; Basnet et al. 2023; Daugbjerg 2023).

The factors that influence the development of organic farming vary considerably across the countries at the top of the ranking. For example, in France, organic dairy farming is seen to have adapted to changing market conditions through higher and more stable prices. This contrasts with the lack of knowledge of Belgian farmers about the real economic potential of organic farming, which has a negative impact on decisions related to the transition to organic production (Kerselaers et al. 2007; Bouttes, Darnhofer, and Martin 2019). Meanwhile, the slower development of organic animal production in the Netherlands has been attributed to, among other things, the lack of differentiation between organic farming guidelines and general agricultural production regulations and the inconsistency of regulations on stocking density (Stubenrauch et al. 2021; Ambrosius et al. 2022; Verburg, Verberne, and Negro 2022). Therefore, the development of organic agricultural production, including organic animal products, requires the dissemination of experiences across the whole of the EU (Wallenbeck et al. 2019; Nikolić, Knežević, and Paraušić 2021).

In conclusion, there remains a need to analyse the factors that influence the development of organic agriculture in the EU and to find common development directions to support the macroeconomic concept of organic agriculture. This may entail adjusting policy instruments or differentiating and specifying the guidelines for organic agriculture in general regulations on agricultural production. The research underscores the importance of prioritising efforts to increase the efficiency of the production of organic animal products through the exchange of experiences, practices, and policy tools used between countries.

Therefore, in the light of our research, it seems that policy support instruments for organic farming development should allow for the dissemination of innovation and the implementation of technological advances in the production process, rather than focusing solely on increasing the share of organic land in total. Moreover, it seems crucial to intensify the use of instruments that influence the demand side of the market by increasing the availability of organic food products, promoting broader consumer awareness and knowledge, and introducing public procurement programmes for organic products. This aligns with the principle that "change starts at the top".

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Appendix

Table 5. Average production yields for diagnostic variables for Variant I 2016

	X_1	X_2	X_3	X_4	X_5	X_6
Austria	5.18	0.044	0.0336	0.29	0.13	0.28
Bulgaria	2.97	0.002	0.0048	0.05	0.00	0.08
Croatia	2.83	0.000	0.0000	0.00	0.10	0.00
Cyprus	6.04	0.000	0.0000	0.45	0.18	0.60
Czechia	4.76	0.006	0.0003	0.02	0.21	0.01
Denmark	8.88	0.108	0.1256	0.12	0.18	0.38
Estonia	5.87	0.007	0.0011	0.08	0.13	0.04
France	5.03	0.040	0.0794	0.19	0.29	0.44
Greece	10.42	0.033	0.0128	1.99	0.19	0.15
Ireland	2.52	0.006	0.0000	0.09	0.25	1.05
Italy	5.23	0.000	0.0000	0.22	0.27	0.00
Latvia	5.05	0.000	0.0000	0.00	0.07	0.00
Lithuania	4.36	0.000	0.0000	0.10	0.18	0.27
Netherlands	7.69	0.009	0.0942	0.25	0.27	0.75
Poland	2.16	0.000	0.0000	0.00	0.11	0.00
Romania	2.31	0.000	0.0028	0.26	0.20	0.00
Slovakia	2.60	0.000	0.0017	0.10	0.04	0.02
Spain	3.55	0.001	0.0014	0.09	0.15	0.39
Sweden	7.56	0.114	0.0147	0.02	0.31	0.56
Mean	5.00	0.019	0.020	0.23	0.17	0.26
Standard deviation	2.34	0.035	0.037	0.44	0.09	0.31

Source: own elaboration.

Table 6. Average production yields for diagnostic variables for Variant II 2016

	X_1	X_2	X_3	X_4	X_6
Austria	5.2	0.044	0.034	0.29	0.277
Bulgaria	3.0	0.002	0.005	0.05	0.083
Croatia	2.8	0.000	0.000	0.00	0.000
Cyprus	6.0	0.000	0.000	0.45	0.605
Czechia	4.8	0.006	0.000	0.02	0.013
Denmark	8.9	0.108	0.126	0.12	0.377
Estonia	5.9	0.007	0.001	0.08	0.040

	X_1	X_2	X_3	X_4	X_6
France	5.0	0.040	0.079	0.19	0.436
Greece	10.4	0.033	0.013	1.99	0.153
Hungary	4.1	0.004	0.007	0.16	0.052
Ireland	2.5	0.006	0.000	0.09	1.051
Italy	5.2	0.000	0.000	0.22	0.000
Latvia	5.0	0.000	0.000	0.00	0.000
Lithuania	4.4	0.000	0.000	0.10	0.270
Netherlands	7.7	0.009	0.094	0.25	0.748
Poland	2.2	0.000	0.000	0.00	0.000
Romania	2.3	0.000	0.003	0.26	0.003
Slovakia	2.6	0.000	0.002	0.10	0.015
Spain	3.5	0.001	0.001	0.09	0.392
Sweden	7.6	0.114	0.015	0.02	0.558
Mean	4.96	0.019	0.019	0.22	0.25
Standard deviation	2.29	0.034	0.037	0.43	0.30

Source: own elaboration.

Table 7. Average production yields for diagnostic variables for Variant I 2020

	X_1	X_2	X_3	X_4	X_5	X_6
Austria	5.6	0.065	0.0414	0.2734	0.13	0.321
Bulgaria	4.3	0.009	0.0000	0.0539	0.18	0.201
Croatia	3.7	0.000	0.0000	0.0079	0.13	0.000
Cyprus	8.2	0.000	0.0000	0.6530	0.19	0.821
Czechia	4.4	0.001	0.0004	0.0171	0.21	0.015
Denmark	9.2	0.099	0.1561	0.1992	0.31	0.398
Estonia	4.9	0.007	0.0022	0.1824	0.18	0.069
France	7.2	0.059	0.1082	0.2651	0.24	0.413
Ireland	2.8	0.005	0.0000	0.0377	0.24	1.623
Latvia	5.0	0.000	0.0001	0.0001	0.09	0.000
Lithuania	5.4	0.000	0.0144	0.1100	0.24	0.242
Netherlands	7.9	0.010	0.0967	0.2545	0.28	0.768
Poland	2.4	0.000	0.0009	0.0052	0.07	0.001
Romania	2.8	0.003	0.0001	0.0014	0.21	0.002
Spain	6.0	0.001	0.0017	0.0660	0.19	0.284
Sweden	8.4	0.047	0.0126	0.0250	0.31	0.474

	X_1	X_2	X_3	X_4	X_5	X_6
Mean	5.5	0.02	0.03	0.13	0.20	0.35
Standard deviation	2.1	0.03	0.05	0.17	0.071	0.43

Source: own elaboration.

Table 8. Average production yields for diagnostic variables for Variant II 2020

	X_1	X_2	X_3	X_4	X_6
Austria	5.6	0.065	0.0414	0.273	0.32
Bulgaria	4.3	0.009	0.0000	0.054	0.20
Croatia	3.7	0.000	0.0000	0.008	0.00
Cyprus	8.2	0.000	0.0000	0.653	0.82
Czechia	4.4	0.001	0.0004	0.017	0.02
Denmark	9.2	0.099	0.1561	0.199	0.40
Estonia	4.9	0.007	0.0022	0.182	0.07
France	7.2	0.059	0.1082	0.265	0.41
Greece	7.0	0.005	0.0022	0.392	0.04
Hungary	4.2	0.005	0.0078	0.151	0.08
Ireland	2.8	0.005	0.0000	0.038	1.62
Italy	6.9	0.340	0.4251	1.585	0.47
Latvia	5.0	0.000	0.0001	0.000	0.00
Lithuania	5.4	0.000	0.0144	0.110	0.24
Netherlands	7.9	0.010	0.0967	0.255	0.77
Poland	2.4	0.000	0.0009	0.005	0.00
Romania	2.8	0.003	0.0001	0.001	0.00
Slovakia	4.2	0.000	0.0059	0.034	0.01
Spain	6.0	0.001	0.0017	0.066	0.28
Sweden	8.4	0.047	0.0126	0.025	0.47
Mean	5.5	0.033	0.04	0.22	0.31
Standard deviation	2.0	0.078	0.10	0.36	0.40

Source: own elaboration.

Ekologiczne produkty pochodzenia zwierzęcego w UE jako wsparcie zrównoważonej konsumpcji

Istnieje potrzeba krytycznej analizy dyskursu badań nad rozwojem rolnictwa ekologicznego, jeśli – tak jak wskazano w Europejskim Zielonym Ładzie (EZŁ) – ma ono przyczynić się do upowszechniania zrównoważonych wzorców konsumpcji. Widoczny jest niedosyt badań w ujęciu makroekonomicznym. Ekologiczne produkty pochodzenia zwierzęcego mogą przyczynić się do realizacji zrównoważonej konsumpcji

i produkcji. To, co konsumujemy i w jakich ilościach, wpływa na nasze zdrowie i środowisko naturalne. Niezbędne jest poszerzanie świadomości konsumentów w kontekście konsekwencji, jakie wynikają z podjętych decyzji zakupowych dotyczących produktów żywnościowych. Celem artykułu jest określenie poziomu rozwoju produkcji ekologicznych produktów pochodzenia zwierzęcego w krajach UE. Syntetyczne wskaźniki poziomu rozwoju krajów UE w latach 2016 i 2020 zbudowano na podstawie metody głównych składowych (PCA). Wykorzystano dane pochodzące z Eurostatu. Na podstawie przeprowadzonego badania, jak również studiów literatury można stwierdzić, że państwa będące w czołówce rankingowej, takie jak Dania, Szwecja, Finlandia, Austria, prowadziły aktywną politykę wspierającą rozwój rolnictwa ekologicznego zarówno od strony podażowej, jak i popytowej. Z drugiej zaś strony w krajach sklasyfikowanych w czołówce rankingowej zauważono również rozbieżność co do czynników wpływających na rozwój rolnictwa ekologicznego. Dlatego rozwój ekologicznej produkcji rolnej, a w tym ekologicznych produktów pochodzenia zwierzęcego, wymaga dyfuzji doświadczeń w krajach UE w celu wsparcia wieloaspektowego paradygmatu OAFR (*organic agriculture and food research*) i celów zrównoważonego rozwoju.

Słowa kluczowe: ekologiczne produkty pochodzenia zwierzęcego, rolnictwo ekologiczne, OAFR, poziom rozwoju, zrównoważona konsumpcja, Europejski Zielony Ład, cele zrównoważonego rozwoju

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Evaluating the Suitability of the Simplified Pairs Trading Strategy for Short-term Equity Market Trading

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Abstract

Pairs trading has been a successful tool for traders since its inception in the 1980s and has evolved significantly with the introduction of algorithmic, machine, and AI trading. This evolution has complicated the implementation of this strategy that traditionally benefits institutional or specialized investors. Despite this, the simplicity of pairs trading remains accessible, indicating potential benefits for ordinary traders. By focusing on the strategy's fundamental principles and employing a real-time market test on a popular trading platform, the study aims to reveal its applicability and efficacy for short-term equity trading. Utilizing basic trading platform tools and Excel functions, the research aims to demonstrate a simplified approach to pairs trading. The findings will provide insights into the strategy's effectiveness, providing non-expert traders with a viable approach to navigate today's volatile markets through a simplified yet effective pairs trading model. The experiment's findings highlight varying performances across different stock pairs, with notable differences in volatility. While five out of 11 pairs achieved positive returns, only two met the closure criteria within the short-term horizon, suggesting that a longer trading period and a more diversified pair's portfolio may be necessary to fully capture expected price convergence.

Keywords: pairs trading, market-neutral strategy, investment strategy, short-term equity trading

JEL: G10, G11, G17

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Introduction

In financial markets, which are highly dynamic and volatile, investors and traders constantly seek strategies to help them achieve stable profits while minimizing risk. In this context, market-neutral trading strategies, such as pairs trading, open opportunities to seek profit regardless of the overall market movements. Research studies on pairs trading reveal a continuous pursuit to find more efficient pairs trading strategies and methodologies that would allow for higher profitability and lower risk.

The existing literature has predominantly emphasized the development and optimization of advanced pairs trading methodologies, typically characterized by complex statistical analyses and algorithmic implementations suited for institutional investors. However, the effectiveness of pairs trading strategies over short-term horizons remains comparatively underexplored. Furthermore, there is a notable scarcity of studies examining simplified pairs trading methodologies specifically tailored to retail investors' practical needs and constraints. This study addresses these gaps by empirically evaluating a simplified pairs trading strategy designed explicitly for short-term trading conditions commonly encountered by retail investors. Such an approach may offer retail traders rapid trading results, frequent reinvestment opportunities, and increased cumulative profitability achievable through multiple trading cycles within a single year. Unlike previous studies that largely depend on historical backtesting or computationally intensive methods, the novelty of this research lies in the real-time market testing of an accessible and simplified methodology. By emphasizing practicality and accessibility, the paper contributes valuable insights to the existing literature and supports retail traders in navigating today's volatile financial markets.

The problem of the research – is it efficient to apply the simplified pairs trading strategy for short-term trading in stock markets?

The object of the research – the simplified pairs trading strategy.

The aim of the research – to evaluate the suitability of the simplified pairs trading strategy for short-term trading in stock markets.

Tasks of the research:

- to describe the concept and principles of the pairs trading strategy, review the results of research studies conducted by academics;
- to prepare a methodology for testing the simplified short-term pairs trading strategy under real market conditions in stock markets;
- to test the suitability of the simplified pairs trading strategy for short-term trading in stock markets under real market conditions.

Research methods: scientific literature analysis, information systematization, quantitative analysis, correlation analysis.

In this study, the term "simplified" specifically refers to an approach that focuses solely on the fundamental procedures of pairs trading that retail investors can execute without specialized knowledge, substantial computational resources, or advanced analytical tools. Unlike

traditional or algorithmic methods, this simplified strategy intentionally avoids extensive stock selection criteria, such as screening based on market capitalization or historical volatility, to save resources and ensure accessibility. By testing this approach under real-time market conditions using a trading simulator, the study reveals critical insights into market dynamics and potential risks faced by retail investors. While large-scale research typically implies that pairs trading is generally profitable due to built-in diversification, this perception can be misleading for retail investors who trade smaller sets of stock pairs, making them vulnerable to risks and fluctuations often overlooked in studies relying on large historical samples. Thus, real-time testing is essential, accurately highlighting the challenges and risks involved in trading under realistic conditions, enabling practical recommendations for strategy improvement, and offering retail investors a clearer perspective on profitability and effective risk management.

The expected results of the research and their practical benefit include a deeper understanding of the effectiveness of the pairs trading strategy in the context of short-term trading, suggestions on how to optimize the strategy for better results, and a contribution to the existing base of academic research in this field.

This paper is structured as follows: Section 2 contains the theoretical part, which introduces the concept, historical background, and market-neutral principles of pairs trading. It also explores the evolution, phases, methods, and previous research on pairs trading strategies. Section 3 describes the research methodology, detailing the simplified pairs trading approach used for the short-term trading experiment. Section 4 contains the research data and results, outlining the data selected, specific steps followed, and providing analysis of the trading performance. Section 5 contains the conclusion. It summarizes key insights, practical implications, and overall suitability of the simplified strategy while also discussing the limitations of the study's constraints. Finally, there are recommendations for future research, identifying directions for extending and optimizing the pairs trading strategy further.

Theoretical analysis of pairs trading strategy

The concept of the pairs trading strategy

Pairs trading is a market-neutral strategy that involves simultaneously buying and selling two highly correlated stocks to profit from the convergence of their price differences (Brunetti and Luca 2023). The concept of this strategy lies in exploiting the fluctuations in the price ratio or difference between the processes of two stocks. The primary objective is to identify two stocks that have historically exhibited a strong positive correlation but have temporarily diverged due to certain reasons. Temporary fluctuations in demand and supply, individual large buy or sell orders, or reactions to company announcements can create price discrepancies between similar financial instruments. Thus, traders seek opportunities when the price ratio of these stocks deviates from the average, anticipating that the ratio will revert to its historical average, allowing for profit from both positions by buying the "undervalued" stock and selling the "overvalued" stock. The primary goal of pairs trading is to generate stable profits while reducing overall market risk. This is achieved

by diversifying investments and using statistical and mathematical analyses to identify the optimal pair for trading.

This strategy differs from traditional investment methods since the profits depend not on the general direction of the market but on the relative performance of specific financial instruments. This means that even in market downturns, this strategy can yield profits if the ratio of the selected stock pair reverts to its average (Gatev, Goetzmann, and Rouwenhorst 2006). This approach to investing helps mitigate specific market risks and offers traders additional protection. For instance, Keshavarz Haddad and Talebi (2023) discovered that even under extreme market conditions, such as the financial markets crisis triggered by the COVID-19 pandemic, the pairs trading strategy was able to maintain its profitability, thereby confirming its characteristic of market neutrality. The ability of such strategies to shield investments from market fluctuations is especially valuable to investors seeking ways to diversify their portfolios and mitigate the negative impact of macroeconomic events.

Pairs trading can also be regarded as a mechanism to hedge not only against market but also sector-specific risks. During sector crises, when the values of both stocks decrease, pairs trading allows for profit generation from the short position and the offsetting of losses from the long position. This implies that profits can be made even in the face of significant market movements, although they may be minimal. The preserved capital from the short position can be utilized to establish a long-term position in the same sector by buying stocks at a lower price (Tenyakov 2017).

The evolution of the pairs trading strategy

The origins and evolution of the pairs trading strategy are one of the earliest forms of algorithmic trading. Its inception is linked to statistical arbitrage strategies, which are extensively utilized by employees of investment banks and hedge funds (Yu and Xie 2021). One of the first and most widely known instances of pairs trading applications is associated with Morgan Stanley in the 1980s, when a group of analysts, led by Gerry Bamberger, began to widely implement this strategy. Bamberger later shared the results with Nunzio Tartaglia and his team of analysts and mathematicians, who developed a mathematical model that enabled the identification and trading of stock pairs based on their historical price correlation. The strategy was based on the assumption that if two companies operate in a similar industry or sector and their stock prices have historically shown a strong correlation, but this correlation is temporarily disrupted due to certain factors, the price ratio of these stocks should eventually return to its historical norm (Gatev, Goetzmann, and Rouwenhorst 2006).

Initially considered complex and accessible only to institutional investors with advanced computational resources, pairs trading evolved with technological advancements and became available to a broader audience. The internet, trading platforms, and data analysis tools have made this strategy accessible not only to professional traders but also to experienced individual investors.

Today, pairs trading is one of the market-neutral strategies employed across various financial markets globally. It may be applied not only in the stock market but also to a wide range of other

financial instruments. For example, in the bond market, it employs two similar-maturity and risk bonds from different issuers yet with comparable credit ratings; within the Forex market, it involves trading pairs of currencies that might be linked by similar economic indicators or regions, like CAD and SEK, AUD and MYR (a high degree of cointegration has been observed among 39 currency pairs out of 139 global currencies) (Moulya, Mohammadi, and Thathaiah 2019); in the commodities market, the strategy employs pairs of similar commodities, such as two precious metals whose price movements could be correlated, crude oil and gasoline, or sugar and coffee (Mohandas 2023).

In the derivatives market, pairs are formed with diverse derivative instruments, such as futures and options, which may be linked to various underlying assets or market indices. For instance, this can include futures contracts on metals or gold or even futures contracts on cryptocurrencies (Soputro, Imron, and Saiban 2023), illustrating the strategy's adaptability to leverage correlations across a broad spectrum of financial instruments for potential gain (Fernández-Pérez et al. 2020). In the cryptocurrency market, algorithmic pairs trading is commonly employed and usually clusters of cryptocurrencies are traded, enabling trades across multiple digital assets at once (Figà-Talamanca, Focardi, and Patacca 2021).

The phases of pairs trading strategy

In pairs trading, the strategy's execution is divided into two primary phases: the formation period and the trading period. This division facilitates the effective implementation of the pairs trading strategy, ensuring the selection of the most optimal stock pairs and the application of the most effective trading tactics (Diao, Liu, and Zhu 2020).

Stage I – formation period. The formation period involves selecting the stocks and determining the historical stock price interval for analysis based on a predetermined stock pairing strategy. This stage involves analyzing historical data to identify stocks with similar price movement characteristics suitable for pair matching. The main objective is to select stock pairs that historically exhibited a strong correlation level.

Stage II – trading period. The trading period is the interval during which actual trading of selected stock pairs occurs. Strategies implemented at this stage aim to capitalize on changes in the price differences of the stock pairs. The trading strategy involves opening positions when the stock price difference is lower or higher than a certain historically established level and closing positions when the price difference reverts to its average. That means estimating trading signals for the opening and closing of the trading positions (Diao, Liu, and Zhu 2020).

A professional approach to planning and executing these phases ensures stable profitability, reducing risk, and maintaining discipline throughout the trading process. Risk management is critically important in pairs trading, as in any other trading strategy. Traders should establish clear risk management rules, including the maximum allowable loss per trade, overall portfolio risk, and strategies for diversifying trading positions. One risk mitigation measure commonly employed in algorithmic trading is setting predetermined stop-loss and take-profit levels, as well as defining capital allocation (He et al. 2023).

The methods in pairs trading strategy

In implementing the pairs trading strategy, several key methods are distinguished for pair selection and trading signal generation. For instance, pair selection commonly utilizes correlation analysis, cointegration analysis, time series analysis, and the copula method; signal generation uses the distance method, stochastic control, as well as various other complex methods, including machine learning (Keshavarz Haddad and Talebi 2023). Each of these methods offers a unique approach to the development and implementation of pairs trading strategies, allowing traders to utilize comprehensive market data analysis techniques to maximize the efficiency of their trading actions under different scenarios. The main difference between these methods lies in the ways they measure the synergy of stock price movements and the speed they revert to the mean. All strategies are based on the assumption that the price difference follows a mean reversion model, where any deviation from long-term equilibrium will be corrected unless the relationship between the two stocks changes and a new equilibrium level of price difference is established (Keshavarz Haddad and Talebi 2023).

Researchers are also combining various methods to create complex approaches aimed at optimizing pairs trading algorithms. For instance, one of the latest ideas involves expanding from a "one-to-one" pairs trading model (which involves two stocks in a pair) to a "many-to-many" pairs trading approach (using clusters of stocks) by utilizing clustering methods. Experimental results indicate that this trading model provides more trading opportunities compared to the traditional pairs trading model (Wang et al. 2023). Various adapted methods and complex approaches employed by researchers will be discussed in Section 2.5. The descriptions of several classic methods are presented below.

The methods of stock pair formation

Correlation. Correlation is a mathematical indicator that reflects how the price movement of one security is related to another. In pairs trading, determining the correlation coefficient between two stocks helps to identify those whose price movements are interrelated. The correlation coefficient ranges from –1 to 1, where –1 indicates a perfect negative correlation, 0 indicates no correlation, and 1 indicates a perfect positive correlation. Pairs trading seeks a high positive correlation between two stocks, suggesting that their prices move similarly. Ideal pairs for pairs trading should historically exhibit a high positive correlation, typically above 0.8 (Liew and Wu 2013).

Cointegration. Unlike correlation, cointegration suggests that despite short-term price fluctuations, the price difference between two stocks eventually reverts to its mean value. This allows traders to identify pairs that, despite temporary divergences, are expected to converge over time, offering profitable trading opportunities. The cointegration method is implemented using regression analysis and vector autoregression models to establish a long-term relationship between the price movements of two stocks, as well as cointegration tests (e.g., Dickey-Fuller test or Johansen's cointegration testing procedure, when determining more than one cointegration event) (Huck and Afawubo 2015; Tadi and Witzany 2023). The application of cointegration tests in pair selection has undoubtedly received significant attention due to its advantage in terms of profitability

(Brunetti and Luca 2023). However, according to Huck and Afawubo (2015), applying the cointegration method to large datasets carries a significant computational burden. For instance, a dataset of 500 assets would require conducting 124,750 cointegration tests to identify all pairs potentially suitable for trading. To overcome this obstacle, they limited their empirical work to cointegration analysis on a pre-selected set of assets based on the determination of the correlation coefficient (Huck and Afawubo 2015). Of course, algorithmic trading and the application of artificial intelligence (AI) can significantly enhance efficiency in large-scale data analysis, including cointegration tests and, theoretically, they could help address the computational burden issue. However, it is essential to consider the associated technological, methodological, and infrastructural costs.

The copula method. In pairs trading, this method represents an innovative strategy for determining the interrelationship of returns between two stocks using an optimal copula. This method facilitates the identification of the relative position of stock pairs based on the statistical dependence between the stocks. The primary goal of the strategy is to ascertain how the return of one stock is related to the return of another and apply this knowledge in trading to profit from stock price movements (Krauss 2015).

The time series analysis method. This method is a multifaceted analysis that encompasses various aspects, including correlation, cointegration, volatility, potential return, and risk assessment. It is particularly valuable because it goes beyond merely monitoring one or a few parameters, evaluating a wide range of variables that could influence trading decisions. Time series analysis is an effective tool for selecting stock pairs in pairs trading, as it reveals and examines stock price behavior over time. Based on the analysis of historical price data sequences, it aims to identify specific patterns, trends, and possible directions of price movement. By employing time series analysis, the behavior of stock pairs under various market conditions can be thoroughly analyzed, assessing their mutual correlation and cointegration and predicting the potential volatility of the stock pairs. Traders gain valuable insights into risk levels and potential returns using this strategy, typically implementing it using various statistical models and machine learning algorithms.

Divergence. Generation of trading signals

Divergence arises when the price ratio of strongly correlated securities deviates from their usual behavior, providing traders with an opportunity to enter the trade. It is crucial to understand and correctly interpret divergence as a signal for buying or selling (Keshavarz Haddad and Talebi 2023).

Figure 1 abstractly illustrates the essence of the pairs trading strategy. It shows two lines, A and B, which reflect the price changes of two stocks over time. At the green point, where lines A and B are furthest apart, the investor initiates positions: selling stock B (opens a "short" position) and buying stock A (opens a "long" position). The investor anticipates and expects that the price of stock B will decrease relative to A, and the price of stock A will increase relative to B. Positions are closed at the red point, where the price ratio of both stocks intersects again, indicating that the ratio has returned to its previous level or historical average. At this point, the investor closes both positions, hoping to profit from the price ratio returning to the mean (Keshavarz Haddad and Talebi 2023).

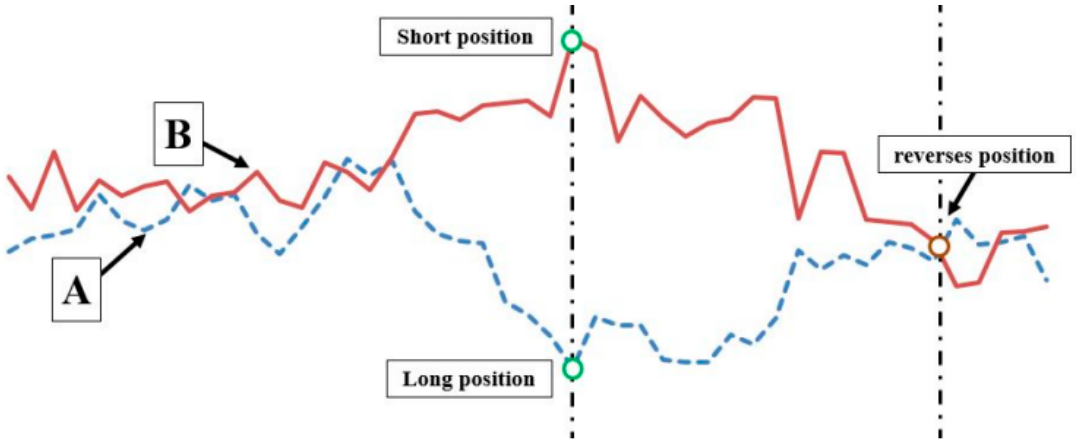

Figure 1. Graphical representation of taking positions in pairs trading strategy
Source: Keshavarz Haddad and Talebi, 2023.

It is important to note that Figure 1 depicts normalized stock prices rather than the individual prices of stocks. This provides a clearer view of the changes in the price ratio of two stocks over time, as normalization reduces the impact of different price scales, making it easier to compare stocks that may have very different starting prices.

Generation of trading signals. Trading signals are essential for effective pairs trading management. These signals can be identified using technical analysis based on charts, trend lines, and technical indicators, as well as mathematical methods – various divergence measurements, with one of the simplest being the distance method, where the price ratio of stocks exceeds the average by two or more standard deviations.

The classic distance method, as thoroughly outlined by Gatev, Goetzmann, and Rouwenhorst (2006), represents a pivotal approach in pairs trading strategies. This method signals the initiation of a trade when the relationship between the prices of two stocks diverges beyond two historical standard deviations.

Another commonly employed method for generating trading signals in pairs trading is the stochastic method. It helps identify "oversold" or "overbought" assets based on their price movement speed and direction over a specific period. In pairs trading, it can be applied to individual assets to identify potential trade entry and exit points when two assets' prices deviate from their usual correlation or cointegration relationship. The stochastic method relies on probabilistic processes, utilizing mathematical and statistical theories to define and predict the behavior of random events, such as stock prices, over time. The core idea of this method is based on the Ornstein-Uhlenbeck process (Lee, Leung, and Ning 2023).

The particularly straightforward price-to-price ratio method involves establishing the ratios of two correlating assets' prices over a chosen period. Then, on a trading day, if this ratio significantly exceeds the average (e.g., by 10–20%), the more expensive stock is sold, and the cheaper is bought; if the price ratio is below average, then the more expensive is bought, and the cheaper is sold. It is crucial to define how much the current ratio exceeds the average – this requires assessing the average's fluctuation range throughout the period. The end-of-trade signal is typically determined when the price difference reverts to its historical average value or reaches a predetermined profit level.

Machine learning and artificial intelligence. Various machine learning techniques, such as artificial neural networks, random forest algorithms, and support vector machines, can be applied to both pair selection and trading signal generation by learning from historical data and identifying complex patterns and relationships between assets. These advanced methods can help traders in pairs trading to more efficiently identify trading opportunities, enhance the profitability of the strategy, and reduce risk. Hedge funds actively employ these technologies for pairs trading (Wang et al. 2023).

Review of pairs trading strategies analyzed and tested by researchers

Researchers and practitioners are continually exploring ways to enhance and optimize the efficiency of pairs trading strategies through various methodologies and analyses. In this section, we will comprehensively review the studies that examine various aspects of pairs trading strategies. We will highlight the methods applied, the conclusions drawn, and the insights provided by researchers regarding the effectiveness of their strategies and the challenges encountered.

One of the earliest studies to examine the long-term success of pairs trading was conducted in 2006 by Evan Gatev, William N. Goetzmann, and K. Geert Rouwenhorst, who decided to explore a strategy often employed on Wall Street, where pairs of historically correlated stocks could offer profitable trading opportunities when their price ratio deviates from the norm. They paired stocks based on the minimal distance between their normalized historical prices from 1962 to 2002. A trading signal was established when the price ratio of a stock pair deviated by 4.76% or more from its historical average, a percentage considered a relatively narrow price difference. This threshold also matched the two-standard deviation signal used in the study for opening pairs' positions. Positions were closed to capture profits when the ratio returned to its average value. They concluded that the pairs trading strategy could generate significant profits, with average annual returns of up to 11%. It was also found that the effectiveness of trading strategies could vary based on factors such as bid-ask spread, significant fees for short positions, company size, and stock type (growth vs. value stocks).

On average, trades were initiated with almost all selected pairs within a six-month trading period, and the average duration of an open position was 3.75 months, suggesting that, as per the rules chosen for this study, pairs trading is suitable as a medium-term investment strategy. It is also noteworthy that despite current recommendations for pairs trading to select stocks from the same industry sectors, Gatev, Goetzmann, and Rouwenhorst (2006) demonstrated profitability even with pairs from different sectors. They paired stocks from computer firms with steel industry companies and utility companies with banks and still achieved positive returns. This indicates that pairs trading can be profitable across each broad sector category, not limited to a specific narrow sector.

Caneo and Kristjanpoller (2020) published a study notable for its analysis of pairs trading over a relatively long period. They examined the profitability of pairs trading strategies in Latin American stock markets, utilizing a multicriteria evaluation method. The methodology was applied across six Latin American countries, testing trades with a total of 338 stocks between 2013 and 2017. They revealed that this strategy outperformed the markets' Sharpe ratio by

an average of 1.55 points. Furthermore, correlation analysis showed that the stock pairs moved in conjunction with the market, while the number of dominating components was inversely related to market volatility. This finding once again highlights the uniqueness of the pairs trading strategy as a market-neutral strategy (Caneo and Kristjanpoller 2020).

Miao and Laws (2016) also analyzed the profitability of pairs trading strategies across various countries. They investigated whether pairs trading yields consistent results through periods of stock market growth and decline, including recent market shocks experienced in the countries studied. The findings indicated that in most countries, this strategy produces positive returns, even during downturns. The pairs trading strategy yielded positive returns even when transaction costs were considered, though returns significantly decreased with higher transaction costs. They also found that the return correlation between pairs trading portfolios and the respective stock market indices is low, confirming its role as an effective diversification tool for traditional long-term investment portfolios (Miao and Laws 2016).

In 2023, Keshavarz Haddad and Talebi investigated the profitability of the pairs trading strategy using data from stocks listed on the Toronto Stock Exchange (TSX). The objective was to create portfolios of stock pairs, explore their price relationships, and compare the efficacy of cointegration and copula method as pair selection tools. The researchers managed three portfolios consisting of five, ten, and twenty stock pairs, thereby distributing risk. They implemented the pairs trading strategy over three consecutive half-year periods: from January to June 2018, January to June 2019, and January to June 2020. The results indicated that the copula method consistently outperformed the cointegration method in terms of profitability across all three analyzed periods (Keshavarz Haddad and Talebi 2023). Interestingly, this study encompassed two unique periods before and after the COVID-19 pandemic, yet it was found that the financial market crisis triggered by the pandemic did not affect the methodologies' effectiveness. Thus, the results of this study affirm that the pairs trading strategy indeed operates as a market-neutral strategy.

In 2023, Sahu et al. analyzed historical prices over a four-year period and selected pairs of stocks from 10 different sectors, each with a Pearson correlation coefficient exceeding 0.5. The sectors analyzed included the automotive industry, information technologies, public enterprises, banking, consumer goods (FMCG), media, metal, oil and gas, and pharmaceuticals. From each sector, ten leading stocks were selected based on market capitalization. While most stock pairs showed positive investment returns, some exhibited negative returns. The metal sector, for example, had several pairs with negative returns. Four areas – oil and gas, pharmaceuticals, media, and information technology – distinctly featured positive return indicators. In order to select the most suitable stock pairs for the study, Sahu et al. applied the cointegration method. However, it was observed that even cointegrated stock pairs could experience negative returns, further confirming the unpredictability of the stock market. The study also revealed that the number of trading signals was limited, offering, on average, one investment opportunity per month.

In 2020, Wu et al. examined the performance of pairs trading strategy based on a specific differential model. The distinctiveness of this research lies in the implementation of the pairs trading strategy using a Lévy-driven Ornstein-Uhlenbeck (OU) process with two-sided jumps,

considering empirical evidence of mean reversion and jumps between the differences in stock pairs. Jumps, modeled using Lévy processes, account for rare but significant market or price changes, such as crises or speculative bubbles. The Lévy-driven OU process is a stochastic process commonly used in financial mathematics to model the dynamics of certain random quantities like stock prices and is a modification of the classic OU process (Wu, Zang, and Zhao 2020).

Lee and Leung (2020) investigated how an optimized position-closing rule impacts pairs trading. They optimized the positions of each asset pair to maximize daily portfolio value adjustment to the OU process, based on the maximum likelihood estimation. Analyzing various asset pairs, they assessed pairs trading strategies with and without the application of the optimized exit rule, evaluating their risks and returns. The study provided empirical evidence that applying optimized trading exit rules enhances the profitability of transactions and reduces turnover.

Diao, Liu, and Zhu (2020) also examined the strategy of an optimized exit rule from trading to enhance the profitability of the strategy. They utilized convex quadratic programming with quadratic constraints (the BQQ model) and analyzed various asset pairs, optimizing positions according to the OU process. The results demonstrated that applying the BQQ model could achieve a higher return rate compared to the traditional pairs trading strategy.

Platania et al. (2023) introduced an innovative study focusing on the application of neural networks in pairs trading. Neural networks are particularly effective at incorporating and analyzing dynamic and nonlinear relationships influenced by numerous factors. As a result, they can identify patterns that may be overlooked using traditional statistical techniques. Given that neural networks have the ability to learn from historical data and adjust their internal parameters accordingly, they can be trained to recognize complex patterns and market dynamics, making them well-suited for predicting trading signals. Once trained, the network can process real-time market data and generate signals indicating optimal buying or selling decisions. The researchers presented a comprehensive multi-dimensional study of the pairs trading strategy, utilizing multi-objective programming and neural networks to optimize the performance of the trading strategy. By incorporating multiple objectives, including maximizing returns and minimizing risk, the multi-objective programming system allowed the researchers to explore various optimal trading options.

In 2023, He et al. investigated three different pairs trading strategies: the conventional linear method, the copula method, and a machine learning technique method, trading two stock indices: Russell 2000 (RUT) and S&P400 (SP400). The primary evaluation criteria were the cumulative returns and Sharpe ratio of each strategy, which were later compared to a long-term investment strategy ("buy and hold") and the overall market return. They demonstrated the durability of pairs trading as a market-neutral strategy using conventional and copula models, which showed consistent and increasing return growth. A more advanced machine learning model was also tested, which confirmed potential profitability and stability in the pairs trading strategy. The only limitation of the study mentioned by He et al. was the overly strict criteria for pair selection, recommending further research with a larger dataset to identify pairs generating potentially higher returns. Consistent with previous research, He et al. emphasized that financial

companies often applied pairs trading due to its stability or profitability. Moreover, during recessions, such as the COVID-19 pandemic period, the cumulative return of pairs trading surpassed the conventional buy-and-hold strategy and even the market.

Overall, the research on pairs trading reveals a continuous effort to find more efficient strategies and methodologies to produce higher profitability and lower risk. And it is possible to identify common trends in the research – the copula method is one of the most effective for pair selection, the cointegration tests increase the probability of selecting more suitable pairs, multi-criteria data evaluation methods have advantages, and machine learning offers opportunities to use complex methods that optimize trading. However, none of these methods can be applied by single retail investors who don't have access to such tools and strategies. Thus, our study examines a simplified pairs trading strategy that emphasizes accessibility for retail investors without requiring advanced technical knowledge or algorithmic models.

Research methodology

In this section, we describe the methodology of the simplified short-term pairs trading strategy for real-time market tests on a popular trading platform.

General guidelines

Trading time horizon. Short-term trading involves strategies that take advantage of market price fluctuations over a relatively short period. The five-week period we set for this study to analyze pairs trading allowed us to identify and exploit short-term price fluctuations between highly correlated stocks, hoping that positions would return to their historical average, enabling profit from these fluctuations.

The trading horizon of five weeks was selected based on evidence in the existing literature on pairs trading, particularly regarding the typical duration for mean reversion among correlated stocks. Prior studies suggest that the time needed for stock pairs to revert to their historical mean price ratio ranges significantly – from as short as one week to several months. Engelberg, Gao, and Jagannathan (2009) demonstrated that after divergence, most stock pairs tend to converge relatively quickly, frequently within approximately eight trading days, indicating that shorter periods can effectively capture mean-reversion profits. Their findings also highlight that if pairs do not revert within the first week, the probability of subsequent convergence declines significantly, although some convergence may still occur over longer durations, albeit with increased risk.

Supporting shorter horizons, Schizas, Thomakos, and Wang (2011) found that roughly 50% of stock pairs reverted within about 40 trading days, while Broussard and Vaihekoski (2012) observed profitable results averaging around 5% monthly, further supporting short-term effectiveness. Similarly, Jacobs and Weber (2015) indicated an average holding period for pairs of about one month, and Buda (2011) underscored significant short-term fluctuations in correlations occurring within 20 trading days, potentially exploitable by investors. Conversely, some researchers, such as Gatev, Goetzmann, and Rouwenhorst (2006), have noted average position-holding periods extending up to three months.

Nevertheless, a notable gap remains in the literature specifically exploring intermediate periods such as one to two months, making the chosen timeframe particularly relevant. Considering this evidence, a five-week trading horizon was chosen as optimal, balancing the potential for capitalizing on short-term price deviations with adequate time allowance for convergence, thus aiming to optimize returns while minimizing systematic market and sector-specific risks.

Allocation of investment funds. An equal amount of money was allocated to each position to ensure positions were balanced, allowing for a more accurate evaluation of data testing.

The choice of trading platform. During the trading period, positions were opened under real-time market conditions on a trading platform, specifically a real-time trading simulator. A reliable trading simulation platform was selected, capable of modelling pairs trading, including order execution, position management, and risk management. Data on all executed transactions, including entry and exit prices, profit or loss, and the duration of positions, were collected during the trading simulation.

Phase I – formation period

Step 1 – selection of stocks for analysis. To ensure diversification and reduce the risk associated with a specific sector, the stocks were selected randomly from seven different economic sectors, avoiding extensive stock selection criteria, such as screening based on market capitalization or historical volatility, to save resources and ensure accessibility. Although different researchers have employed varying industry classifications to choose stocks, there is no fundamental reason to prioritize one sector over another. The critical consideration is to select stocks from industries or business areas whose companies exhibit similar reactions to market conditions, resulting in historically correlated price movements. Consequently, any sector that meets this condition could be suitable for pairs trading, and thus, the particular sectors included in this study were selected randomly rather than based on perceived suitability. In each sector, ten stocks were chosen, all from the two leading exchanges: NYSE and Nasdaq. These exchanges were chosen for their liquidity, accessibility, and diversity of stocks.

Step 2 – collection of historical stock prices. Daily closing price data of the selected stocks covering a three-month period was obtained from publicly available financial data sources, such as "Yahoo Finance" (Yahoo Finance, 2024). For testing short-term strategies, historical daily price data for three months provided relevant information on market movements and stock price correlation. The data were obtained in the following way: the data were exported from "Yahoo Finance" to MS Excel and were then prepared in a suitable format for further processing.

Step 3 – calculation of the correlation coefficients. The correlation coefficient between the prices of the stocks in the same industry branches/business sectors was calculated, and correlation matrices were created, allowing for a visual assessment of which stock pairs had a strong positive correlation. The correlation data were evaluated to select stock pairs that were potentially suitable for strategy implementation. Stock pairs with a correlation coefficient exceeding 0.8 were selected for the experiment. The following equation was used to calculate the correlation (Vakrina 2007):

$$r = \frac{\Sigma\left(X_i - \bar{X}\right)\left(Y_i - \bar{Y}\right)}{\sqrt{\Sigma\left(X_i - \bar{X}\right)^2 \Sigma\left(Y_i - \bar{Y}\right)^2}}, \tag{1}$$

where: r – the correlation coefficient between two stock prices, indicating how strongly the prices of the two stocks move in relation to each other; X_i – the price of stock X at time i within the specific period; Y_i – the price of stock Y at time i within the specific period; $\bar{X}$ and $\bar{Y}$ – the average prices of stock X and Y correspondingly over the specific period. The following equations were used to calculate $\bar{X}$ and $\bar{Y}$

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i, \tag{2}$$

$$\bar{Y} = \frac{1}{n}\sum_{i=1}^{n} Y_i, \tag{3}$$

where: $\bar{X}$ and $\bar{Y}$ – the average prices of stock X and Y, respectively, over the specific period; X_i – the price of stock X at time i within the specific period; Y_i – the price of stock Y at time i within the specific period; n – the total number of observations for stock X and Y, respectively.

While this study focuses on a manual approach to pairs trading, there are websites that allow users to easily determine historical correlations between selected stocks.

Phase II – trading period

Step 1 – Trade signal generation and position opening. For the generation of the trade signal, we relied on the classical two standard deviations method. According to this method, if the price ratio of a stock pair deviated from the average by more than two standard deviations, it was treated as a trading opportunity – as a signal for trading.

In this step, we performed several actions:

a) We calculated the price ratio of each selected stock pair for every day of the historical period according to the formula:

$$PR_{xy} = X_i / Y_i, \tag{4}$$

where: PR_{xy} – the price ratio of the stock pair being analyzed, with x and y representing the two different stocks; X_i – the price of stock X at time i within the specific period; Y_i – the price of stock Y at time i within the specific period; $X > Y$ (the numerator and the denominators here are determined according to which price is higher on the day before the first trading date).

b) We calculated the daily deviation of each stock pair's ratio from the average using the formula:

$$D_i = PR_{xy_i} - \frac{1}{n}\sum_{i=1}^{n} PR_{xy_i}, \tag{5}$$

where: D_i – the deviation of the price ratio on day i from the average price ratio; PR_{xy_i} – the price ratio of the stock pair on day i; n – the total number of observations within the selected period.

c) We calculated the standard deviation for each stock pair using the formula (Vakrina 2007):

$$\sigma = \sqrt{\sum_{i=1}^{n} D_i^2 \mathbb{I}(n-1)}, \tag{6}$$

where: σ – the standard deviation of the price ratios over the period; D_i – the deviation of the price ratio on day i from the average price ratio; n – the total number of observations within the selected period.

d) We calculated how many standard deviations the last day's (before the trading period) stock ratio deviated from the average. This was done by dividing the ratio's deviation from the average by the standard deviation using the formula (compiled by the authors according to Gatev, Goetzmann, and Rouwenhorst (2006) method):

$$Z = D_{last} / \sigma, \tag{7}$$

where: Z – the number of standard deviations the last day's stock price ratio of each stock in the pair deviated from the mean; D_{last} – the deviation of the stock pair's price ratio from the mean on the last day; σ – the standard deviation of the price ratios over the period;

If the resulting value of Z was greater than 2 or less than –2 (i.e., the deviation was greater than two standard deviations), it was considered to be a signal to open a position. If the value was more than 2, the stock with the higher price was sold (a "short" position was opened), and the stock with the lower price was bought (a "long" position was opened). If it was less than –2, then the stock with the higher price was bought (a "long" position was opened), and the stock with the lower price was sold (a "short" position was opened).

Step 2 – evaluation of trading results and position closing. During the trading simulation, data were collected on all executed transactions, including entry and exit prices, as well as the duration of the positions. The return of each stock position was calculated using the formula:

$$Ret = (P_{t+1} - P_t) / P_t, \tag{8}$$

where: Ret – is the return on the investment; P_{t+1} – the value of the investment at the end of the period; P_t – the initial value of the investment.

The return for each stock pair, as well as for the cluster of stock pairs, was calculated using the formula (Zivot 2015):

$$Ret_{total} = \frac{1}{n}\sum_{i=1}^{n} Ret_i, \quad (9)$$

where: Ret_{total} – the total return of the stock pair or of the set of all pairs; Ret_i – the return of the i-th position; n – the number of pairs for which the return is calculated.

Positions were planned to be closed when the return reached 0.07 or higher, or –0.11 or lower. This setup introduces an asymmetrical risk-to-reward ratio, where the potential loss exceeds the potential gain. The rationale behind this allows for short-term adverse movements in the price spread while anticipating a longer-term convergence.

Research results

General guidelines

Trading time horizon. According to the methodology, a five-week term was chosen for the experiment. All positions were opened on February 20, 2024, and the trading results were observed until March 26, 2024. The return was calculated twice a week. The positions were closed hypothetically but remained open in the trading simulator for further observation since the testing was conducted under real-time market conditions within the simulator.

Allocation of investment funds. Equal amounts of money were allocated to each position – $100 per position – to ensure the positions were balanced and to allow for a more accurate assessment of data testing.

Platform choice for trading. The eToro platform was chosen for its user-friendly interface and extensive selection of securities. It is a reliable trading simulation platform that enables accurate modeling of pairs trading, including order execution, position management, and risk management under real-time market conditions. A very important feature of the platform is the ability to simultaneously open both buy and sell positions for the same stock, as well as the ability to purchase fractions of stocks, giving us the opportunity to allocate $100 for each stock position.

Phase I – formation period

Step 1 – selection of stocks for analysis. The list of the stocks selected for the analysis is presented in Appendix 1.

Step 2 – collection of historical stock prices. Daily closing price data of the selected stocks covering the period from November 17, 2023, to February 19, 2024, were exported from "Yahoo Finance" to MS Excel for further processing (Yahoo Finance, 2024).

Step 3 – calculation of the correlation coefficients. The correlation coefficients were calculated for the stocks that corresponded to each selected sector. For the correlation analysis, historical stock prices were used, covering the period from November 17, 2023, to February 19, 2024. Stock pairs with a correlation coefficient that exceeded the 0.8 threshold – indicating a strong mutual relationship – were selected for further investigation. In total, 45 stock pairs were selected.

Phase II – trading period

Step 1 – Trade signals generation and position opening. Based on the research methodology, the following calculations were performed for each selected stock pair: the daily price ratio of the historical period was calculated, the daily deviation of this ratio from its average was calculated, and the standard deviation was calculated. Additionally, it was determined how many standard deviations the last day's (before the trading period) stock ratio deviated from its average. The trading signals were identified for the following pairs (results of calculated trading signals according to **Section 3, Phase II Step 1, action d** are presented in brackets).

- Non-energy metals and Online software applications: no trading signals.
- Finance sector: JPM/IBKR (–2.5), MS/WFC (–2.55), GS/WFC (–2.59), GS/JPM (–2.03).
- Automobiles industry: REVG/F (3.45), GM/REVG (–3.19).
- Apparel and retail trading: RL/TGT (2.61), ANF/TJX (2.14), LR/ LEVI (2.37).
- Health industry: HCA/AZTA (2.19).
- Restaurants, food service networks: SHAK/EAT (4.21), SHAK/FWRG (2.82), SHAK/SG (3.73).

The stock pairs REVG/F and GM/REVG were eliminated from the study because the option to open a "short" position was deactivated on the trading platform. In total, 11 pairs were selected for the study.

Step 2 – evaluation of trading results and position closing. During the trading period, the trading results were observed and based on the methodology, the return was calculated twice a week. The return on each observation date is presented in Table 1. All service costs were included in the bid-ask spread, and at the time of the experiment, no additional commissions were applied on eToro. Thus, trading costs, specifically bid-ask spreads, were integrated directly into the recorded entry and exit prices. Therefore, all reported profitability figures already reflect net returns after transaction costs. The applied average bid-ask spreads correspond to realistic market conditions, as identified in prior research, where transaction costs typically range from 0.2% (Broussard and Vaihekoski 2012) to 1% per transaction (Mashele, Terblanche, and Venter 2013). Consistent with existing findings (Gatev, Goetzmann, and Rouwenhorst 2006; Bowen and Hutchinson 2016; Miao and Laws 2016), our results confirm that transaction costs are crucial for accurately evaluating pairs trading profitability.

We summarize the results from the experiment below.

Table 1. Returns on each pair of stocks observed on the specific dates

Pairs of stocks	Return on 2024-02-23	Return on 2024-02-27	Return on 2024-03-01	Return on 2024-03-05	Return on 2024-03-08	Return on 2024-03-12	Return on 2024-03-15	Return on 2024-03-19	Return on 2024-03-22	Return on 2024-03-26
MS/WFC	–0.02	–0.04	–0.03	–0.03	–0.05	–0.06	–0.05	–0.04	–0.02	–0.02
JPM/IBKR	0.00	0.00	–0.02	0.00	0.01	0.01	0.01	0.02	0.03	0.02
GS/WFC	–0.02	–0.02	–0.03	–0.04	–0.05	–0.05	–0.06	–0.05	–0.03	–0.02

Pairs of stocks	Return on 2024-02-23	Return on 2024-02-27	Return on 2024-03-01	Return on 2024-03-05	Return on 2024-03-08	Return on 2024-03-12	Return on 2024-03-15	Return on 2024-03-19	Return on 2024-03-22	Return on 2024-03-26
GS/JPM	0.00	0.00	–0.01	–0.02	–0.02	–0.02	–0.03	–0.03	–0.02	*–0.02*
RL/TGT	–0.03	–0.01	0.00	0.05	***0.07***					
ANF/TJX	–0.01	–0.01	–0.05	–0.09	–0.01	–0.01	–0.01	–0.04	–0.06	*0.00*
RL/LEVI	–0.02	0.00	–0.01	0.00	0.01	0.01	0.00	0.01	–0.01	*0.01*
HCA/AZTA	–0.02	0.00	0.02	0.00	–0.02	–0.02	–0.06	–0.08	–0.07	*–0.07*
SHAK/EAT	0.01	0.00	–0.03	0.02	0.02	0.02	0.00	–0.02	–0.05	*0.01*
SHAK/FWRG	–0.01	–0.01	–0.03	–0.01	–0.02	–0.02	–0.03	–0.05	–0.07	*–0.03*
SHAK/SG	–0.02	0.00	***0.13***							

Sources: compiled by the authors.

Varying performance across pairs: the returns for each pair fluctuate across the dates, with some pairs showing more stability and others displaying significant swings. JPM/IBKR and GS/WFC appear to have more consistent performances, while SHAK/SG shows a more volatile pattern. Although five out of the eleven pairs achieved positive returns by March 26, the best result was largely driven by an extreme price movement involving the SHAK/SG pair. Specifically, between February 23 and March 1, 2024, the SHAK/SG pair generated a notable 13% return primarily due to the stock price surge of Sweet Green (SG). This rapid increase occurred following Sweet Green's quarterly earnings announcement, which significantly exceeded market expectations and included an optimistic revenue forecast for 2024, alongside plans for new restaurant openings (Hurťák 2024).

Such substantial price movements highlight the importance of diversifying the portfolio by increasing the number of stock pairs. This is because unfavorable movements can occur at any time. Diversification can mitigate the risk associated with extreme price movements affecting individual pairs, thereby distributing potential gains or losses more evenly across the entire portfolio.

Profitability thresholds: there are instances where the return on investment reaches or exceeds the 0.07 threshold, such as SHAK/SG on 2024-03-01, and RL/TGT on 2024-03-08, suggesting that setting a profit closure at +7% could be a reasonable target for this strategy under certain conditions.

Loss thresholds: reviewing the data, the returns do not reach a –0.11 loss on any given day. The closest is a –0.09 (or –9%) loss, suggesting that the market did not move unfavorably enough to reach the –11% loss threshold according to the strategy parameters. Consequently, positions had more room to move without being prematurely stopped out. The conservative threshold prevented early exits, allowing for potential recovery in the pairs' spread. This approach can be beneficial in avoiding significant losses, provided that the pairs eventually revert to the mean.

The fact that only two out of the eleven positions reached the closure threshold within the five-week trading period suggests that the short-term horizon may need to be extended. This longer duration could provide the pairs with additional time to converge or diverge sufficiently to meet the profit or loss thresholds. While short-term horizons can capture quick mean reversions, this particular set of trades indicates that the chosen pairs may require a longer period to realize the expected returns or to hit the stop-loss conditions. Adjusting the time horizon could potentially improve the chances of more positions reaching the closure criteria, assuming that the underlying assumptions about the pairs' correlations remain valid over the extended period.

In the simulated environment of this experiment, the impact of dividend payments on short positions was not considered, as the focus was on price movements and spread convergence. However, it is important to highlight that in a real-world application, special attention must be given to dividend-paying stocks when shorting. Shorting dividend stocks prior to the ex-dividend date, if the positions remain open through the dividend payment day, will result in the dividend amount being charged from the trader's account, thereby diminishing potential profits.

Conclusions

After analyzing various pairs trading strategies described in the scientific literature, it is evident that there is no single universally best method – effectiveness depends on market conditions, data quality, and the trader's ability to apply complex analyses. While more sophisticated methods may offer better understanding and greater accuracy, non-professional traders can still apply basic methods and benefit from this market-neutral strategy. Thus, this study employs a fundamental pairs trading method with trade signals determined by the two-standard deviation rule, focusing on its core principles to evaluate the strategy's effectiveness for short-term equity market trading. The goal is to offer non-expert traders a practical approach to navigating today's volatile markets.

The study included a formation period during which highly correlating stocks were selected and a trading period during which trading signals were calculated and trades were executed. The methodology introduced an asymmetrical risk-to-reward ratio, where positions are set to close upon achieving a 0.07 or higher return in a stock pair or a –0.11 or lower return. This allowed more room for the trades to move against the position in the short term in anticipation of long-term price convergence.

The experiment's findings highlight varying performances in pairs trading, with different pairs showing varying levels of volatility. Instances where returns exceeded the +7% profit threshold validated the potential of this target. However, the limited number of positions (only two out of the 11) that met the closure criteria within the short-term horizon suggests the need for a longer trading period to capture the expected convergence of price spreads and a more diversified portfolio of pairs.

The experiment also suggests that employing the strategy for a cluster of stock pairs, rather than individual pairs, could yield promising results. This is concluded by the observed total return of 4% across all 11 pairs if the pairs were traded as a unified cluster (see Appendix 1).

Research limitations

The study is limited by the specific market conditions during the testing period. Future research should explore different market environments to further validate the findings.

Recommendations for future research

We recommend additional research to clarify whether the described simplified method would be justified for a medium or long-term strategy. Future research should also further validate these findings across varied market conditions. We also recommend conducting additional research applying the described simplified pairs trading method to trading with clusters of stock pairs. By spreading exposure across multiple pairs within the same cluster, the strategy may reduce the impact of adverse movements in any single pair, thereby stabilizing overall returns. This diversification could be beneficial when dealing with the short-term volatility observed in individual stocks. Setting a cumulative profit target for all open pairs, rather than individual targets, could facilitate faster realization of overall profit goals. Closing all trades when the aggregate profit target is reached simplifies the exit strategy. It avoids the need to continuously monitor individual pairs for convergence, potentially saving time and reducing execution delay.

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Appendix 1

Table 1. The list of the stocks selected for the analysis

Sector	Company
Non-energy metals	Southern Copper Corporation (SCCO), MP Materials Corp. (MP), Hecla Mining Company (HL), Newmont Corporation (NEM), Rio Tinto Group (RIO), Franco-Nevada Corporation (FNV), Agnico Eagle Mines Limited (AEM), Commercial Metals Company (CMC), Martin Marietta Materials, Inc. (MLM), Ternium S.A. (TX).
Finance sector	JPMorgan Chase & Co. (JPM), Bank of America Corporation (BAC), Morgan Stanley (MS), The Goldman Sachs Group (GS), HDFC Bank Limited (HDB), ICICI Bank Limited (IBN), Barclays PLC (BCS), Interactive Brokers Group (IBKR), UBS Group AG (UBS), Wells Fargo & Co (WFC).
Automobiles industry	Ford Motor Company (F), General Motors Company (GM), Mullen Automotive, Inc. (MULN), Tesla, Inc. (TSLA), Rivian Automotive, Inc. (RIVN), Stellantis N.V. (STLA), Toyota Motor Corporation (TM), REV Group, Inc. (REVG), Blue Bird Corporation (BLBD), Ferrari N.V. (RACE).
Apparel and retail trading	NIKE, Inc. (NKE), Target Corporation (TGT), TJX Companies, Inc. (TJX), Levi Strauss & Co. (LEVI), Deckers Outdoor Corporation (DECK), Estée Lauder Companies Inc. (EL), Abercrombie & Fitch Co. (ANF), Under Armour (UA), Ralph Lauren Corporation (RL), The Gap, Inc. (GPS).
Health care	Medpace Holdings, Inc. (MEDP), Option Care Health, Inc. (OPCH), Teladoc Health, Inc. (TDOC), Amedisys, Inc. (AMED), Azenta, Inc. (AZTA), Community Health Systems, Inc. (CYH), HCA Healthcare, Inc. (HCA), Laboratory Corporation of America Holdings (LH), Elevance Health, Inc. (ELV), Alkermes plc (ALKS).
Restaurants and food service	McDonald's Corporation (MCD), Yum! Brands, Inc. (YUM), Shake Shack, Inc. (SHAK), Brinker International, Inc. (EAT), Kura Sushi USA, Inc. (KRUS), First Watch Restaurant Group, Inc. (FWRG), Papa John's International, Inc. (PZZA), Sweetgreen, Inc. (SG), Dine Brands Global (DIN), Darden Restaurants, Inc. (DRI).
On-line software	Salesforce, Inc. (CRM), Uber Technologies, Inc. (UBER), ServiceNow, Inc. (NOW), Shopify, Inc. (SHOP), Snowflake, Inc. (SNOW), Datadog, Inc. (DDOG), Dynatrace, Inc. (DT), HubSpot, Inc. (HUBS), Tyler Technologies, Inc. (TYL), Dayforce, Inc. (DAY).

Sources: compiled by the authors.

Table 2. Totals of returns observed during the trading period

Stock pairs	Return 2024-02-23	Return 2024-02-27	Return 2024-03-01	Return 2024-03-05	Return 2024-03-08	Return 2024-03-12	Return 2024-03-15	Return 2024-03-19	Return 2024-03-22	Return 2024-03-26
MS/WFC	−0.02	−0.04	−0.03	−0.03	−0.05	−0.06	−0.05	−0.04	−0.02	−0.02
JPM/IBKR	0.00	0.00	−0.02	0.00	0.01	0.01	0.01	0.02	0.03	0.02
GS/WFC	−0.02	−0.02	−0.03	−0.04	−0.05	−0.05	−0.06	−0.05	−0.03	−0.02
GS/JPM	0.00	0.00	−0.01	−0.02	−0.02	−0.02	−0.03	−0.03	−0.02	−0.02
RL/TGT	−0.03	−0.01	0.00	0.05	0.07	0.05	0.07	0.04	0.03	0.06
ANF/TJX	−0.01	−0.01	−0.05	−0.09	−0.01	−0.01	−0.01	−0.04	−0.06	0.00
RL/LEVI	−0.02	0.00	−0.01	0.00	0.01	0.01	0.00	0.01	−0.01	0.01
HCA/AZTA	−0.02	0.00	0.02	0.00	−0.02	−0.02	−0.06	−0.08	−0.07	−0.07
SHAK/EAT	0.01	0.00	−0.03	0.02	0.02	0.02	0.00	−0.02	−0.05	0.01

Stock pairs	Return 2024-02-23	Return 2024-02-27	Return 2024-03-01	Return 2024-03-05	Return 2024-03-08	Return 2024-03-12	Return 2024-03-15	Return 2024-03-19	Return 2024-03-22	Return 2024-03-26
SHAK/FWRG	−0.01	−0.01	−0.03	−0.01	−0.02	−0.02	−0.03	−0.05	−0.07	−0.03
SHAK/SG	−0.02	0.00	0.13	0.23	0.25	0.30	0.40	0.42	0.49	0.50
Total return	**−0.01**	**−0.01**	**−0.01**	**0.01**	**0.02**	**0.02**	**0.02**	**0.02**	**−0.02**	**0.04**

Sources: compiled by the authors.

Ocena przydatności uproszczonej strategii pary handlowej do krótkoterminowego handlu na rynku akcji

Handel parami od czasu swojego powstania w latach osiemdziesiątych XX wieku był skutecznym narzędziem dla traderów i znacznie ewoluował wraz z wprowadzeniem handlu algorytmicznego, maszynowego i AI. Ta ewolucja skomplikowała implementację tej strategii, tradycyjnie przynoszącej korzyści instytucjonalnym lub wyspecjalizowanym inwestorom. Pomimo tego prostota handlu parami pozostaje dostępna, co wskazuje na potencjalne korzyści dla zwykłych traderów. Koncentrując się na podstawowych zasadach strategii i przeprowadzając test rynku w czasie rzeczywistym na popularnej platformie handlowej, badanie ma na celu ujawnienie jej przydatności i skuteczności w krótkoterminowym handlu akcjami. Wykorzystując podstawowe narzędzia platformy handlowej i funkcje Excela, badanie ma na celu również pokazanie uproszczonego podejścia w handlu parami. Wyniki mają dostarczyć wgląd w skuteczność strategii, oferując nieeksperckim traderom realne podejście do poruszania się po dzisiejszych zmiennych rynkach za pomocą uproszczonego, ale skutecznego modelu handlu parami.

Słowa kluczowe: handel parami, strategia rynkowo-neutralna, strategia inwestycyjna, krótkoterminowy handel akcjami

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The Green Economy for a Sustainable Future: Experience from the Visegrad Group Countries

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Abstract

The objective of this paper is to identify the significance of the green economy for a sustainable future and compare the situation and developments in achieving the European Green Deal (EGD) in the Visegrad Group (V4) countries. To achieve this objective, the paper focuses on the challenges, risks and opportunities of implementing green economy policies. Comprehensive data analysis is conducted, and a European Green Deal Index (EGDI) for the V4 countries is developed. The Eurostat database is used to monitor 18 key indicators in the V4 countries from 2015 to the latest year available. The results show that Slovakia is the best-performing V4 country with the highest EGDI score, while Poland shows the most significant improvement, mainly in the category *Enabling a green and just transition*. Between 2015 and 2023, Slovakia and Czechia experienced negative trends in the percentage of the population unable to keep their home adequately warm for financial reasons. The paper highlights the social dimension of the EGD and the green economy as well as the importance of a just transition concept across the whole European Union since increased household spending on the green transition could affect public support.

Keywords: European Green Deal, European Green Deal Index, green economy, just transition, Visegrad Group

JEL: O13, Q54, Q58

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Introduction

The European Commission presented the European Green Deal (EGD) on 11 December 2019 as one of its six political priorities for the period 2019–2024. The EGD should help make Europe the first climate-neutral continent by 2050 while strengthening the economy and improving people's health and quality of life. However, there is also criticism of the EGD. In the transition to a green economy, the biggest uncertainty is associated with the social dimension, in the sense that individual steps within the implemented policies are aimed at ensuring a just transition for all individuals and all regions. The green economy is the key to achieving the set goals because this concept is based on respecting the limits of our planet and on the importance of using natural resources wisely and justly. The social pillar has the same importance as the environmental and economic pillars within the green economy.

The objective of this paper is to identify the significance of the green economy for a sustainable future and compare the situation and developments in achieving EGD goals in the Visegrad Group (V4) countries – Czechia, Hungary, Poland and Slovakia.

The paper is organised as follows. Section 2 provides the theoretical background and focuses on previous research in the area of green economy. It offers an overview of selected policies to support the development of the green economy and highlights the challenges for V4 countries in the green transition. Section 3 summarises the data and methodology utilised and presents the European Green Deal Index (EGDI) developed for this research. The empirical findings, which include a comparison of the V4 countries, are presented in Section 4, followed by a discussion and conclusions in Sections 5 and 6, respectively.

Theoretical background

There is general agreement that certain policy interventions are needed to address the challenges of unsustainable development and the loss of well-being over time (Figure 1). However, there is no agreement regarding the appropriate level or extent to which it is desirable to implement interventions. As Huberman (2010) notes, policy recommendations are primarily formulated at the macroeconomic level and reflect the need for global solutions. This is because macroeconomic analyses are useful for outlining major trends and identifying key sectors that are associated with contemporary global challenges. Lawn (2008) offers his own perspective on the issue, stating that environmental crises cannot be effectively faced at the global level. Meanwhile, Barbier (2012) emphasises the need for a mix of short-term and long-term policies. When compiling an appropriate mix of policies and tools for their implementation, it is also necessary to consider whether the context is that of a rich or poor country. Additionally, it is essential to recognise that compromises will be necessary in the implementation of various policies, even when they have a common goal, i.e., supporting the development of the green economy (Table 1).

The choice of an appropriate policy to develop a green economy depends on how the concept is defined and interpreted. Newton and Cantarello (2014) state that many policymakers perceive no conflict between the way the economy or society functions and a healthy environment.

And therefore, they argue, there is no need for fundamental social and economic changes. Cato (2011) states that if fundamental social and economic changes are not implemented, it is ecological modernisation, that is, the development of the green economy, that preserves economic structures such as corporations and markets. Products are produced more efficiently and their production consumes less energy and materials.

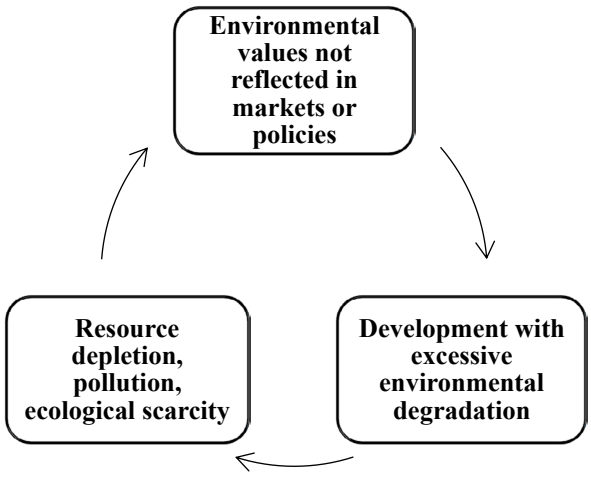

Figure 1. The vicious cycle of unsustainable development
Source: Barbier and Markandya 2013.

For supporters of ecological modernisation, the solution to the environmental crisis is ecological efficiency. However, Cato (2009) contends that if we want to move towards a truly green economy, we need to fundamentally change the system that created the environmental and social problems. Fiorino (2018) notes that the concept of ecological modernisation has both supporters and critics. Much of the criticism parallels the problems connected with the green economy today, particularly the ongoing dominance of rich countries and corporations, which are seen as key contributors to ecological degradation. However, the validity of the criticism depends on the specific version of ecological modernisation in question – whether it emphasises ecological efficiency and innovation or a more systemic approach based on institutional changes. However, Jänicke (2008) concludes that, despite the impressive potential of ecological modernisation, this concept is not sufficient to ensure long-term environmental stability. Solving many problems requires certain social and lifestyle changes, and even a significant increase in ecological efficiency will not be enough to counter exponential growth. Nonetheless, proponents of ecological modernisation highlight its significant contribution in that most environmental research is based on the assumption that the way industry and states operate is the cause of ecological damage (Murphy 2000).

The transition to the green economy can be initiated and driven by several factors. The International Labour Organization (ILO 2011) notes that within the market mechanism, there are incentives to trigger such a transition. However, for structural change, an exogenous shock is necessary, which could come mainly from one of four areas: energy prices, new technology, changes in preferences and demand, or the role of policies. The transition will vary significantly between countries due to differences in natural and human capital and the relative level of development of each country.

The United Nations Environment Programme (UNEP 2011) states that countries will face a number of challenges and opportunities as part of the transition to the green economy. Some have achieved a high level of human development, but often at the cost of excessive depletion of natural resources, environmental degradation and high greenhouse gas emissions. The challenge for these countries will be to reduce their ecological footprint per capita without compromising quality of life. Practical examples include improving green spaces in cities and investing in low-carbon public transportation.

Conversely, less developed countries, which typically have a relatively low ecological footprint per capita, will need to improve the level of service provision and the standard of living. The biggest challenge for these countries is that increasing overall well-being should not be associated with an extreme increase in their ecological footprint. Patrick ten Brink et al. (2012) emphasise that the transition to the green economy will require the adoption of a wide range of political and financial instruments aimed at promoting sustainable production and consumption. The greening of economic sectors will have to be supported by tools and approaches designed to achieve social goals.

The main elements of a green policy agenda are principles, policy instruments and indicators. Principles express the basic ideas and criteria for evaluating policy instruments and their application. Policy instruments are mechanisms designed to change behaviour to achieve set goals. They should reflect the principles and link them to desired outcomes. Indicators are used to measure the extent to which the agenda is being fulfilled and, therefore, whether it is successful or not.

The basis of the green political agenda is the principles on which it is based. In public policy, these principles guide the decision-making process and the use of policy tools. These principles emphasise that policy instruments, or their combinations, should be a) effective in achieving their intended goals; b) fair, ensuring they do not disadvantage or favour certain groups; c) cost-effective in achieving desired outcomes; and d) feasible in terms of gaining the necessary political support.

Within this framework, individual strategies should be designed to reduce environmental and human health risks, promote local control and be implemented only if the expected benefits outweigh the costs (Fiorino 2018). However, the transition to the green economy has perceived contradictions in certain cases and raises concerns within society. For example, the OECD (2011) highlights a widespread perception that some people will be worse off because of green policies. Even if this is not the case, it is necessary to deal with this perception so that key policies in the transition are not called into question. All stakeholders likely to be affected by the transition must be part of the policymaking process from the beginning. The policy-making process must be transparent and clearly explain the rationale for the reforms. Any negative effects on poorer households must be compensated by well-targeted measures that consider the tax and transfer system. When there are negative impacts on the competitiveness of companies, compensation schemes may be justified, although they are costly.

Therefore, it is important to coordinate adopted policies with all stakeholders. For example, while phasing out fossil fuel subsidies will have positive effects on the environment and the economy,

negative consequences are also likely in some countries or within certain population groups. A key problem is the time mismatch between negative and positive effects: increases in fuel prices will be significant and immediately obvious to some people, while environmental positives will be more diffused and will be visible over a longer time horizon. It is for this reason that, within the transition to the green economy, it is necessary to introduce compensatory measures aimed at the most vulnerable segments of the population.

According to the World Bank (2012), strategies must be adapted to maximise local and immediate benefits on the one hand while ensuring that the process of greening economies is not hindered. Effective green policies require governments to better manage market and governance failures. Optimal solutions will vary across countries, as there are differences in institutional capacity, transparency and accountability. It is important to recognise that even if a certain strategy is extremely successful in one country, it may fail completely in another country. Therefore, strategies must be adapted to the conditions of the given country.

Strategies for greening economies should aim to minimise transition costs while offsetting them as much as possible with visible and immediate benefits. It is, therefore, essential to design policies to maximise short-term local benefits such as increased efficiency, productivity, safety and resilience, job creation and poverty alleviation. However, governments cannot make all the necessary changes at once. They have limited resources and limited implementation capacity to address complex issues. Their political capital to push for change and defend their policies against interest groups and political opposition is also limited. Therefore, governments must focus on sectors and interventions that are most urgent and can help reduce inertia and prevent irreversible harm within their economies.

Table 1. Overview of selected policies to support the development of the green economy

Political difficulty of implementation	Local and immediate benefits versus global and long-term benefits		
	Fewer trade-offs	Some trade-offs	More trade-offs
Easy	a) Energy conservation b) Landuse planning	a) Improved drinking water and sanitation b) Development of fuelefficient vehicles	a) Carbon sequestration projects
Moderate	Public transport	a) Lowcost clean energy supply b) Removal of fossil fuel subsidies c) Subsidies for clean energy R&D	a) Ocean conservation and fisheries management b) International payment and ecosystem services c) Largescale water management projects
Hard	Pollution regulation and pricing	a) Natural resource management and pricing b) Sustainable intensification of agriculture c) Water pricing d) Removal of water subsidies e) Carbon pricing	a) Global carbon tax b) Highcost clean energy supply c) Removal of agricultural subsidies

Source: Barbier 2012.

Table 1 presents examples of principles for creating strategies for greening economies and also offers local and immediate benefits. While low-carbon energy from renewable sources is highly desirable, it is easier to build renewable energy plants later than to try to reverse the poor land-use planning that led to sprawling cities. Good spatial planning and public urban transport can provide short-term benefits, such as reducing congestion and exposure to natural disasters, as well as prioritising denser and more energy-efficient development. For lower-income countries, three policy categories are particularly relevant:

1. Those that have zero economic costs due to development synergies. Examples include the development of hydropower or expanding family planning policies to manage population pressures and improve education and health outcomes.
2. Policies with some economic costs that have a direct impact on welfare. They are focused on local environmental problems such as natural hazards and air pollution.
3. Externally financed policies, including carbon trading.

The approach of the national government is key to development. Borel-Saladin and Turok (2013) argue that adopting a comprehensive range of available tools for greening economies can lead to either a partial or a transformational change in the economy. The green economy is a complex set of solutions that must be appropriately combined to enable countries and regions to move towards a sustainable future. In this process, the government's attitude is a crucial determinant of whether a country achieves partial or transformational change. In some cases, achieving partial change is closely linked to a lack of commitment to green solutions and may be more about creating the impression that the country is greener than it really is. Conversely, adopting a bold vision of the green economy involves implementing the full range of available tools to transform the current economic system into one that is inherently environmentally friendly and sustainable. Ultimately, it is political will that is the key to achieving the transformational change necessary to green the economy and make substantial progress towards long-term sustainability.

While numerous studies (Tomaszewski 2020; Riepl and Zavarská 2023; Streimikis et al. 2024; Takyi et al. 2024) acknowledge that significant progress has been made toward a greener economy, the V4 countries still lag behind their EU counterparts in several key aspects of the green transition. Achieving green targets poses a significant challenge for the V4 countries due to their fossil fuel-dependent industries and heavy reliance on coal mining in certain regions. Consequently, progress toward the green transition in the region has been uneven.

Riepl and Zavarská (2023) identified five key challenges that the V4 face: a low starting point, less societal awareness and political prioritisation of the climate crisis, the role of the automobile industry, the fear of social fallout in mining regions, and reducing their dependence on Russian fossil fuel imports. The lower starting point means that V4 countries face difficulties in reducing emissions while still striving to catch up economically, as their development trajectory may sometimes seem at odds with climate objectives. Furthermore, the automotive sector's crucial role in the economy and employment of all V4 countries makes the EU's decision to end the sale of new combustion engine vehicles by 2035 a particularly challenging issue.

Takyi et al. (2024) examined the relationship between green innovation, the circular economy, renewable energy, economic growth, and urbanisation in relation to carbon emissions in the V4 countries. They found that these countries have been actively exploring the potential of the green and circular economy to address both environmental and economic challenges. Their findings indicate that the V4 can mitigate environmental externalities and reduce carbon emissions by implementing green innovation practices and circular economy strategies.

Data and methodology

A comprehensive data analysis was conducted, and a European Green Deal Index (EGDI) for the V4 countries was developed. The Eurostat database offers 27 key indicators that are important to achieve the EGD objectives. Nine indicators were excluded for two reasons: some indicators are not available for all V4 countries, and others are collected only every 3 years and, therefore, are not up-to-date. As a result, 18 key indicators were used in this research to monitor progress in the V4 countries from 2015 to the latest year available (2022 or 2023).

The year 2015 is used as a baseline due to data availability for each V4 country. For two indicators – generation of waste and environmental tax revenues – 2016 and 2018 were chosen as the baseline years, respectively, as data for 2015 were not available for all countries. These years are the closest to the general baseline year. Selected indicators are important to achieve the EGD objectives. The indicators are divided into three main components:

1. *Reducing our climate impact* (7 indicators)
2. *Protecting our planet and health* (3 indicators)
3. *Enabling a green and just transi*tion (8 indicators).

Table 2 presents all indicators and units of measurement for the EGDI.

Table 2. European Green Deal Index

Main components	Indicator	Unit of measure	Baseline year	Latest data available
Reducing our climate impact	Net greenhouse gas emissions	Tonnes per capita	2015	2022
Reducing our climate impact	Renewable energy	% of gross final energy consumption	2015	2023
Reducing our climate impact	Primary energy consumption	Tonnes of oil equivalent per capita	2015	2023
Reducing our climate impact	Household energy consumption	GJ per capita	2015	2022
Reducing our climate impact	Zero-emission vehicles	% of new vehicles registered in the year	2015	2023
Reducing our climate impact	Passenger transport – rail	% in inland passenger-km	2015	2022
Reducing our climate impact	Freight transport – rail	% in inland freight tonnes-km	2015	2022

Main components	Indicator	Unit of measure	Baseline year	Latest data available
Protecting our planet and health	Organic farming area	% of utilised agricultural area	2015	2022
Protecting our planet and health	Premature deaths due to exposure to fine particulate matter (PM2.5)	Rate	2015	2022
Protecting our planet and health	Waste generation	Kilograms per capita	2016	2022
Enabling a green and just transition	Raw material consumption	Tonnes per capita	2015	2023
Enabling a green and just transition	Circular material use rate	% of material input for domestic use	2015	2023
Enabling a green and just transition	Gross domestic expenditure on R&D	% of GDP	2015	2023
Enabling a green and just transition	Population unable to keep their home adequately warm	% of population	2015	2023
Enabling a green and just transition	Greenhouse gas emissions intensity of employment	t GHG / employed	2015	2023
Enabling a green and just transition	High-speed internet coverage	% of households	2015	2023
Enabling a green and just transition	Environmental tax revenues	% of total tax revenue	2015	2023
Enabling a green and just transition	Environmental protection expenditure	% of GDP	2018	2022

Source: own elaboration based on Eurostat database.

Each indicator was ranked on a scale from 1 to 4 based on the relative performance of each country. For each indicator and year, the country with the best outcome received a score of 4, while the country with the poorest outcome received a score of 1. For example, if net greenhouse gas emissions in 2015 were the highest in Czechia and lowest in Hungary, Czechia would receive 1 point and Hungary 4 points.

Findings

As Figure 2 shows, the V4 countries have experienced varying developments between the baseline year and the latest data available in each main component of the EGDI.

Reducing our climate impact

This category includes seven indicators: Net greenhouse gas emissions, Renewable energy, Primary energy consumption, Household energy consumption, Zero-emission vehicles, Passenger transport – rail, and Freight transport – rail. Major improvements can be seen in Poland (from 14 to 16 points) and Slovakia (from 19 to 21 points). Poland's progress is primarily driven by advancements in 2 indicators: Zero-emission vehicles (from 0.03% in 2015 to 3.6% in 2023)

and Passenger transport – rail (from 6.7% in 2015 to 8.3% in 2022). In contrast, Hungary experienced a decline, specifically in the area of Passenger transport – rail, dropping from the leading position in 2015 (9.7%) to the lowest in 2022 (8.2%). According to the latest data available, Slovakia leads in this category, with a slight improvement over the years, especially in reducing Net greenhouse gas emissions (from 6.6 tonnes per capita in 2015 to 5.5 tonnes per capita in 2022).

Protecting our planet and health

This category consists of 3 indicators: *Organic farming area*, *Premature deaths due to exposure to fine particulate matter (PM2.5)*, and *Generation of waste*. The current leaders are Czechia and Slovakia, each with 10 points. In Czechia, there are no changes from the baseline year, while Slovakia shows a slight improvement (from 9 to 10 points). Poland recorded the highest decrease due to declines in the share of *Organic farming area* (from 4.3% in 2015 to 3.91% in 2022) and the rate of *Premature deaths due to exposure to fine particulate matter (PM2.5)* (from 117 in 2015 to 94 in 2022).

Enabling a green and just transition

This category includes eight indicators: *Raw material* consumption, *Circular material use rate*, *Gross domestic expenditure on R&D*, *Population unable to keep home adequately warm*, *Greenhouse gas emissions intensity of employment*, *High-speed internet coverage*, *Environmental tax revenues*, and *Environmental protection expenditure*. The current leader is Poland, which has improved significantly since the baseline year, particularly in increasing *Gross domestic expenditure on R&D* (from 1% in 2015 to 1.56% in 2023), expanding *High-speed internet coverage* (from 9% in 2015 to 81.1% in 2023), and reducing the percentage of *Population unable to keep home adequately warm* (from 7.5% in 2015 to 4.7% in 2023). By contrast, Slovakia, surprisingly, has substantially increased the percentage of *Population unable to keep home adequately warm* (from 5.8% in 2015 to 8.1% in 2023), which has contributed the most to its weaker performance in this component.

As Table 3 shows, Slovakia is currently the best-performing V4 country, achieving a score of 49. Hungary ranks second with a score of 47, followed by Czechia (43) and Poland (41). The data analysis shows the most significant changes occurred in Poland, particularly in the categories *Reducing our climate impact* and *Enabling a green and just transition*. Poland demonstrated notable progress in several areas. First, the percentage of newly registered zero-emission passenger vehicles significantly increased from 0.03% in 2015 to 3.6% in 2023. Zero-emission vehicles do not produce any direct exhaust emissions and include both hydrogen fuel cell vehicles and battery electric vehicles. Second, the share of passenger transport by rail experienced a substantial rise, from 6.7% in 2015 to 8.3% in 2022. Third, gross domestic expenditure on R&D grew from 1% of GDP to 1.56% of GDP between 2015 and 2023. Fourth, *High-speed internet coverage* expanded significantly, from 9% in 2015 to 81.1% in 2023, indicating a major increase in households with access to very high-capacity fibre optic networks. Finally, there was a significant decrease in *Population unable to keep their home adequately warm* due to financial reasons, which fell from 7.5% in 2015 to 4.7% in 2023.

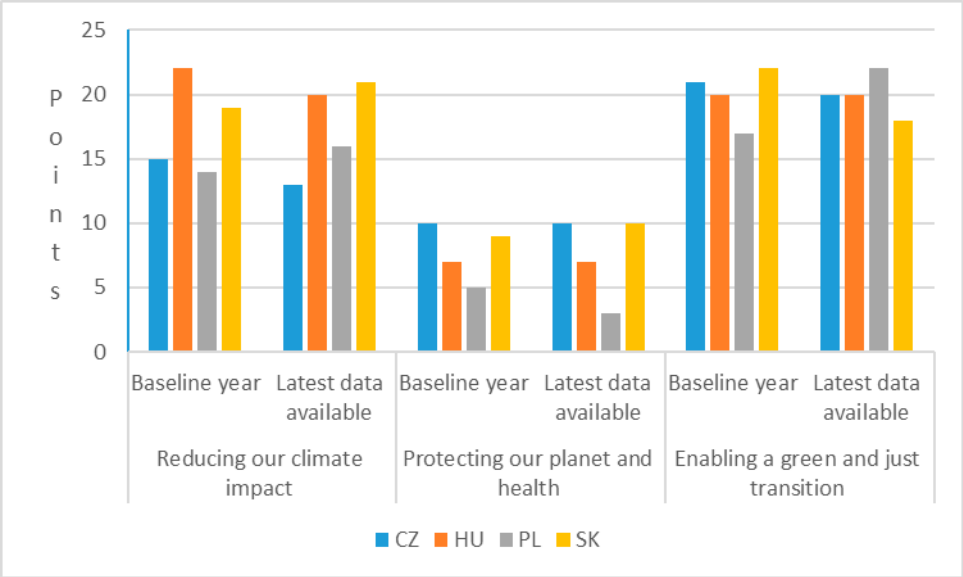

Figure 2. Main components of the European Green Deal Index in the V4 countries

Source: own elaboration based on Eurostat data.

Despite these improvements, it was not enough to surpass Slovakia, Hungary, and Czechia. Slovakia leads in only six out of the 18 monitored indicators (*Net greenhouse gas emissions, Household energy consumption, Passenger transport – Rail, Freight transport – Rail, Generation of waste,* and *Raw material consumption*), although it ranks second in another four categories, which is the reason for its final EGDI score.

Table 3. European Green Deal Index and its components in the V4 countries

	Reducing our climate impact		Protecting our planet and health		Enabling a green and just transition		EGDI	
	Baseline year	Latest data available	Baseline year	Latest data available	Baseline year	Latest data available	Baseline year	Latest data available
CZ	15	13	10	10	21	20	**46**	**43**
HU	22	20	7	7	20	20	**49**	**47**
PL	14	16	5	3	17	22	**36**	**41**
SK	19	21	9	10	22	18	**50**	**49**

Source: own elaboration based on Eurostat data.

Discussion

The EGD is designed to inspire and guide fundamental changes in the way the green transition is understood and implemented. Green measures and initiatives used to be the responsibility of specialised institutions focused on biodiversity conservation and climate change mitigation. However, as highlighted in the report *Implementing the European Green Deal: Handbook for Local and Regional Governments* (European Union 2022), the EGD seeks to empower actors at all levels and across all sectors to help protect and preserve ecosystems, health, food and water security, human security and human development. Gradual changes are no longer enough; transformational changes are required.

The empirical results of this research suggest that no single country can lead across all EGDI indicators (Table 2, Table 3, and Figure 1). Thus, countries must choose and set their priorities for the future due to budget restraints. The findings also show that the indicator *Population unable to keep home adequately warm*, which is perceived more sensitively within the population, is deteriorating in some V4 countries like Czechia, where it increased from 5.0% in 2015 to 6.1% in 2023, and Slovakia, which saw a rise from 5.8% in 2015 to 8.1% in 2023. By contrast, the indicator *Environmental tax revenues*, which measures the share of environmental taxes in total revenues from taxes and social contributions, improved in all V4 countries between 2015 and 2023.

There is broad consensus that the most sustainable path to long-term prosperity and growth throughout the European Union (EU) is a transition to environmentally and climate-friendly technologies and methods of production and consumption. The EGD, which is conceived as a growth strategy, offers a stable framework for transitioning to the green economy at the local and regional levels (European Union 2022). However, there are also criticisms of the EGD and the just transition. The biggest questions arise in the social area, and our findings show that *Household energy consumption* improved only in Hungary (from 18.6 to 18.2 GJ per capita) between 2015 and 2022. All the other V4 countries experienced an increase: Slovakia from 10.5 to 14.5 GJ per capita, Czechia from 18.1 to 19.7 GJ per capita, and Poland from 13.8 to 14.8 GJ per capita. The more energy that households use, the more they have to pay. Additionally, the findings contradict Riepl and Zavarská (2023), who concluded that retrofitting schemes are working well in the V4 in terms of reducing household energy consumption. Thus, this offers a possibility for future research.

Akgüç, Arabadjieva, and Galgóczi (2022) emphasise that the social dimension of the EGD remains underdeveloped. The challenges associated with greening are mainly related to job losses, retraining and increasing the qualifications of the workforce, protecting citizens' social rights, citizen participation and the distributional effects of the green transition. Actions to mitigate climate change without further measures might deepen social inequalities, as initiatives designed to ensure a just transition remain fragmented.

The just transition must be considered an integral part of the EGD and not just a set of additional measures to solve problems that have arisen. The European Environmental Bureau (EEB 2022) report praises the EGD for its vision, strategies, long-term commitments and the important legislative reforms it has brought. However, it lags behind, particularly in the pace of making real changes and introducing financial and restrictive measures. This slow progress reflects ongoing resistance from industry, political groups and other stakeholders seeing to maintain the status quo and avoid implementing new measures.

A fundamental task for the coming decades is the decarbonisation of economies and the transition to a low-carbon and green economy. However, this transition can only succeed if it is fair and that no one is left behind. According to Galgóczi (2018), the term just transition appeared in the early 1990s as a response to trades unions' demand to harmonise labour, social and environmental priorities. In 2010, it began to appear in international agreements, and since then, it has become a well-established policy tool at the global level. The 2015 Paris Agreement (UNFCCC 2015) requires that the just transition of the workforce and the creation of decent work and quality jobs be taken into account in line with development priorities defined at the national level.

A just transition should involve more than just welfare adjustments; it requires proactive societal support and clearly defined decarbonisation goals. Unlike other shifts that affect people's working and living conditions, such as digitisation and globalisation, this transition demands targeted and holistic approaches when creating and implementing policies. It should not be merely a supplement to climate policy; it must be an integral part of the political framework of sustainable development. Functionally, there are two main dimensions.

1. Outcome-oriented: A new working and social environment that eradicates poverty and ensures decent work for all in an inclusive society.

2. Process-oriented: It focuses on how we get to the desired results and should be based on a controlled transition with meaningful social dialogue at all levels. It will ensure that the distribution of the burden is fair and that no one is left behind (Galgóczi 2018).

The shift to a low-carbon and green economy requires prioritising indicators related to decarbonisation, such as net greenhouse gas (GHG) emissions, renewable energy, and GHG emissions intensity of employment. However, it is equally essential to consider various other indicators which are important for a just transition, like the population being unable to keep their home adequately warm for financial reasons and the generation of waste.

Our findings show that between 2015 and 2022, there were reductions in net GHG emissions in Czechia (from 11.7 to 11.4 tonnes per capita), Hungary (from 5.8 to 5.6 tonnes per capita), and Slovakia (from 6.6 to 5.5 tonnes per capita). However, despite a massive EU campaign supported by large-scale financial instruments, Poland experienced a surprising increase (from 9.2 to 9.4 tonnes per capita).

The EU's energy and climate policy presents a major challenge, both at the EU level and for individual Member States. For Poland, this problem is particularly challenging due to its current energy production model, which relies heavily on fossil fuels, mainly lignite and hard coal (Tomaszewski 2020; Riepl and Zavarská 2023; Takyi et al. 2024).

All V4 countries increased the share of renewable energy in gross final energy consumption between 2015 and 2023: Czechia from 15.7 to 18.6, Hungary from 14.5 to 17.1, Poland from 11.9 to 16.6, and Slovakia from 12.9 to 17.0. While Poland showed a significant improvement, some authors consider it to be the least prepared of the V4 for the green transition in the energy sector (Tomaszewski 2020; Riepl and Zavarská 2023; Streimikis et al. 2024).

Poland is the worst-performing V4 country on the indicator that tracks GHG emissions per employed person, providing insight into the potential social impact of the green transition (Riepl and Zavarská 2023). Nonetheless, all V4 countries, including Poland, made progress. Between 2015 and 2023, Hungary experienced the most significant decrease (from 12.2 to 9.7 tonnes), followed by Slovakia (from 14.9 to 12.4), Czechia (from 20.4 to 16.2), and Poland (from 21.3 to 18.7 tonnes).

A successful green and just transition must focus not only on decarbonisation indicators like net GHG emissions, renewable energy, and GHG emissions intensity of employment but also on waste generation and the population unable to keep home adequately warm for financial

reasons. Another indicator in which Poland lags the other V4 countries is waste generation, which measures all waste generated in a country in kilograms per capita. The V4 countries typically produce significantly less municipal waste per capita compared to the EU average, which can be attributed to their lower levels of economic development, which result in reduced purchasing power (Riepl and Zavarská 2023).

Between 2016 and 2022, Poland reduced its waste generation from 4793 to 4739 kilograms per capita. In contrast, Czechia (from 2402 to 3672 kg), Hungary (from 1624 to 2838 kg), and Slovakia (from 1953 to 2462 kg) increased their waste generation. Takyi et al. (2024) and Streimikis et al. (2024) conclude that the V4 countries mitigate their environmental externalities and carbon emissions by adopting circular economy strategies and implementing green innovation practices.

Riepl and Zavarská (2023) argue that managing the green transition requires particularly strong and well-implemented social policies. However, the experience from the V4 countries is mixed. Two countries faced negative trends in energy poverty. In Slovakia, the percentage of the population unable to keep their home adequately warm increased from 5.8% in 2015 to 8.1% in 2023, while in Czechia, it rose from 5% to 6.1% over the same period. This trend presents an opportunity for future research, as the transition to a green economy requires support from all stakeholders, especially lower-income households.

In 2015, the International Labour Organisation adopted the *Guidelines for a just transition towards environmentally sustainable economies and societies for all* (ILO 2015). They provide a policy framework and an operational tool to address environmental change in a way that promotes social justice and the creation of decent jobs (ILO 2022). The guidelines identify two core principles for addressing the challenges of a just transition.

First, greening economies within the framework of sustainable development and poverty eradication requires a combination of macroeconomic, industrial, sectoral and labour market policies. This integrated approach will create an enabling environment for the development of sustainable businesses and the creation of decent job opportunities by mobilising and directing public and private investment towards sustainable environmental activities. The goal should be to create decent jobs, improve skills and increase productivity throughout the supply chain. Second, sustainable development must be addressed in all policy areas. Effective integration of economic, environmental and social dimensions requires cooperation and coordination at regional, national and global levels. Institutional conditions must also be created for meaningful social dialogue at all levels.

Galgóczi (2018) states that the just transition should not be considered an abstract concept because it appears in many policies; these policies must be adapted to national, regional and sectoral circumstances. The concept is present in programs supporting the transition between jobs due to company closures, in green public procurement (in decent work clauses), and in international framework agreements. Climate change increases the likelihood of natural disasters, which can affect the economy, cause financial losses, and affect GDP, employment, the sectoral distribution of jobs and labour productivity.

The ILO (2022) states that green macroeconomic growth policies should help reduce negative economic effects and ensure a just and equitable transition to a green economy for everyone. The global policy framework must be adapted to the circumstances of individual countries to address the effects of climate change on labour markets and business environments. Just transition policies could foster job creation, business resilience, social inclusion and inclusive growth. As part of the just transition, it will be important to support vocational training and retraining programs, implement investment in long-term climate projects, support green business, green innovations and green jobs, improve social protection networks, health and safety conditions at work and facilitate the reallocation of workers to green activities.

As the just transition is part of the EGD, the Just Transition Mechanism (JTM) was created alongside the EGD (European Commission 2019), as only a just and inclusive transition can be successful. The JTM aims to support and protect regions that will be most affected by the shift away from fossil fuels, often those where jobs are tied to heavy industry, which is dependent on fossil fuels. The JTM supports low-carbon activities and the retraining of workers. It also provides easy access to loans and financial support for these activities (Fetting 2020), as well as financial support and technical assistance to those most affected by the transition to the green economy.

Conclusion

The big challenge of the 21st century is to find a solution to achieve global development that considers economic, social and environmental aspects. Currently, there are significant differences between the state of the environment and the EU's short- and long-term objectives. When planning for the future, it is crucial to adopt new approaches and move beyond traditional methods. For that reason, the Eurostat database offers 27 key indicators that are relevant to the objectives of the EGD, making it possible to compare and highlight both positive and negative developments across countries. In this research, due to data availability, 18 key indicators were used to monitor progress in the V4 countries.

When adopting new measures, emphasis must be placed not only on the quantitative outcomes but also on qualitative aspects, with more emphasis now being placed on the social dimension of the green transition. Nevertheless, between 2015 and 2023, Slovakia and Czechia experienced negative trends, with an increase in the percentage of the population unable to keep their home adequately warm for financial reasons. Rising household costs associated with the green transition could affect public support for it.

The concept of the just transition is widely supported with increasing efforts to address the needs of those most affected by the transition to a green economy. Successful management of a sustainable transition requires careful consideration of both potential risks and opportunities, with policies playing a vital role in achieving a just transition. Our findings show that Poland experienced a major improvement in the category *Enabling a green and just transition* between 2015 and 2023 in comparison to the other V4 countries. Nevertheless, it is necessary to realise that financial resources are limited, and countries must prioritise their actions in the coming years.

Support will be needed for companies and workers in declining industries, whether through retraining, subsidies or technical assistance and investment for negatively affected regions. Early identification of emerging risks and opportunities related to technological and social development is a key task for the V4 countries and all EU Member States in the decades ahead.

This study has several limitations that must be acknowledged. It focuses on the V4 countries and could be extended to cover all EU27 countries and/or groups of countries. Combining data from multiple sources would strengthen the analysis. In 2019, the European Commission launched the EGD as one of its six key political priorities for the 2019–2024 period. Therefore, future research could focus on evaluating the entire 2019–2024 time frame to provide a more comprehensive assessment of progress.

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Zielona gospodarka dla zrównoważonej przyszłości: doświadczenia krajów Grupy Wyszehradzkiej

Celem artykułu jest zidentyfikowanie znaczenia zielonej gospodarki dla zrównoważonej przyszłości oraz porównanie sytuacji i postępów w realizacji założeń Europejskiego Zielonego Ładu (EGD) w krajach Grupy Wyszehradzkiej (V4). Aby osiągnąć ten cel, w artykule skoncentrowano się na wyzwaniach, zagrożeniach i szansach związanych z wdrażaniem zielonej gospodarki. Dokonano kompleksowej analizy danych oraz opracowano Indeks Europejskiego Zielonego Ładu (EGDI) dla krajów V4. Wykorzystano dane z bazy danych Eurostatu do monitorowania 18 kluczowych wskaźników w krajach V4 od roku 2015 do ostatniego roku, dla którego dostępne były dane. Wyniki pokazują, że Słowacja jest najlepiej radzącym sobie krajem V4, z najwyższym wynikiem EGDI, podczas gdy Polska wykazuje największą poprawę, głównie w kategorii *Umożliwienie zielonej i sprawiedliwej transformacji*. W latach 2015–2023 na Słowacji i w Czechach odnotowano negatywne tendencje w zakresie odsetka ludności, która nie jest w stanie odpowiednio ogrzać swoich domów z powodów finansowych. W dokumencie podkreślono społeczny wymiar Europejskiego Zielonego Ładu i zielonej gospodarki, a także znaczenie koncepcji sprawiedliwej transformacji w całej Unii Europejskiej, ponieważ zwiększone wydatki gospodarstw domowych na transformację ekologiczną mogą wpłynąć na wsparcie publiczne.

Słowa kluczowe: Europejski Zielony Ład, Indeks Europejskiego Zielonego Ładu, zielona gospodarka, sprawiedliwa transformacja, Grupa Wyszehradzka

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The Role and Significance of EU Guidelines on Non-financial Reporting for SMEs

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Abstract

This study investigates the role and impact of non-financial reporting (NFR) regulations on small and medium-sized enterprises (SMEs) in the European Union. While large enterprises are the primary focus of directives such as the Non-Financial Reporting Directive (NFRD) and the Corporate Sustainability Reporting Directive (CSRD), SMEs are increasingly affected due to supply chain dependencies and financial incentives. The research aims to assess SME awareness, challenges, and expected benefits related to NFR adoption.

The study is based on an empirical survey of 151 SMEs in the Kuyavian-Pomeranian Voivodeship in Poland, utilizing statistical methods such as correlation analysis and regression modeling to evaluate attitudes toward compliance and perceived barriers.

The findings reveal that while SMEs acknowledge the growing relevance of NFR, resource limitations and lack of expertise hinder effective implementation. Nevertheless, SMEs that have proactively adopted NFR practices report benefits, including enhanced stakeholder relationships and a competitive market advantage.

The study highlights the necessity for targeted policy interventions, including financial support, simplified compliance frameworks, and dedicated training initiatives to facilitate SME adaptation to sustainability reporting standards.

This research contributes to the ongoing discussion on sustainability reporting by focusing on SMEs, a sector often neglected in NFR policy discussions. The study also provides empirical insights into how regulatory developments shape SME behavior, offering recommendations for policymakers on supporting sustainability transitions in the SME sector.

Keywords: non-financial reporting, accounting, Corporate Sustainability Reporting Directive (CSRD), ESG factors (environmental, social, governance), SME, sustainability, social responsibility

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Introduction

The increasing urgency of global climate change has driven the European Union (EU) to implement comprehensive policies aimed at sustainability and corporate responsibility. A cornerstone of this approach is the European Green Deal (EGD), which aims to decarbonize the European economy by 2050, with an interim goal of reducing greenhouse gas (GHG) emissions by 55% by 2030 (Ruiz, Martin-Moreno, and Perez 2023). This shift represents a move from previous economic policies, which focused primarily on crisis management while integrating climate considerations (Ossewaarde and Ossewaarde-Lowtoo 2020). In this evolving regulatory landscape, the role of non-financial reporting (NFR) has gained significance. The EU has introduced directives such as the Non-Financial Reporting Directive (NFRD) and its successor, the Corporate Sustainability Reporting Directive (CSRD), both of which aim to standardize sustainability disclosures (Directive 2004/109/E, Directive 2006/43/EC, Directive 2013/34/EU). While these directives primarily target large enterprises, their effects extend to small and medium-sized enterprises (SMEs) through supply chain dependencies and financing requirements. SMEs increasingly find themselves required to report on environmental, social, and governance (ESG) factors to remain competitive and compliant with financial and corporate partners (Karaszewski et al. 2021; Modrzyński and Karaszewski 2022). Despite the growing importance of non-financial reporting, significant research gaps remain, particularly regarding SMEs. The existing literature has primarily focused on large corporations, leaving a limited understanding of how SMEs perceive and implement NFR. While studies on Corporate Social Responsibility Reports, Sustainable Development Reports, and Integrated Reports have proliferated (Michalak, Staszkiewicz, and Waniak-Michalak 2023), there is a lack of research examining SMEs' specific challenges and opportunities in this area. Given their resource constraints and different market dynamics, SMEs require tailored policy solutions to facilitate NFR adoption.

This article aims to analyze the role of NFR in SMEs, assess its challenges, and explore its potential benefits for long-term business sustainability[1]. The study employs a quantitative research approach based on survey data collected from SMEs. The expected outcome is an improved understanding of SME readiness for NFR compliance and the development of policy recommendations to support them in this transition. By identifying key barriers and opportunities, the study seeks to contribute to the broader discussion on sustainability reporting in the SME sector.

Both the Securities and Exchange Commission (SEC) and the Public Company Accounting Oversight Board (PCAOB) also address the issue of the scope of information included in sustainable development reports and the role of the auditor in reporting on sustainable development (Liu et al., 2023).

The introduction of uniform reporting standards (*European Sustainability Reporting Standards* – ESRS) (Godemann and Michelsen 2011) and key performance indicators for assessing organizational outcomes necessitates collecting extensive data. The obligation to prepare a sustainability

1 The article was presented at the EBES conference in Istanbul from July 4–6, 2024.

report will significantly impact the scope of work and the accounting tools used, both in financial and managerial accounting. Thus, non-financial reporting aligns with the initiatives launched by the European Council in June 2019 related to climate transformation. The newly adopted strategic program for 2019–2024, within one of its four priority areas, aims to build a climate-neutral, environmentally friendly, just, and socially equitable Europe (European Council 2019). In November 2019, the European Parliament declared a climate emergency and called on the European Commission to continue legislative efforts to reduce greenhouse gas emissions. As a result of the actions taken by the European Commission, the EGD was adopted. It aims to guide the EU towards ecological transformation and ultimately achieve climate neutrality by 2050 (European Commission 2019).

To verify the achievement of environmental goals outlined in the EGD, appropriate monitoring tools, such as non-financial reports, were necessary. The European Parliament, through the Accounting Directive (2013/34/EU) (The European Parliament and of the Council, 2013) amended by the Corporate Sustainability Reporting Directive (CSDR–2022/24642), mandated that large enterprises, SMEs listed on regulated markets, and controlling entities of large groups include essential sustainability impact information in a separate section of their reports. This information, compliant with the European Sustainability Reporting Standards (ESRS), should cover:

- Time-bound sustainable development goals set by the entity.
- Roles of governing, managing, or supervisory bodies concerning sustainability, including relevant expertise.
- The entity's policies on sustainable development.
- The existence of incentive systems related to sustainability.
- Due diligence processes regarding sustainability, including significant adverse impacts.
- Actions taken to address these impacts and their results.
- Significant sustainability-related risks.
- Key indicators related to required disclosures.

Relevant cases should include information about the entity's operations, value chain, products, services, business relationships, and supply chains. Sustainability reporting standards must ensure information quality, avoid disproportionate administrative burdens, specify necessary disclosures for environmental, social, human rights, and management factors, and address the difficulties in collecting value chain information. They must also ensure proportional and suitable disclosures for SMEs and align with global standards and EU requirements (Directive 2004/109/E, Directive 2006/43/EC, Directive 2013/34/EU; Global Reporting Initiative 2024).

Theoretical background and hypothesis development

Despite the very broadly defined requirements for non-financial reporting in sustainable development, it is challenging to establish uniform guidelines. For this purpose, the European Commission, in its communication in 2017, introduced guidelines on non-financial

information reporting, which boiled down to defining its methodology (The European Parliament and of the Council 2017). According to the guidelines, the following principles were established for presenting non-financial information in reports: (1) disclosure of significant information, (2) fair, balanced, and understandable information, (3) comprehensiveness, (4) strategic and future-oriented, (5) stakeholder focused, and (6) consistent and uniform. For a better and more comprehensive understanding of the methodology presented by the European Commission for classifying information in non-financial reports, A table with examples and critical indicators was developed (Table 1).

Table 1. Comparison of principles, methodology, and critical indicators for capturing non-financial information in reporting according to the guidelines of the European Commission

Principles of capturing information	Methodology	Example and critical indicators of effectiveness
(1) Disclosure of significant information	In Article 2 (16) of the Accounting Directive (2013/34/EU), significant information is defined as "the status of information where it can reasonably be expected that its omission or inaccuracy may influence the economic decisions taken by users based on the financial statements of a particular entity. The materiality of individual items is assessed in the context of other similar items." The impact of a company's activities is a significant matter to consider when disclosing non-financial information. The effect can be either positive or negative. The disclosure of substantial information should encompass both types of information clearly and rationally. The statement on non-financial information is expected to reflect a fair picture of the information needed by relevant stakeholders, as presented by the company.	A bank may consider that its water consumption in offices and branches is not a significant issue to be included in the activity report. However, the bank may assess that the social and environmental impact of projects it finances and its role in supporting the real economy of a city, region, or country constitutes significant information. A company may deem the impact exerted through its supply chain at earlier stages to be a relevant and significant matter. Therefore, it may include it in the submitted reports. The impact can be direct or indirect. For example, a company producing mineral water may consider specific measures taken to protect water resources on which it relies.
(2) Fair, balanced, and understandable	Relevant information should be presented in the appropriate context to facilitate its understanding. A company's results can be presented, for example, in relation to its strategy and broader objectives. Companies must describe how non-financial issues are connected to their long-term strategy, significant risks, and policies. Clarity can also be enhanced by explaining key internal elements of disclosed information, such as measurement methods, underlying assumptions, and their sources.	A company disclosing specific key performance indicators can enhance transparency by providing information about the purpose and linkage to the company's strategy, definition and methodology, information sources, assumptions and constraints, the scope of relevant activities; benchmarks, goals, trends, potential changes in methods, and any qualitative explanations regarding historical and expected results.
(3) Comprehensive	As a minimum requirement, the material information regarding specific categories of issues reflected in the directive must be disclosed, namely: (1) environmental, social, and employee-related matters, (2) respect for human rights, and (3) anti-corruption and anti-bribery.	The company may summarize information, focus on material details, eliminate generic information, limit details, avoid elements that are no longer significant, use references and markers, etc.

Principles of capturing information	Methodology	Example and critical indicators of effectiveness
(4) Strategic and Future-oriented	Companies are expected to disclose relevant information about their business model, including strategy and objectives. The disclosure of information should provide insight into the strategic approach to relevant non-financial issues, such as the company's business profile, how it operates, and for what purpose.	A company can disclose its approach to a sustainable business strategy and how environmental, social, and management performance results can contribute to achieving its business objectives. It may also disclose goals related to key performance indicators in the report and explain uncertainties and factors that may form the basis for future information and perspectives.
(5) Oriented towards stakeholders	Businesses are expected to consider the information needs of all relevant stakeholders. They should focus on the information needs of stakeholders as a group rather than the needs or preferences of individual or atypical stakeholders or stakeholders with irrational information requirements.	A company may disclose relevant information about its collaboration with stakeholders and explain its implications for the decisions made by the company, its results, and the impact of its activities.
(6) Consistent and uniform	Consistency is expected between the statement on non-financial information and other elements of the activity report. The content of the non-financial information report should be consistent over time. This allows users of the information to understand and compare historical and current changes in the development of the enterprise, its situation, results, and the impact of its activities and to credibly relate to future-oriented Information.	The enterprise may identify relationships and connections between its business model and aspects related to corruption and bribery.

Source: own compilation based on the European Commission guidelines on non-financial reporting – The European Parliament and of the Council 2017, p. 215.

However, research indicates that SMEs often struggle with these principles due to a lack of standardized frameworks adapted to their specific needs (Ortiz-Martínez, Marín-Hernández, and Santos-Jaén 2023). Recent literature emphasizes the increasing role of Environmental, Social, and Governance (ESG) factors in corporate decision-making. The Global Reporting Initiative (GRI) has played a crucial role in standardizing sustainability reporting by providing structured guidelines for measuring and disclosing ESG-related activities (Bais, Nassimbeni, and Orzes 2024). However, studies suggest that while large enterprises have successfully adopted these standards, SMEs face significant barriers in implementation, primarily due to resource constraints and a lack of regulatory clarity (Ozkan, Romagnoli, and Rossi 2023). One of the emerging challenges in non-financial reporting is integrating digital ethics and data sustainability into ESG frameworks. Research highlights the need to balance sustainability disclosures with data privacy concerns, especially as digitalization becomes a fundamental component of corporate governance strategies (Balboni and Francis 2024). This underscores the need for a more holistic approach to sustainability reporting, incorporating both environmental impact and ethical data management practices.

Table 2. Thematic areas of European Sustainability Reporting Standards

General	Environment	Society	Corporate Governance
ESRS 1 – general requirements ESRS 2 – general disclosures	ESRS E1 – Climate change ESRS E2 – Pollution ESRS E3 – Water and marine resources ESRS E4 – Biodiversity and ecosystems ESRS E5 – Resource use and circular economy	ESRS S1 – Employment ESRS S2 – Employees in the value chain ESRS S3 – Social environment ESRS S4 – Consumers and end-users	ESRS G1 – Business practices

Source: own compilation based on the EU Directive on corporate sustainability reporting – The European Parliament and of the Council, 2022.

Reviewing EU legislation (The European Parliament and of the Council 2022), attention should be given to the EU Directive on corporate sustainability reporting, presented in 12 standards covering various thematic areas (Table 2). The directive divides reporting standards into environmental, social, and governance factors, aligning with existing global frameworks such as the International Financial Reporting Standards (IFRS) and the Task Force on Climate-related Financial Disclosures (TCFD) (Cronin and Doyle-Kent 2022):

1. Environmental Factors:
   - Climate change mitigation and greenhouse gas emissions.
   - Adaptation to climate change.
   - Water and marine resources.
   - Resource use and circular economy.
   - Pollution.
   - Biodiversity and ecosystems.
2. Social and Human Rights Factors:
   - Equal treatment and opportunities, including gender equality, equal pay, training, employment of persons with disabilities, prevention of workplace violence and harassment, and diversity.
   - Working conditions, including safe employment, working hours, adequate remuneration, social dialogue, freedom of association, works councils, collective bargaining, workers' rights to information, consultation, participation, work-life balance, and occupational health and safety.
   - Respect for human rights, fundamental freedoms, and principles of democracy, including international and European conventions and charters.
3. Management-Related Factors:
   - Roles of governing, managing, and supervisory bodies in sustainability, their composition, expertise, and skills.
   - Internal control and risk management systems related to sustainability reporting and decision-making.

- Business ethics and corporate culture, including anti-corruption measures, protection of whistleblowers, and animal welfare.
- Political influence activities, including lobbying.
- Management and quality of relationships with customers, suppliers, and communities affected by the entity's activities, including payment practices, especially regarding delays in payments to small and medium-sized entities.

ESG reporting obligations

Most specialists anticipate that, at the outset of the ESG reporting process, companies will make mistakes due to the complexity of the matter. However, a crucial aspect of this process will be hiring individuals with the appropriate qualifications and training selected employees who will be responsible for preparing the reports. Currently, companies often complain about an excess of legal regulations and may not show particular commitment to reducing their carbon footprint, focusing mainly on financial results and short-term actions. In November 2022, the European Council finally approved the Corporate Sustainability Reporting Directive (CSRD). It introduces new reporting obligations, which have been phased over four stages based on a specified timeline, as follows:

- Stage I (in 2025 for the financial year 2024) – obligation for companies already subject to the Non-Financial Reporting Directive.
- Stage II (in 2026 for the financial year 2025) – obligation for large companies not yet subject to the NFRD (applies to firms meeting two out of three criteria: employing more than 250 employees, total balance sheet exceeding EUR 20 million, annual revenues exceeding EUR 40 million).
- Stage III (in 2027 for the financial year 2026) – obligation for listed SMEs (excluding micro-enterprises), small and non-complex credit institutions, and internal insurance institutions.
- Stage IV (in 2029 for the financial year 2028) – obligation for companies from third countries, provided they generate over EUR 150 million in net sales revenue in the EU and have at least one subsidiary or branch here exceeding certain thresholds.

Data and methodology

Despite the fact that SMEs are not yet legally required to prepare non-financial reports, their increasing relevance and importance necessitate further research into this area. NFR is gaining significance due to its role in sustainable business practices and its growing impact on financial decision-making. This study aims to assess the role and significance of non-financial reporting among SMEs in Poland and examine how it contributes to building sustainable development strategies within enterprises.

To achieve this objective, a structured questionnaire survey was conducted among SMEs located in the Kuyavian-Pomeranian Voivodeship of Poland. The survey targeted businesses affiliated with key industry and professional organizations, including the Association of Accountants in Poland and the Chamber of Commerce and Industry. The research tool consisted of 20 closed-ended questions using a Likert scale, designed to evaluate awareness, usage, and the perceived benefits and challenges of non-financial reporting. The questionnaire also investigated the expected financial and operational impact of NFR on SMEs, including compliance costs and access to external financing.

The study specifically examined the extent to which SMEs engage in non-financial reporting due to external pressures, such as supply chain dependencies and financing conditions. Given that access to preferential financing (e.g., grants and preferential loans) increasingly requires sustainability-related disclosures, SMEs are becoming more involved in ESG reporting.

The questionnaire covered three key research areas: (1) awareness of non-financial reporting requirements, (2) anticipated obligations and reporting areas likely to affect SMEs, and (3) the prioritization of key sustainability factors in corporate decision-making. The survey was conducted in May 2024 using an online questionnaire distributed to SMEs affiliated with the mentioned industry organizations. In total, 151 enterprises participated in the study (Table 3).

Table 3. Characteristics of respondents – structure of enterprises by size

Characteristics of enterprises	Number of enterprises	Share %
Micro enterprise	40	26.5
Small enterprise	79	52.3
Medium enterprise	32	21.2
Total	151	100.0

Source: own elaboration based on the results of own research.

Research results

The survey confirms that non-financial reporting remains an unfamiliar concept for most SMEs. Only a small fraction of respondents indicated some level of engagement with these reports, mainly due to collaborating with larger entities that are already subject to such requirements. The most relevant aspects of non-financial reporting for SMEs relate to environmental considerations (Chart 1).

This low level of awareness aligns with findings from prior research (e.g., Michalak, Staszkiewicz, and Waniak-Michalak 2023), which highlights that SMEs are often excluded from regulatory discussions on sustainability reporting. However, the growing role of supply chain dependencies suggests that even if legal obligations do not yet apply, indirect pressures from larger corporations will encourage SMEs to adopt non-financial reporting practices. This raises the question of whether policy measures should focus more on SME education and support in this area.

SMEs largely anticipate that non-financial reporting obligations will be extended to their sector within the next three years, with environmental issues being the primary focus. Social, human rights, and anti-corruption reporting are seen as less immediate concerns, while diversity reporting remains a relatively low priority (Chart 2). The respondents overwhelmingly agreed that the environmental area of non-financial reporting is currently the most important (92.7%). The strong expectation that environmental reporting will become mandatory suggests that SMEs recognize regulatory trends, even if they are not yet directly affected. This finding supports previous studies (Karaszewski et al. 2021; Modrzyński and Karaszewski 2022) that indicated that sustainability concerns are increasingly shaping business strategies across all enterprise sizes. However, the relatively low anticipation of social and diversity reporting suggests that these aspects are still perceived as secondary, which may indicate a need for further regulatory incentives or awareness campaigns.

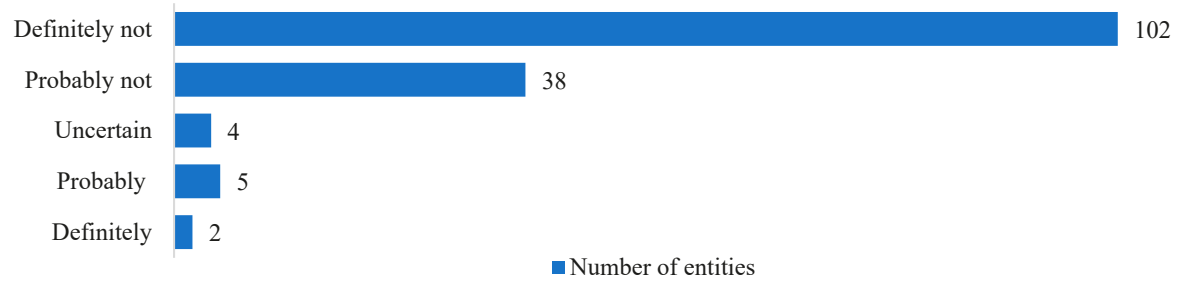

Chart 1. Survey results for the question: 'Does the company you work for prepare non-financial reports (e.g., related to environmental protection) in any capacity?'

Source: own elaboration based on the results of own research.

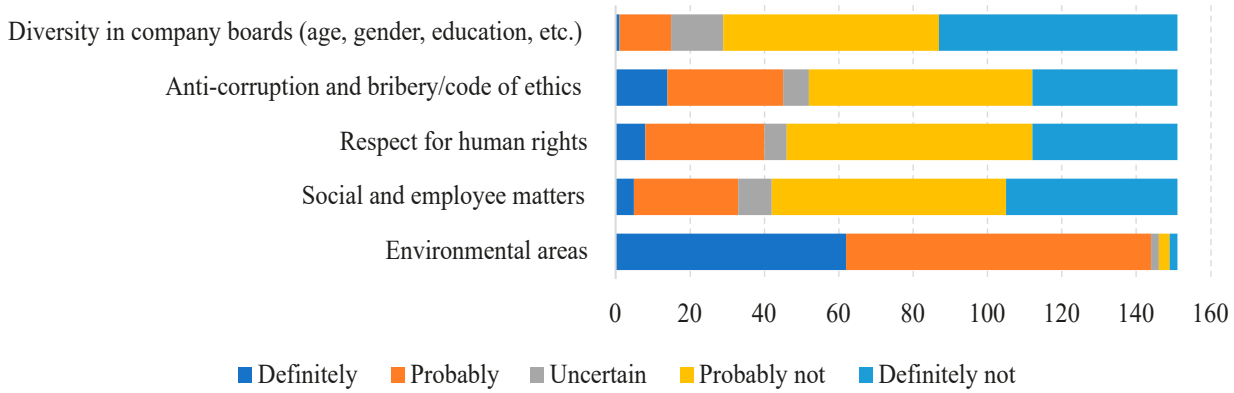

Chart 2. Survey results for the question: 'Will the company you work for, in your opinion, be preparing non-financial reports within the next 3 years?'

Source: own elaboration based on the results of own research.

The respondents largely agreed that non-financial reporting will become a prerequisite for securing both repayable and non-repayable external financing. This highlights the growing role of sustainability criteria in financial decision-making (Chart 3).

Business owners acknowledge both the challenges and benefits of environmental policies. While they anticipate higher operational and investment costs, they also see potential long-term gains in corporate reputation and financial performance (Chart 4). This reflects a common dilemma

among SMEs: while sustainability initiatives can enhance brand perception and competitiveness, the immediate financial burden often discourages smaller firms from implementing them. Prior studies (Ossewaarde and Ossewaarde-Lowtoo 2020) highlighted that SMEs require external incentives, such as tax reliefs or grants, to balance these costs. This suggests that policymakers should consider additional support mechanisms to encourage early adoption of sustainable business practices.

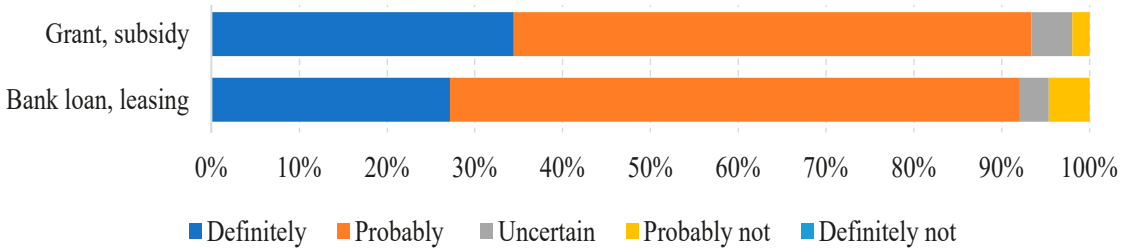

Chart 3. Survey results for the question: 'Do you think that preparing non-financial reports may become a formal requirement in the future, conditioning the possibility of obtaining repayable or non-repayable external financing for the company?'

Source: own study based on the results of own research.

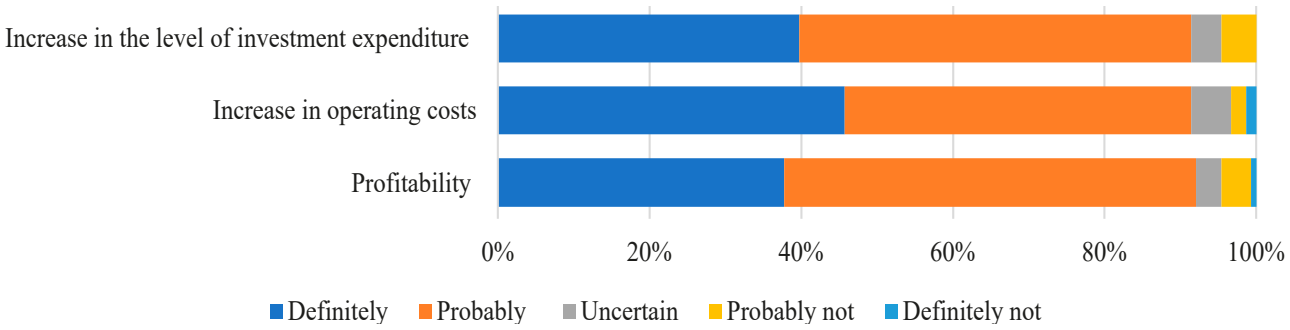

Chart 4. Survey results for the question: 'Do you think that preparing non-financial reports by the company can have a positive impact on its operations?'

Source: own elaboration based on the results of own research.

The SME sector reports a need for participation in training regarding the obligations and substantive scope of non-financial reporting. Almost 63% of respondents definitively expressed a willingness to participate in such training, and an additional 32.5% indicated that they might positively consider such an offer.

Discussion

Interpretation of the research results

The research results were interpreted using descriptive statistics tools, specifically a Pearson's correlation matrix, regression analysis, Chi-square tests, t-tests, and dependency analysis based on Cohen's Kappa coefficients (Tables 4–7). For statistical calculations, the Gretl econometric analysis platform was used.

Table 4. Pearson correlation matrix of questions included in the survey questionnaire

	Q1	Q2	Q3	Q4	Q5a	Q5b	Q5c	Q5d	Q5e	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
Q1	1	−0.233	0.083	0.058	0.163	−0.027	−0.068	−0.108	−0.027	0.099	−0.143	0.060	−0.160	−0.055	0.184	0.083	0.009	−0.058	0.002	−0.159
Q2	−0.233	1	0.284	0.061	0.060	0.146	0.250	0.341	0.193	−0.123	−0.019	−0.046	0.129	−0.089	0.012	0.077	−0.003	−0.039	0.230	0.047
Q3	0.083	0.284	1	0.533	−0.023	0.230	0.181	0.247	0.174	0.087	−0.050	−0.081	0.000	−0.021	−0.059	0.129	−0.132	−0.141	0.172	0.061
Q4	0.058	0.061	0.533	1	−0.011	0.249	0.139	0.139	0.102	0.183	0.091	−0.058	0.021	−0.086	0.063	0.087	−0.172	−0.038	0.113	0.108
Q5a	0.163	0.060	−0.023	−0.011	1	0.167	0.121	0.121	0.120	0.065	0.106	0.140	0.149	0.211	0.139	−0.133	0.179	0.155	0.022	0.055
Q5b	−0.027	0.146	0.230	0.249	0.167	1	0.689	0.602	0.410	0.175	−0.032	0.063	−0.071	−0.071	−0.063	0.092	−0.142	−0.100	0.255	0.144
Q5c	−0.068	0.250	0.181	0.139	0.121	0.69	1	0.694	0.445	0.069	−0.110	−0.049	0.001	−0.086	−0.111	0.146	−0.124	−0.041	0.226	0.088
Q5d	−0.109	0.341	0.247	0.139	0.121	0.602	0.694	1	0.339	0.018	−0.174	−0.060	−0.052	−0.130	0.083	0.135	−0.059	−0.066	0.272	0.055
Q5e	−0.027	0.193	0.174	0.102	0.120	0.410	0.445	0.339	1	0.114	0.014	0.095	0.021	−0.036	−0.077	0.094	0.030	0.021	0.068	−0.012
Q6	0.099	−0.123	0.087	0.183	0.065	0.175	0.069	0.018	0.114	1	−0.009	0.132	−0.069	−0.014	−0.115	0.042	−0.098	0.059	−0.035	0.029
Q7	−0.143	−0.019	−0.050	0.091	0.106	−0.032	−0.110	−0.174	0.014	−0.009	1	0.372	0.427	0.460	−0.331	−0.315	0.311	0.290	−0.110	0.007
Q8	0.060	−0.046	−0.081	−0.058	0.140	0.063	−0.049	−0.060	0.095	0.132	0.372	1	0.344	0.517	−0.126	−0.280	0.357	0.277	−0.220	−0.138
Q9	−0.160	0.129	0.000	0.021	0.149	−0.071	0.001	−0.052	0.021	−0.069	0.427	0.344	1	0.461	−0.138	−0.296	0.244	0.190	−0.147	−0.071
Q10	−0.055	−0.089	−0.021	−0.086	0.211	−0.071	−0.086	−0.130	−0.036	−0.014	0.460	0.517	0.461	1	−0.253	−0.440	0.450	0.351	−0.146	−0.051
Q11	0.184	0.012	−0.059	0.063	0.139	−0.063	−0.111	0.083	−0.077	−0.115	−0.331	−0.126	−0.138	−0.253	1	0.307	−0.155	−0.225	0.087	−0.085
Q12	0.083	0.077	0.129	0.089	−0.133	0.092	0.146	0.135	0.094	0.042	−0.315	−0.280	−0.296	−0.440	0.307	1	−0.601	−0.595	0.054	0.088
Q13	0.010	−0.003	−0.132	−0.172	0.179	−0.142	−0.124	−0.059	0.030	−0.098	0.311	0.356	0.244	0.450	−0.155	−0.601	1	0.623	−0.099	−0.165
Q14	−0.058	−0.039	−0.141	−0.038	0.155	−0.100	−0.041	−0.066	0.021	0.059	0.290	0.277	0.190	0.351	−0.225	−0.595	0.623	1	0.038	−0.116
Q15	0.002	0.231	0.172	0.113	0.022	0.255	0.226	0.272	0.068	−0.035	−0.110	−0.220	−0.147	−0.146	0.087	0.054	−0.099	0.038	1	0.120
Q16	−0.159	0.047	0.061	0.108	0.055	0.144	0.088	0.055	−0.012	0.029	0.007	−0.138	−0.071	−0.051	−0.085	0.088	−0.165	−0.116	0.120	1.0

Source: own study based on the results of own research.

Table 5. Chi-Square test results – dependencies between company size and individual survey questions

Question	Chi-Square test results	p-value
Q1	10.85	0.029
Q2	15.67	0.003
Q3	12.33	0.015
Q4	9.45	0.051
Q5a	13.89	0.008
Q5b	11.27	0.024
Q5c	14.56	0.005
Q5d	10.34	0.035
Q5e	16.22	0.002
Q6	8.88	0.065
Q7	10.22	0.037
Q8	14.45	0.005
Q9	13.34	0.009
Q10	15.12	0.004
Q11	12.78	0.018
Q12	13.56	0.008
Q13	16.78	0.001
Q14	11.89	0.020
Q15	10.67	0.032
Q16	14.89	0.004

Source: own elaboration based on the results of own research.

Table 6. Cohen's Kappa coefficient presenting agreement ratings between pairs of questions

The first question included in the pair for assessing the level of agreement	The second question included in the pair for assessing the level of agreement	Cohen's Kappa coefficient
Q1	Q2	0.32
Q3	Q4	0.29
Q5a	Q5b	0.34
Q6	Q7	0.27
Q8	Q9	0.31
Q10	Q11	0.30
Q12	Q13	0.33
Q14	Q15	0.28
Q16	Q1	0.25

Source: own elaboration based on the results of own research.

Table 7. OLS regression results

Statistic			Value	Statistic		Value
Dep. Variable:			y	**R-squared:**		0.072
Model:			OLS	**Adj. R-squared:**		0.059
Method:			Least Squares	**F-statistic:**		5.657
No. Observations:			151	**Prob (F-statistic):**		0.00422
Df Residuals:			148	**Log-Likelihood:**		–160.22
Df Model:			2	**AIC:**		326.4
Covariance Type:			nonrobust	**BIC:**		335.4
Variable	Coefficient	Standard Error	t-Statistic (t)	p-Value (P>|t|)	95% Confidence Interval [0.025, 0.975]	
const	sty.54	0.110	16.081	0.000	1.548	1.983
Company Size	0.1635	0.047	3.460	0.001	0.071	0.256
Position	–0.0142	0.020	–0.717	0.475	–0.054	0.025
Statistic			Value	Statistic		Value
Omnibus:			29.947	**Durbin-Watson:**		2.029
Prob (Omnibus):			0.000	**Jarque-Bera (JB):**		41.922
Skew:			–1.125	**Prob (JB):**		7.73e-10
Kurtosis:			4.321	**Cond. No.**		4.19

Source: own elaboration based on the results of own research.

Analyzing the correlation matrix of individual questions included in the questionnaire

We can observe strong correlations (0.450, p-value < 0.05) between questions Q7 and Q10, which pertain to opinions on preparing non-financial reports and their impact on the company's development strategy and profitability. A strong positive correlation suggests that respondents who believe that non-financial reports influence development strategy also believe they positively impact profitability. Additionally, a strong correlation (0.623, p-value < 0.05) can be noted between questions Q12 and Q13, which concern opinions on preparing non-financial reports and the impact of these activities on operational and investment costs. This strong correlation indicates that respondents who foresee an increase in operational costs also perceive an increase in investment expenditures. A strong negative correlation (–0.600, p-value < 0.001) between questions Q11 and Q12 indicates that individuals who observe an increase in operational costs are less likely to believe in the positive impact of reports on profitability.

Small positive correlations are observed between questions Q5a and Q5d (correlation = 0.27, p-value < 0.05) and Q5b and Q5c (correlation = 0.22, p-value < 0.05), indicating dependencies between predictions of non-financial reporting in different areas, particularly in social issues and employee treatment, as well as respect for human rights.

Interpreting the research results using statistical tests

The descriptive statistics also utilized t-tests (Table 8), which indicated significant differences in responses to questions regarding knowledge about the substantive scope of non-financial reporting (Q1) and knowledge about companies subject to this requirement (Q2) (t-stat = 9.676, p-value < 0.05). The significant difference in responses to these questions suggests that respondents' level of knowledge about the substantive scope of non-financial reporting differs from their knowledge about companies subject to this requirement.

Another area of difference appears between opinions on preparing non-financial reports in the environmental area (Q5a) and in the social area and employee treatment (Q5b) (t-stat = –7.938, p-value < 0.05). The significant difference in responses to these questions suggests that respondents have different expectations regarding future non-financial reporting in the environmental and social areas. This may indicate different priorities or perceptions of the importance of these areas.

Further differences are observed in questions Q7 and Q10 (t-stat = 17.471, p-value < 0.05), which asked about the potential impact of non-financial reports on creating a positive corporate image and their potential impact on profitability. The large difference in responses to these questions suggests that respondents who see image benefits may have different opinions on profitability impacts, possibly due to different understandings of these two aspects. The respondents who believe that non-financial reports create a more favorable company image also more often believe they positively affect profitability.

Differences in the assessment of the impact of non-financial reports are evident in the context of the respondents' positions and the size of the company. Higher-ranking employees more frequently predict an increase in operational costs associated with preparing non-financial reports (Q11 vs. Q12: t-stat = –7.25, p-value < 0.001), while larger companies perceive an increase in operational and investment costs (Q12 vs. Q13: t-stat = 9.44, p-value < 0.001).

Table 8. Significant T-test results

Question 1	Question 2	t-statistic	p-value
Q1	Q2	9.68	< 0.001
Q5a	Q5b	– 7.94	< 0.001
Q7	Q10	17.47	< 0.001
Q11	Q12	– 7.25	< 0.001
Q12	Q13	9.44	< 0.001

Source: own study based on the results of own research.

To verify the conclusions, a one-way ANOVA analysis was additionally used, which allowed us to verify whether there are statistically significant differences between the size of the surveyed enterprise (micro, small, medium) and the responses to individual survey questions (Table 9).

Table 9. Statistically significant results of analysis of variance (ANOVA)

Question	F-statistic	p-value
Q1	4.56	0.013
Q2	5.78	0.004
Q3	3.45	0.034
Q4	4.12	0.058
Q5a	3.98	0.018
Q5b	4.78	0.021
Q5c	4.03	0.009
Q5d	5.23	0.019
Q5e	3.67	0.006
Q6	5.45	0.065
Q7	4.34	0.028
Q8	5.12	0.005
Q9	4.34	0.015
Q10	5.12	0.007
Q11	3.98	0.021
Q12	4.67	0.010
Q13	5.89	0.003
Q14	3.23	0.041
Q15	4.12	0.018
Q16	5.23	0.006

Source: own elaboration based on the results of own research.

The one-way ANOVA analysis allowed us to verify questions with the lowest p-values ($p < 0.01$) and the highest F-statistic values, indicating the strongest dependencies. Statistically significant variance dependencies from the ANOVA analysis are presented in Table 10.

Table 10. Statistically significant variance dependencies in ANOVA

Question	Analysis of variance (ANOVA)	Description	Conclusions
Q2	F-stat. = 5.78, p-value = 0.004	A significant difference in knowledge about companies subject to non-financial reporting requirements between different sizes of firms. Larger firms are better informed on this matter.	Larger firms may be more aware of the regulations and requirements concerning non-financial reporting, which could be due to greater resources allocated to compliance and more developed legal and financial departments.
Q5e	F-stat. = 5.23, p-value = 0.006	Larger companies anticipate more comprehensive non-financial reporting on management diversity.	Larger companies may be more advanced in implementing diversity and inclusion policies, which is reflected in their expectations regarding future non-financial reports.
Q8	F-stat. = 5.45, p-value = 0.005	A significant difference suggests that larger companies are more likely to see the impact of non-financial reports on their development strategy.	Larger companies may view non-financial reporting as a key strategic element that can enhance their long-term competitiveness and market image.
Q10	F-stat. = 5.12, p-value = 0.007	Larger companies are more likely to recognize the positive impact of non-financial reports on profitability.	Larger companies may see non-financial reporting as a way to increase transparency, build trust among stakeholders, and attract investors, which in the longer term can contribute to profitability growth.
Q13	F-stat. = 5.89, p-value = 0.003	Larger companies are more likely to assign responsibility for preparing non-financial reports to specific departments or individuals.	In larger companies, the organizational structure is more complex, allowing them to designate dedicated teams or departments to handle non-financial reporting.

Source: own study based on the results of own research.

Research conclusions

Based on the collected descriptive statistics results, we can draw significant conclusions:

- Medium-sized enterprises see more financial challenges related to preparing non-financial reports. This is evident in increased operational and investment costs. This may result from the larger scale of operations and more complex regulatory requirements that they must meet.
- Higher-ranking employees have a more positive attitude towards the impact of non-financial reports on the company's profitability. They may perceive long-term strategic and image benefits that are not as obvious to employees in lower positions.
- Higher-level employees more frequently predict an increase in operational costs associated with pro-environmental actions. This may stem from their greater awareness of regulations and necessary investments in sustainable development.

- Practical Implications: The analysis indicates the need to further educate employees about various aspects of non-financial reporting and draw attention to differences in perception between areas, which can help better prepare enterprises for future requirements.
- Dependencies in Perception of Non-Financial Reports in the Context of Company Size and Position: The results of the ANOVA analysis for the questions included in Table 10 indicate significant differences in perceptions and predictions regarding non-financial reports depending on company size. Larger companies exhibit greater awareness of regulations, see a more strategic impact of reports on development and profitability, and have more organized structures for managing these processes.

Conclusions

Looking at the evolution that financial reports, especially those of companies listed on stock exchanges, have undergone (Beattie 2005), with an emphasis on increasing the transparency of information published in them and the management's responsibility for their publication, we can see the impact of economic events on this area (Cullinan 2004; Ahmed et al. 2010; Vakkur, McAfee, and Kipperman 2010; Chu and Hsu 2018). Reinstein et al. (2014) point out that the Sarbanes-Oxley Act (The Senate and House of Representatives of the United States of America in Congress 2002) was enacted to improve the transparency of financial reports of companies listed on the American stock exchange. However, it should be expanded to cover other economic entities as well as public entities and local government units (Reinstein et al. 2014). In the relevant literature, there has been extensive discussion about the impact of legislative changes introduced by the Sarbanes-Oxley Act, which was a response to the notorious bankruptcy of the publicly traded company Enron and, subsequently, the audit firm Arthur Andersen (Burrowes, Kastantin, and Novicevic 2004; Gordon et al. 2006; Litvak 2007; Zhang 2007; Aono and Guan 2008; Canada, Kuhn, and Sutton 2008; DiGabriele 2008; Kang, Liu, and Qi 2010; Wang, Davidson, and Wang 2010; Parker, Swanson, and Dugan 2011; Bianconi, Chen, and Yoshino 2013; Dah, Frye, and Hurst 2014; Li, 2014; Abdioglu et al. 2015; Gu and Zhang 2017).

The development of NFR and the continuous expansion of EU guidelines in this area interest not only large enterprises listed on stock exchanges but also SMEs. As the most numerous sector, SMEs contribute significantly to the GDP of various countries and create the most jobs. Consequently, they approach NFR consciously. Companies in this sector are gradually and consistently providing environmental information to their large contractors. The SME sector estimates that in the near future – within the next three years – these companies will be obliged to disclose non-financial data in the environmental area. According to SMEs, obtaining external financing, both repayable and non-repayable (grants), will involve additional reporting obligations for these entities. Research results indicate that medium-sized companies – the largest within the SME sector – clearly perceive the benefits of such reporting, including improved company image and, consequently, profitability. However, these actions will require additional costs at both the operational and investment levels. Notably, business owners express a significant need for training

and substantive support in preparing non-financial reports. While our results do not fully exhaust the topic, they contribute to the ongoing discussion in the literature and partially fill the research gap.

In conclusion, the study provides a comprehensive assessment of the role and significance of NFR in SMEs, with a particular focus on regulatory challenges, financial implications, and strategic benefits. The findings indicate that while SMEs recognize the growing relevance of NFR, they face substantial barriers related to resource constraints, lack of expertise, and unclear regulatory expectations.

One of the key contributions of this research is the identification of an anticipated shift in regulatory obligations. While SMEs are currently exempt from mandatory reporting under the Corporate Sustainability Reporting Directive (CSRD), the majority of the surveyed enterprises expect that compliance with NFR requirements will soon become a necessity, particularly in the environmental domain. These insights highlight the need for targeted policy interventions, including financial incentives and structured training programs aimed at enhancing SME preparedness.

The study also underscores the critical role of non-financial reporting in securing external financing, as the respondents overwhelmingly indicated that sustainability disclosures would become a prerequisite for obtaining both repayable (e.g., bank loans, leasing) and non-repayable (e.g., EU grants) funding. This observation aligns with previous research highlighting the increasing importance of ESG transparency in financial decision-making. Furthermore, the research emphasizes the broader strategic implications of NFR for SMEs, particularly in terms of corporate reputation and competitive positioning. As sustainability reporting standards continue to evolve, firms that proactively integrate ESG disclosures into their operations may gain a long-term competitive advantage, benefiting from improved stakeholder relations and enhanced market credibility. Given these findings, future research should explore how standardized auditing practices can be adapted to SME-oriented NFR frameworks, ensuring the reliability and comparability of sustainability disclosures. Additionally, a more detailed sector-specific analysis of challenges in NFR adoption is necessary, particularly for industries with a high environmental footprint. Another critical area of investigation should focus on the financial performance of SMEs that have voluntarily adopted sustainability reporting, assessing its long-term impact on profitability and investment attractiveness.

By addressing these research gaps, future studies will provide a more comprehensive understanding of how regulatory frameworks and market expectations shape the role of non-financial reporting in SMEs. Although NFR in SMEs is still at an early stage, this study contributes to the ongoing discussion by identifying key barriers and highlighting strategic opportunities that can support SMEs in transitioning toward sustainable business practices.

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Attachment 1. Summary of question numbers and questions included in the survey questionnaire

No.	Question
1	Do you have knowledge about the substantive scope of non-financial reporting resulting from EU directives?
2	Do you have knowledge about which enterprises are required to prepare non-financial reports?
3	Does the company you work for prepare non-financial reports to any extent (e.g., related to environmental protection)?
4	If the enterprise you work for prepares non-financial reports, please indicate the substantive scope.
5a	In your opinion, will the enterprise you work for prepare non-financial reports within the next three years? Environmental area.
5b	In your opinion, will the enterprise you work for prepare non-financial reports within the next three years? Social issues and employee treatment.
5c	In your opinion, will the enterprise you work for prepare non-financial reports within the next three years? Respect for human rights.
5d	In your opinion, will the enterprise you work for prepare non-financial reports within the next three years? Anti-corruption and bribery/code of ethics.
5e	In your opinion, will the enterprise you work for prepare non-financial reports within the next three years? Diversity in company boards (age, gender, education, etc.)
6	Please indicate which substantive area of non-financial reports you consider the most important.
7	In your opinion, could preparing non-financial reports become a formal requirement in the future for obtaining external repayable financing (credit, leasing, etc.) for the enterprise?
8	In your opinion, could preparing non-financial reports become a formal requirement in the future for obtaining external non-repayable financing – i.e., grants (e.g., from the EU)?
9	In your opinion, does preparing non-financial reports create a more favorable company image?
10	In your opinion, will preparing non-financial reports influence the company's development strategy?
11	In your opinion, can preparing non-financial reports positively impact the company's profitability?
12	In your opinion, will preparing non-financial reports significantly increase the level of operational costs?
13	In your opinion, will preparing non-financial reports significantly increase the level of investment expenditures?
14	In your opinion, will the company's actions to reduce the impact of its operations on the natural environment significantly increase operational costs?
15	In your opinion, who is/would be responsible for preparing non-financial reports in the enterprise?
16	Would your enterprise need training or substantive support in preparing non-financial reports?
17	Respondent's gender
18	Respondent's position
19	Size of the enterprise where the respondent works
20	Length of the respondent's employment in the current position

Rola i znaczenie wytycznych UE dotyczących raportowania niefinansowego dla MŚP

Celem artykułu jest analiza roli i wpływu regulacji dotyczących raportowania niefinansowego (NFR) na małe i średnie przedsiębiorstwa (MŚP) w Unii Europejskiej. Choć dyrektywy, takie jak Dyrektywa w sprawie raportowania informacji niefinansowych (NFRD) oraz Dyrektywa w sprawie sprawozdawczości przedsiębiorstw w zakresie zrównoważonego rozwoju (CSRD), koncentrują się głównie na dużych firmach, ich oddziaływanie obejmuje także MŚP. Wynika to zarówno z zależności w łańcuchach dostaw, jak i z bodźców finansowych. W artykule oceniono poziom świadomości MŚP, wyzwania oraz potencjalne korzyści związane z wdrażaniem raportowania niefinansowego.
W przeprowadzonych badaniach wykorzystano jako narzędzie badawcze kwestionariusz ankietowy, który został skierowany do 151 MŚP z województwa kujawsko-pomorskiego. W celu określenia podejścia przedsiębiorstw do zgodności z regulacjami oraz identyfikacji kluczowych barier zastosowano metody statystyczne, takie jak analiza korelacji i modelowanie regresyjne.
Wyniki badań wskazują, że choć MŚP dostrzegają rosnące znaczenie raportowania niefinansowego, ograniczone zasoby oraz brak specjalistycznej wiedzy stanowią istotne bariery jego wdrażania. Jednocześnie firmy, które zdecydowały się na proaktywne wprowadzenie zasad NFR, dostrzegają wymierne korzyści, w tym poprawę relacji z interesariuszami oraz przewagę konkurencyjną.
Wyniki badań wskazują na potrzebę wdrożenia dedykowanych działań wspierających MŚP w adaptacji do standardów raportowania zrównoważonego rozwoju. Kluczowe rekomendacje obejmują wsparcie finansowe, uproszczone mechanizmy zgodności oraz specjalistyczne programy szkoleniowe.
Artykuł wnosi istotny wkład w debatę na temat raportowania zrównoważonego rozwoju, koncentrując się na sektorze MŚP, który często pozostaje na marginesie polityki NFR. Ponadto dostarcza empirycznych dowodów na wpływ regulacji na funkcjonowanie MŚP oraz wskazuje kluczowe obszary wymagające wsparcia ze strony decydentów w procesie transformacji ku zrównoważonemu rozwojowi.

Słowa kluczowe: raportowanie niefinansowe, rachunkowość, dyrektywa CSRD, czynniki ESG (środowiskowe, społeczne, zarządcze), MŚP, zrównoważony rozwój, odpowiedzialność społeczna

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The Pan-European Personal Pension Product – Managers' Challenges and Savers' Expectations

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Abstract

The Pan-European Personal Pension Product (PEPP) is a strategic initiative of the European Union (EU) aimed at creating a harmonized, portable pension savings framework that addresses the challenges of population aging, increased labor mobility, and the widening pension gap across Member States. This article investigates the implementation and performance of the PEPP in four EU countries – Poland, Slovakia, Croatia, and the Czech Republic – through a mixed-methods research design.

The study combines a legal and comparative analysis of national pension systems with qualitative interviews conducted with PEPP fund managers and quantitative surveys of PEPP savers. The findings reveal significant disparities in regulatory approaches, tax treatment, and supervisory frameworks between countries, which affect both the attractiveness and functionality of PEPP. Despite the shared design principles of transparency, safety, and cost-efficiency, savers' expectations differ notably across countries – especially in relation to customer service, information delivery, and minimum return expectations – while also being shaped by sociodemographic factors.

The qualitative research highlights that fund managers face challenges such as regulatory fragmentation, high administrative burdens, and competition from national products with more favorable tax treatment or employer-based incentives. At the same time, digital tools and passive investment strategies are seen as key to enhancing PEPP's scalability and efficiency.

The article concludes that for PEPP to succeed as a truly pan-European product, further regulatory harmonization, consistent tax incentives, and comprehensive financial education efforts are essential. The authors also propose that increased provider competition and adaptive national policies could

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accelerate the product's uptake. The study offers practical insights for EU policymakers, national regulators, and financial institutions aiming to promote inclusive and sustainable retirement savings across the continent.

Keywords: pension system, private pension schemes, PEPP

JEL: H55, H75, J32

Introduction

Europe – like most continents – is aging at a rapid pace. In 2060, there will be two working-age people for every pensioner, in comparison with four working-age people at the present time. This puts the sustainability of the diverse traditional pension systems across Europe under significant pressure, despite reforms that are currently underway in many European countries (van Meerten 2023). European demographic structure and age composition are currently in a state of flux – life expectancy has increased, fertility rates have dropped, and baby boomers have reached retirement age. The implications of these changes, coupled with the fragmented market for personal pension products throughout the EU, are vast and call for close scrutiny of the relationship between financial and pension markets (Borg, Minto, and van Meerten 2019).

Market freedoms are now being furthered to cover not just occupational pension schemes but also the private pension market. In light of such developments at the European Union (EU) level, including the development of pan-European Personal Pension (PEPP) products, what is evident is a significant shift in the establishment of an EU-wide private pension market, mirroring developments in the United States in what is known as 'individual retirement accounts' (IRAs) (Butler 2021).

The pension systems in place in EU countries are based on the principle of intergenerational solidarity, whereby current benefits are paid through the current contributions of scheme members. However, European pension systems have limited capacity to provide an adequate and sustainable income for pensioners after retirement. In practice, this means that successive generations will face an ever-decreasing replacement rate as a result of the ratio of benefit payments to past labor income. The projected expenses of future pensioners will not be able to be covered by the benefits received in the future, the so-called 'pensions gap'. In view of this phenomenon, it is necessary to build up a pension capital based on various sources of funds. The consequence is the growing importance of individual pensions in the structure of pension savings in the EU (Dimitrov 2021). These phenomena form the basis for defining a framework to create more flexible individual savings products with a pension purpose.

The aim of this article is to examine how Pan-European Personal Pension Products (PEPPs) operate in different countries. This analysis aims to show to what extent the new pension instrument responds to the challenges of an aging society and the pension gap. The research objective will be achieved by using quantitative surveys aimed at savers, which will allow us to understand users awareness, motivations and preferences regarding PEPPs.

Literature review

The field of social security research extends from the analysis of international documents containing the obligations of states to establish and operate social security systems. The recognition of the welfare state concept of social security in European states is also manifested in the inclusion of social rights in the catalog of human rights in international conventions such as The Universal Declaration of Human Rights, the International Covenant on Economic, Social and Cultural Rights, the European Social Charter, and the Charter of Fundamental Rights of the European Union. Comparative aspects of old-age security systems have been discussed by Barr (1993), Castles (2000), Esping-Andersen (2010), and Hill (2010).

Polish authors who have covered the topic of social security include Księżopolski (1999) and Anioł (2013). Previous research on supplementary old-age security focused primarily on legal and economic issues. Authors addressing these issues recognized the state's role in building additional social security systems by pointing out the need for additional fundraising within the framework of social insurance (e.g., Kawiński, Szumlicz, and Więckowska 2019). Meanwhile, Kopeć and Wojewódka (2005) and Szczepański (2010) investigated detailed solutions for the social security system within the framework of employee pension schemes, while Kolek and Sobolewski (2022) examined how employee equity plans function. Synthesizing these findings, it can be observed that supplementary social security systems can be divided into group schemes and individual products.

Table 1. Additional forms of old-age risk insurance

Criteria	Group programs	Individual products
Nature of the program	Organized by the company/employer	Choice and conclusion of the contract are dependent on the individual
Participation	Voluntary, with possible automatic enrolment	Voluntary
The role of the state	Record-keeping and monitoring, possible subsidies from public funds	Records and monitoring

Source: own work.

The PEPP is a product that has been in operation in EU Member States since 2022 that allows people to accumulate savings to counteract the risks of old age. Back in 2019, the European Parliament and the Council, in response to negative demographic trends, decided to anchor a PEPP at the EU level to respond to citizens' need for mobility and to facilitate their ability to save regardless of the country in which they reside at different stages of their career.

The legal framework for the operation of the PEPP is regulated by Regulation (EU) 2019/1238 of the European Parliament and of the Council of 20 June 2019 on a PEPP. The introduction of the PEPP into the legal order of the Member States stems from the fact that the EU's internal market of individual pension products does not function efficiently, is fragmented, and there are long-term savings products in the Member States that do not allow savings to be transferred between countries. The PEPP is a product that is not tied to a single employer but is individual and characterized by its voluntary nature. Therefore, it is intended to complement

both public pension schemes and existing funded solutions. As Baggio (2023) notes, the PEPP is one of the tools that supports the development of the Capital Markets Union by promoting cross-border, long-term savings in the EU. According to Dieleman (2020), the lack of a uniform approach to the taxation of PEPPs in individual Member States weakens its attractiveness as a pan-European savings product (Bär 2022).

The PEPP, as an individual product, is based on the assumption that more than 11.3 million EU citizens of working age (20 to 64 years) live in a Member State other than their Member State of nationality, and a further 1.3 million EU citizens work in a Member State other than their Member State of residence. Therefore, as Dimitrov (2021) noted, the PEPP was introduced to increase the number of people saving in individual pension products who previously did not have an appropriate product.

The Regulation harmonizes a number of core features of the PEPP that relate to key elements such as distribution, minimum contractual content, investment policy, switching, cross-border product offering and cross-border transferability (Šebo, Danková, and Králik 2020; Waliszewski and Banaś 2023). According to the developers, the harmonization of key product features will level the playing field, benefiting providers of individual pension products, which in turn will increase competition between providers on a pan-European scale and generate economies of scale to the benefit of savers. Notably, there is no common legislation in the EU on the taxation of individual pensions. Therefore, it is left to the Member States to deal with the tax incentives and taxation rules for savings paid out from PEPPs.

Importantly, disclosure obligations have also been harmonized. The Regulation includes detailed requirements for two mandatory information documents for PEPP clients – the PEPP Key Information Document (PEPP KID) and the PEPP Benefit Statement (PEPP BS). The aim is to provide PEPP customers with the right information to make pre-contract decisions easier and to monitor the effects of savings.

In Poland, individuals can begin saving for retirement through PEPP accounts starting at 15 years of age, making it accessible from a relatively young age. The funds are accumulated in an individual account, and the provider offers an investment policy with a risk profile tailored to the needs of the saver. Based on Polish regulations, income from the investment of funds paid into the PEPP will be exempt from taxation, provided that the withdrawal of these funds takes place only after the saver reaches the age of 60 or 55 (provided that pension entitlements have been acquired, and contributions have been made to the PEPP sub-account for at least any five calendar years, or more than half of the value of the contributions has been made no later than five years prior to the date of application for withdrawal)[1].

Analyzing the legal regulations that shape the functioning of the PEPP, Kaleta (2021) notes, 'the solutions contained in the discussed regulation[2] are a facilitation especially for the increasing number of defined contribution pension security schemes.' At the same time, he states

1 Act of 7 July 2023 on a pan-European individual pension product (Journal of Laws of 2023, item 1843).

2 Regulation (EU) 2019/1238 of the European Parliament and of the Council of 20 June 2019 on a pan-European personal pension product (PEPP) OJ 2019, L 198, p. 1.

that, given the personal scope of the PEPP, it is expected that this product will be used by a small number of professions with specific qualifications moving between EU Member States. Meanwhile, Wrzesiński states that the idea of creating a PEPP facilitates the transfer of savings in the event of relocation. However, he notes that the key to the success of the PEPP will be in the tax arrangements in individual countries, which the Regulation leaves to the discretion of the Member States. He also points out that the introduction of Employee Capital Plans in Poland in 2019 has limited the space for the introduction of additional functioning pension products (Wrzesiński 2021).

The EU's financial regulator, EIOPA (European Insurance and Occupational Pensions Authority), examined how supportive national laws are toward the growth of PEPP in different countries. EIOPA conducted a study on the overall friendliness of the environment for PEPP products in terms of national legislation based on an assessment of the 10 areas presented in Table 2. A country is considered to offer highly favorable conditions for PEPP market development if PEPP products are subject to the same terms and conditions as similar national public pension products, savers can switch between products, the taxation of returns is friendly (Exempt Exempt Tax taxation regime), and the saver has flexible drawdown options in retirement (EIOPA 2024).

The overall score for EU countries suggests that national rules for PEPP products make the single market a diverging market. Thus, the example of PEPP products suggests that we are united in terms of product conditions but divergent in the development of the PEPP market.

Table 2. Overall score – favorable national market conditions for PEPP product

Country	AT	BE	BG	CZ	DE	DK	EE	ES	FI	FR	EL	HR	HU	IE	IT	LU	LT	LV	NL	PO	PT	RO	SK	SI	SE
Law passed	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
Employer benefits equal to similar scheme/plan	0		1	1		1	1	1	1	0		1	0	1	0	1	1	1	0	0		1	0	0	0
Employer benefits	0		2	2		1	1	1	2	0		2	1	2	0	0	1	2	0	0		1	0	0	0
Employee benefits equal to similar scheme/plan	0		1	1		1	1	1	1	1		0	0	1	1	1	1	1	0	0		1	1	0	0
Employee benefits	0		2	2		1	2	1	0	1		0	2	2	2	1	1	2	2	2		1	0	0	1
Returns taxation favorability	2		1	1		2	1	2	0	1		0	1	2	2	1	1	0	0	0		1	1	1	0
Pay-out restrictions (age)	2		1	1		1	2	2	0	1		2	0	1	1	0	2	2	0	1		0	1	0	0
Pay-out forms flexibility	0		1	2		1	0	1	0	2	2	2	1	2	2	2	2	2	1	2		2	1	1	2
Possibility to transfer from/to other pension plans	0		0	1		0	0	0	1	1		0	0	0	0	0	1	0	1	1		0	0	0	0
Limits on contribution	0		0	1		1	1	1	2	1		0	1	0	1	1	2	0	0	1		1	0	1	2
Overall score	**5**	**0**	**10**	**13**	**0**	**10**	**10**	**11**	**8**	**9**	**3**	**8**	**7**	**12**	**10**	**8**	**13**	**11**	**5**	**8**	**0**	**9**	**5**	**4**	**6**

Source: EIOPA 2024.

Research methodology

Given the design of the PEPP and the regulations adopted in each country to allow the operation of the PEPP, it is crucial to gather information on the practice of the product. The research contained in this study aims to answer the following research questions that arise after the first months of PEPP operation:

- How are the PEPPs that operate in different countries regulated?
- How are PEPPs that operate in different countries supervised?
- What are the differences between PEPPs managed by the same institution in different countries?
- How are the expectations of PEPP savers shaped in different countries?
- How do the expectations of PEPP savers differ between countries?

In order to answer the research questions, the following research hypotheses were formulated.

- H1 There are significant differences in the regulation of PEPPs in different EU Member States, which affects their structure, operating rules, and accessibility for savers.
- H2 There are differences in the supervisory systems for PEPPs in different EU Member States, which may affect the level of protection of savers.
- H3 Significant differences between PEPPs managed by the same institution in different countries are due to differences in regulation and savers' expectations.
- H4 The expectations of PEPP savers vary based on the country in which the PEPP product operates.
- H5 The expectations of PEPP savers do not vary from country to country but depend on the sociodemographic factors of the savers.

To answer the research questions, we used quantitative methods to collect data on the expectations of PEPP savers, as well as qualitative research that identified the challenges faced by PEPP fund managers.

- Quantitative survey: surveys collected information on the level of knowledge about PEPP, savers' expectations of potential benefits, investment decisions and access to information about PEPP.
- Qualitative study: provided an understanding of the challenge of managing funds operating at the EU level while being supervised by individual Member States.

The quantitative and qualitative research was preceded by a literature review and an analysis of the legal regulations governing the operation of PEPPs in EU countries.

How PEPPs function in selected EU countries

The PEPP is a long-term savings product in the EU that has been in operation since 2022, although it currently operates in only four Member States. This is because, although there are regulations at the EU level, the PEPP product called the 'European Pension' has been registered by only one entity. The PEPP is managed by the robo-advisor Finax, a Slovak brokerage house. The main account of the product in this case is in Slovakia, while the products in Poland, Croatia, and the Czech Republic act as sub-accounts. Slovakia's third pillar legislation, which introduced a cap on the total cost to savers at 1% of capital per year from 2023 (identical to the EU-imposed cap for PEPPs), undoubtedly also helped the product to emerge specifically in Slovakia. Nevertheless, in each of the countries analyzed, there are differences between the PEPP and other third-pillar pension products. This also results in differences in the performance of PEPP from the same provider between countries.

Slovakia

The Slovak pension system, which was reformed in 2022, comprises three pillars: 1) the obligatory base system (priebežne financovaný dôchodkový systém), 2) the capital system (dobrovoľný dôchodkový doplnkový systém sporenia), and 3) the voluntary capital system of pension savings (Poteraj 2008). Pillar 1 is compulsory and administered by the Slovak equivalent of the Social Insurance Institution. Working people finance the benefits of current pensioners from their contributions (pay-as-you-go). It receives 12.5 percent of the gross wages of those who work. If a person does not contribute to Pillar 2, this percentage increases to 18%.

Since 2005, there have been pension funds in Slovakia under the mandatory but individual account-based Pillar 2. From 2022, it is automatic for those under 40, but there is an option to opt out. A contribution of 5.5% of a person's salary (with a target of 6% from 2027) goes into one or two pension funds of the person's choice, and they can be changed at will.

Pillar 3 covers both employees and employers, with both parties able to make unrestricted contributions to pension funds, and in both cases, they are not subject to income tax. For employees, however, there is an upper threshold of €180 per year for contributions treated in this way. For employers, voluntary contributions up to the value of 6% of the monthly salary are a tax-deductible cost, which means that up to this level, they have the right to deduct the contributions from the tax base. There is no tax exemption for pension payments from the third pillar. There are four pension funds in Pillar 3, and around 900,000 Slovaks save in them (Socialna Poistovna 2024). Retirement age is reached, regardless of gender, at 63. For women, this level may be lower, depending on the number of children raised.

Table 3. How the PEPP functions in Slovakia

Employer contribution as under Pillar 3	No
Employers' contribution	No. The employer's contribution is fully taxable and must be part of the payroll and deductions
Employee contribution as in other Pillar 3 products	Yes
Benefit for the employee	Reduces the saver's tax base by employee contributions by up to €180 per year (€15 per month)
Taxation of profits	Yes, fully taxed on pension payments
Liquidity	Payment at retirement age with some exceptions
Forms of pension	Perpetual annuity or regular payment for at least 5 years. One-off payment only if savings are less than four average monthly salaries
Pillar 3 transferability	No
Contribution limits	No. Unlimited regular or one-off contributions

Source: own work.

Poland

The pension system in Poland also comprises three pillars. Pillar 1 is the pay-as-you-go system managed by the public Social Insurance Institution (ZUS). It receives 12.22% of the salary. Contributions are credited to an individual account and are indexed for inflation and salary increases. The retirement age in Poland is 65 for men and 60 for women.

Pillar 2 is the universal mandatory funded system, which comprises a sub-account with ZUS or an account with an Open Pension Fund (OFE). Savers can pay 7.3% of their salary, either fully to the ZUS account or split between 2.92% to OFEs and 4.38 to ZUS. Unlike in Pillar 1, the funds accumulated in the ZUS account are inheritable and can form part of the assets divided during a divorce.

Pillar 3 is entirely optional, and Poland stands out from other EU countries in the multiplicity of pension schemes available, which can be combined simultaneously. Voluntary pension savings can be made through organized group schemes involving the saver's employer, such as the Employee Pension Scheme (PPE) and Employee Capital Plan (PPK), or through individual schemes like the Individual Pension Account (IKE), Individual Retirement Security Account (IKZE) and the PEPP. Group schemes are chosen by the employer. All Pillar 3 products are exempt from capital gains tax, and the PPK also includes a surcharge from the state. The latter is the most popular Pillar 3 product, but at the end of 2022, only around 2.5 million Poles used it for saving (PFR PPK Portal 2023).

The basic contribution to PPK is 2% of the salary (which can be increased to 4%) from the employee and an additional 1.5% (which can also be increased to 4%) from the employer. The employee receives an initial PLN 250 welcome payment from the state and an additional PLN 240 every year. Funds can be withdrawn after age 60 upon retirement. To retain all PPK benefits, participants can withdraw 25% of the amount earned at once and spread

the remaining 75% over at least 120 monthly installments. Withdrawal of the funds before retirement is possible but results in a loss of state subsidies, and 30% of employer contributions will be transferred to the individual's Social Security account for future retirement.

The IKE is an individual retirement savings account offered by banks, insurance companies, brokerage houses, Universal Pension Companies, and investment funds. An incentive for savers is the exemption from capital gains tax, while annual contributions are limited to three times the average projected monthly salary. An identical limit also applies to the PEPP, modelled by regulations on the IKE. IKZE has a lower limit of 1.2 times the average salary per year or 1.8 times for non-agricultural business owners. In this case, contributions can be deducted from the income tax base in a given year, with a flat 10% tax payable on the amount withdrawn. Funds from IKE, IKZE and the PEPP can be withdrawn before the legally required age, but a capital gains tax of 19% is then payable.

Table 4. How the PEPP functions in Poland

Employer contribution as under Pillar 3	No, the law assumes no connection to employment
Employers' contribution	No
Employee contribution as in other Pillar 3 products	No
Benefit for the employee	No
Taxation of profits	No capital gains tax if all required conditions are met
Liquidity	Withdrawal at retirement age (several conditions), possibility of early withdrawal but no tax benefits
Forms of pension	As a one-off payment or in monthly installments
Pillar 3 transferability	Yes, only from IKE
Contribution limits	Yes (annual limit is three average projected salaries per month)

Source: own work.

A survey conducted in 2023 among IKE holders in Poland, on which the PEPP implementation is modeled, revealed moderate satisfaction with the financial performance of IKE (scoring 6.62 out of 10). This result reflects a greater number of critics over promoters, resulting in a negative *Net Promoter Score* (NPS) of more than 26. Respondents interested in the PEPP expressed a desire to invest in foreign and global assets, such as ETFs, equities, and global bonds. Such investments could potentially yield higher returns on OPIE compared to IKE in the future, which could translate into improved customer satisfaction and a better NPS index (Waliszewski and Barankiewicz 2023). Pelc (2023) noted that integrating PEPP with the Polish pension system faces challenges due to competition from existing Pillar 3 products.

Croatia

The Croatian pension system also consists of three pillars. Pillar 1 is compulsory and state-owned, operating on a system where current workers finance the benefits of current pensioners through their contributions. The pension system is based on a defined benefit model. Employees insured only in Pillar 1 contribute 20% of their gross salaries to the system.

Employees under 40 years of age must also contribute to Pillar 2, to which 5% of their salary is allocated (with the remaining 15% going to Pillar 1). The retirement age is 65 for men and 63 for women, with the retirement age for women scheduled to match that of men by 2030.

At the end of 2022, there were only four pension funds operating in both Pillars 2 and 3. Pillar 3 offers complete flexibility regarding age, investment period, contribution amount, or even the option not to contribute at all. The only condition for benefiting from the money collected in the fund is reaching the age of 50.

Pillar 3 provides two types of incentives: state subsidies and tax exemptions for employers who support savers. The state subsidizes 15% of annual contributions (up to a maximum of around €100) (Better Finance 2023). Contributions can also be covered by the employer. Within an annual limit (equivalent to around €800), these contributions are tax-free and not deposited in social security. However, pensions received from Pillar 3 are subject to individual taxation. At the end of 2022, around 400,000 Croats (22% of the working population) were saving in Pillar 3.

Table 5. How the PEPP functions in Croatia

Employer contribution as under Pillar 3	Yes
Employers' contribution	If an employer contributes up to €66.36 (HRK 500) per month or €796.30 (HRK 6,000) per year to an open or closed voluntary pension fund for its employees, the payment is considered a tax-deductible expense for the employer
Employee contribution as in other Pillar 3 products	Not all employees contribute
Benefit for the employee	Voluntary pension insurance contributions (PEPP) paid by an employer for its employee up to €66.36 (HRK 500) per month or €796.30 (HRK 6,000) per year constitute employee income but are not subject to income tax
Taxation of profits	Neither capital gains tax nor income tax is payable on funds paid into the PEPP or on pension withdrawals
Liquidity	You can withdraw 100% of your PEPP savings when you reach the age of 55
Forms of pension	Pension, single payment, interim payment, or a combination of these forms
Pillar III transferability	No
Contribution limits	No. Unlimited regular or one-off contributions are allowed

Source: own work.

Czech Republic

Among the countries analyzed, only the Czech pension system consists of two pillars. The equivalent of the Polish open pension funds (Pillar 2) existed in the Czech Republic between 2013 and 2015.

Pillar 1 is mandatory and state-owned, operating as a defined benefit (DB) system. This system gives more of a premium to those with low salaries. Contributions to Pillar 1 amount to 28% of the employee's gross salary: 6.5% is paid directly by the employee and 21.5% by the employer. The pension consists of two parts: a fixed amount defined by law, and a variable amount based on the amount of pension contributions paid (Poteraj 2009).

Pillar 3[3] operates in the form of insurance or investment products, with various risk profiles available, which can be changed. Individual pension accounts enjoy tax incentives and subsidies from the state budget. The tax model involves relief on contributions, no tax on profits during investment, and taxation of withdrawals, which is similar to the Polish IKZE. If an employer participates in the pillar (in group form), contributions are exempt from social security contributions and can be tax deductible for the employer. The prerequisite for tax benefits and subsidies from the state is reaching retirement age (65, regardless of gender). At the end of 2022, 4.4 million future Czech pensioners were saving in Pillar 3 and had accumulated 41.5 billion Kč (€1.7 billion).

Table 6. How the PEPP functions in the Czech Republic

Employer contribution as under Pillar 3	Yes
Employers' contribution	Employer contributions are tax expenditures up to 50,000 Kč (€ 2,083)/year and are up to the limit free of social and health insurance. Since 1.1.2024, the PEPP has operated as a ‚long-term investment account,' and the same tax benefit also applies to the PEPP
Employee contribution as in other Pillar 3 products	Yes
Benefit for the employee	Reduces the saver's tax base to 48,000 Kč (€2,000)/year (4,000 Kč (€166)/month)
Taxation of profits	After 3 years of investing, profits are exempt from taxes (or if income falls below 100,000 Kč within a year). Otherwise, 15/23% (if income is higher than 48 times the average salary) tax
Liquidity	After 120 months + in the year turning 60
Forms of pension	Lump sum payment, gradual withdrawal, or a combination
Pillar 3 transferability	No
Contribution limits	No. Any regular or one-off payments

Source: own work.

3 To aid comparison, we refer to this as Pillar 3, although, as stated, the Czech Republic only has two pillars.

Results of qualitative research

To answer the research questions posed, interviews were conducted with people responsible for managing PEPP funds, specifically, those directly managing the assets collected under the PEPP. The study also used a self-administered questionnaire in a Microsoft Word document distributed via e-mail, which respondents completed independently and returned electronically. The interviews were conducted in July/August 2024 with four representatives from Finax who are responsible for managing PEPP funds in Poland, Slovakia, the Czech Republic and Croatia. The survey instrument comprised 13 questions, structured to progress from general financial market issues to more specific inquiries concerning PEPP product management and operation. Responses were subsequently grouped based on similarities and differences and conclusions were drawn on this basis. The interviews were conducted one-to-one and were open-ended, focusing on the formal and professional perspectives of the fund managers. The selection of respondents was intended to elicit insights derived from their day-to-day work and experiences of directly handling PEPPs.

When questioned about the biggest challenges currently facing the financial industry, respondents identified increasing competition from speculative investment products such as cryptocurrencies, CFDs and forex instruments. Other concerns included the over-regulation of the market, the falling cost of investment services, and the investment conservatism of Polish society. In addition, one respondent highlighted the low popularity of investment products. Another respondent indicated that due to high inflation in recent years, many households have been experiencing financial stress, resulting in investment decisions being deferred.

Regarding factors that hinder satisfactory returns on PEPP investments, respondents observed that current regulations permit more dynamic investments, which yield better results in the long run. Furthermore, the respondent from the Czech Republic noted that while active funds employ large teams of portfolio managers and analysts, the PEPP product, due to its long-term orientation and limits on the amount of costs, allows for a lower cost structure for savers.

The respondents from Poland and Slovakia identified the high competition of "cost-dumping" products as a major risk, leading to an outflow of funds from long-term products. In view of these risks, in response to a question about strategies to counter these risks, the respondents indicated that Finax bases its operations on global investing and automated, passive investment strategies. They also detailed a plan to gradually convert investment portfolios to less risky (higher debt content) allocations ten years before switching. Importantly, these portfolios are designed to maintain this composition throughout the decumulation phase to increase potential returns. A more conservative approach would have been ineffective, as clients in retirement can also multiply accumulated funds. Seth Khanna (2023) offers an interesting point of comparison by analyzing micro-pensions in Africa as models adapted to societies with low levels of formal employment. They could serve as an inspiration for PEPP development in less-developed EU economies.

Regarding the impact of regulation on PEPP asset management, the respondents showed that the regulations were forcing a more passive investment approach. However, the Finax

representatives from Slovakia and Croatia emphasized the attractiveness of the product relative to the existing solutions present in their respective countries. This suggests that the introduction of the PEPP at the EU level has contributed to the creation of competitive savings products that were not previously available in such an attractive form in these Member States.

Importantly, according to the respondents, the main expectations of PEPP clients are financial performance exceeding the market benchmark and having a safe place where their savings will not lose value. Other important client considerations include protection from local political decisions, the ability to outperform bank deposits or bond investments, and being able to take advantage of tax incentives.

Referring to the provision of adequate customer service, the respondents from Finax highlighted initiatives for customer financial education, including blogs, podcasts, webinars, and on-site presentations. They also mentioned a presence across various communication channels (email, helpline, app) and reducing management service fees below the EU-required threshold of 1% of total costs.

Regarding the impact of technology on PEPP customer service, the respondents acknowledged that new technologies facilitate account management and automate the investment process. However, the Finax representative from Slovakia noted that, in some cases, basing customer service on new technologies can be an obstacle, as some customers are not sufficiently familiar with technology to open a pension account via their smartphone. Nevertheless, the respondents see a future for digital platforms that provide clients with real-time access to investment performance, transaction history, and account details.

When asked to predict the greatest challenges impacting the PEPP product in the coming years, the respondents primarily identified an increase in interest in the products due to an aging population but also low competition in the market from PEPP suppliers. A respondent from the Czech Republic indicated that when more global players start offering PEPP products, which can vary significantly from supplier to supplier, cost-cutting competition may start.

In response to a question about possible regulatory changes or market trends that could have a significant impact on the management of PEPPs, the respondents expressed concerns about the difficulty of product development when the product is individual-based rather than group-based (organized by the employer). Other respondents highlighted the challenges of changing financial market legislation at both the EU and Member State levels. At the same time, a respondent from the Czech Republic indicated that it is important that the PEPP product features the same tax benefits as existing local long-term savings products and schemes.

Results of the quantitative research

The aim of the quantitative survey was to collect information from PEPP holders in the four countries where PEPP is offered. The study focused on assessing their knowledge of PEPP, their expectations of potential benefits, their investment decisions, and their access to information about PEPP. The survey was conducted using the CAWI (Computer-Assisted Web Interviewing)

technique. An online survey was prepared via Google Forms in 5 language versions: Polish, Slovak, Czech, Hungarian and English. The survey was also distributed via Finax, the only PEPP provider. The results of the survey for each country will be presented below, followed by a comparative analysis of the results and statistical testing. The Czech Republic was excluded from the quantitative analysis because the study was conducted shortly after the introduction of PEPP in that country, and fewer than 100 holders participated.

Characteristics of the study group

A total of 236 respondents from Poland, 142 from Croatia, and 130 from Slovakia took part in the survey. Men accounted for 85.6% of the Polish group, 64.1% of the Croatian group and 87.7% of the Slovak group. Analysis using Pearson's χ^2 test showed that there was a statistically significant difference between the country groups in the gender distribution $V = 0.25$; $p < 0.001$, with the highest proportion of female PEPP users in the Croatian group.

Table 7. Gender characteristics of the study group

Gender	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Woman	34	14.4	51	35.9	16	12.3	0.25	***
Male	202	85.6	91	64.1	114	87.7		

V – strength of Cramer's V relationship, *p* – level of statistical significance, *** $p < 0.001$.

Source: own work.

There was also a statistically significant difference in age structure between the groups ($V = 0.13$; $p < 0.05$). There was a higher proportion of people over 45 years of age in the Polish group than in the Croatian and Slovak groups. The results of the analyses are presented in Table 8.

Table 8. Age characteristics of the study group

Age	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
15–24 years	3	1.3	3	2.1	4	3.1	0.13	0.025*
25–34 years	54	22.9	53	37.3	49	37.7		
35–44 years	103	43.6	57	40.2	42	32.3		
45–54 years	63	26.7	24	16.9	30	23.1		
55 years and over	13	5.5	5	3.5	5	3.8		

V – strength of Cramer's V relationship, *p* – level of statistical significance, * $p < 0.05$.

Source: own work.

Based on the results in Table 9, the groups also showed statistically significant differences in the distribution of residence size ($V = 0.16$; $p < 0.001$). The majority of residents from Poland and Croatia (over 50% in each country) lived in large cities with more than 250,000 inhabitants. In contrast, 32% of Slovak residents lived in cities with more than 250,000 inhabitants, although

a large proportion lived in cities between 50,000 and 250,000 inhabitants (20%), as well as in rural residents (23.8%).

Table 9. Characteristics of the study group in terms of place of residence

Place of residence	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Village	34	14.4	19	13.4	31	23.8	0.16	0.001**
City of up to 25,000 inhabitants	17	7.2	14	9.9	18	13.8		
City of 25,000–50,000 inhabitants	14	5.9	15	10.6	13	10.0		
City of 50,000–25,000 inhabitants	36	15.3	16	11.3	26	20.0		
City of over 250,000 inhabitants	135	57.2	78	54.8	42	32.2		

V – strength of Cramer's V relationship, *p* – level of statistical significance, ** $p < 0.01$.

Source: own work.

In contrast, there was no statistically significant difference between the residents of the different countries in terms of education ($V = 0.09$; $p = 0.251$) (Table 10). In each country, approximately 65% of the people had a master's degree, followed by a smaller proportion with a bachelor's, secondary, or doctoral degree.

Table 10. Characteristics of the study group in terms of education

Education	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Medium	30	12.7	23	16.2	29	22.3	0.09	0.251
Bachelor's degree	36	15.3	21	14.8	12	9.2		
MSc	160	67.8	91	64.1	82	63.1		
Doctorate	10	4.2	7	4.9	7	5.4		

V – strength of Cramer's V relationship, *p* – level of statistical significance.

Source: own work.

Among the respondents, 61% of Polish residents, 88% of Croatian residents, and 76.9% of Slovakians were employed. The remainder were self-employed, with a statistically significant higher proportion of self-employed individuals in Poland ($V = 0.26$; $p < 0.001$).

Table 11. Characteristics of the study group in terms of the form of employment

Form of employment	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Working on a permanent basis	144	61.0	125	88.0	100	76.9	0.26	***
Own business	92	39.0	17	12.0	30	23.1		

V – strength of Cramer's V relationship, *p* – level of statistical significance, *** $p < 0.001$.

Source: own work.

Analysis with Pearson's χ^2 test showed a statistically significant difference between country groups in the distribution of professional occupations $V = 0.32$; $p < 0.001$. Professionals accounted for 49.6% of the Polish group, 31.7% of the Croatian group and 35.4% of the Slovak group. In contrast, there was a high proportion of manual workers in the Croatian (34.5%) and Slovakian (29.2%) groups.

Table 12. Characteristics of the study group in terms of occupation

Workstation	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Specialist	117	49.6	45	31.7	46	35.4	0.32	***
Manager	28	11.9	22	15.5	32	24.6		
Director	23	9.7	5	3.5	6	4.6		
Manual worker	11	4.7	49	34.5	38	29.2		
Own business	51	21.6	16	11.3	0	0.0		
Other	6	2.5	5	3.5	8	6.2		

V – strength of Cramer's V relationship, *p* – level of statistical significance, *** $p < 0.001$.

Source: own work.

Comparison of countries in terms of their approach to the PEPP

The respondents were asked to determine the minimum rate of return on investment on their PEPP. Descriptive statistics and the results of the comparative analysis using the Kruskal–Wallis test are presented in Table 13. The Kruskal–Wallis test yielded a statistically insignificant result between the countries ($\chi^2 = 2.46$; p = 0.293; $\eta^2 = 0.00$). Additionally, Mann–Whitney comparisons were performed, which also showed no statistically significant differences between Poland, Croatia and Slovakia in terms of the expected minimum rate of return on PEPP investment.

Table 13. Descriptive statistics and Kruskal–Wallis test results for minimum expected annual return on PEPP investments by country

What minimum average annual rates of return on PEPP investments do you expect (in %)?	*Min*	*Max*	*M*	*SD*	*Q1*	*Me*	*Q3*	χ^2	*p*	η^2
Poland	2.5	50	7.53	3.90	5	7	8.38	2.46	0.293	0.00
Croatia	3	20	7.03	2.54	5	7	8			
Slovakia	0.08	30	7.67	3.72	6	7	8.25			

Min – minimum, *Max* – maximum, *M* – mean, *SD* – standard deviation, *Q1* – first quartile, *Me* – median, *Q3* – third quartile, χ^2 – Kruskal–Wallis statistic, *p* – level of statistical significance, η^2 – magnitude of differences.

Source: own work.

Table 14 shows the results of the Mann–Whitney U-test analyses for a cross-country comparison of the expected minimum return on PEPP investments.

Table 14. A detailed comparison of expected minimum return on PPE investments

			Z	*p*	*r*
Poland	vs	Croatia	1.18	0.239	0.06
Poland	vs	Slovakia	0.54	0.589	0.03
Croatia	vs	Slovakia	1.51	0.132	0.09

Z – Mann–Whitney U statistic, *p* – level of statistical significance, *r* – magnitude of differences.

Source: own work.

Subsequently, Pearson's χ^2 test was used to compare the preferred channels for receiving information about PEPP was compared between countries. The results of the analysis are presented in Table 15. The majority of respondents preferred to receive information about PEPP online: this was indicated by 97% of Poles, 91.5% of Croats and 96.2% of Slovaks. The difference between countries was statistically significant ($V = 0.11$; $p < 0.05$). Respondents less frequently expressed a preference for receiving information in paper form or during a meeting with an advisor or expert.

Table 15. Preferred channels for receiving information on PEPP by country

How would you like to receive information on PEPP?	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Online	229	97.0	130	91.5	125	96.2	0.11	0.045*
In paper form	5	2.1	4	2.8	4	3.1	0.03	0.835
Meeting with an advisor/expert	10	4.2	10	7.0	4	3.1	0.07	0.272

V – strength of Cramer's V relationship, *p* – level of statistical significance, * $p < 0.05$.

Source: own work.

A further analysis using Pearson's χ^2 test revealed statistically significant differences between countries in terms of the expected frequency of receiving information about the PEPP ($V = 0.23$; $p < 0.001$): 51.7% of Poles, 53.4% of Croats and 22.3% of Slovaks would like to receive feedback from PEPP every quarter; 22.9% of Poles, 23.2% of Croats, and 33.1% of Slovaks preferred every 6 months; and 21.2% of Poles, 11.3% of Croats, and 40% of Slovaks preferred annual updates.

Table 16. Preferred frequency of receiving information on PEPP by country

How often would you like to receive information on PEPP?	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Quarterly	122	51.7	90	63.4	29	22.3	0.23	***
Once every 6 months	54	22.9	33	23.2	43	33.1		
Once a year	50	21.2	16	11.3	52	40.0		
Other	10	4.2	3	2.1	6	4.6		

V – strength of Cramer's V relationship, *p* – level of statistical significance, *** $p < 0.001$.

Source: own work.

Regarding expectations of customer service offered by PEPP, fast and efficient service was most commonly cited: it was indicated by 60.2% of Poles, 75.4% of Croats, and 56.9% of Slovaks. This was followed by the availability of various channels of communication, as indicated by 27.1% of Poles, 24.6% of Croats, and 33.1% of Slovaks. Competent and polite advisors were mentioned less frequently – by 11.4% of Poles, 13.4% of Croats and 23.1% of Slovaks. Croats were more likely to indicate fast and efficient service ($V = 0.15$; $p < 0.01$), and Slovaks were more likely to indicate competent and polite advisors ($V = 0.14$; $p < 0.05$).

Table 17. Customer service expectations regarding PEPP by country

What are your expectations regarding the level of customer service offered by PEPP?	Poland		Croatia		Slovakia		*V*	*p*
	N	%	*N*	%	*N*	%		
Fast and efficient service	142	60.2	107	75.4	74	56.9	0.15	0.002**
Availability of different communication channels (e.g., telephone, e-mail, online chat)	64	27.1	35	24.6	43	33.1	0.07	0.280
Competent and polite advisors	27	11.4	19	13.4	30	23.1	0.14	0.010*

V – strength of Cramer's V relationship, *p* – level of statistical significance, * $p < 0.05$, ** $p < 0.01$.

Source: own work.

Discussion

Capital solutions in the pension system can be subject to criticism. As L. Oręziak (2013) showed, privatizing pension systems and transferring public funds to private financial institutions can carry risks. Still, voluntary and complementary retirement savings cannot remain important in contemporary economic thinking. According to Akerlof and Shiller (2015), the authors of Phishing for Phools, financial markets are not immune to manipulation and information asymmetry, which puts consumers in a disadvantageous situation. However, it is not the existence of the market itself that is inherently problematic, but the lack of an appropriate regulatory framework and financial education to protect individuals from abuse. In this context, PEPP – which is standardized and supervised by state institutions – has the potential to serve as a safe investment tool that allows citizens to build retirement capital while also helping to finance the real economy.

Despite its potential benefits, the PEPP faces several significant barriers that limit its implementation and effectiveness in EU Member States. One of the main challenges is the lack of consumer awareness and financial literacy. Many people are not familiar with the existence of the PEPP or do not fully understand how it works and how it differs from national pension products, which discourages participation. Another major barrier is the fragmented tax treatment across the EU. Although the PEPP is designed as a unified product, its tax attractiveness is highly dependent on national tax incentives, which differ significantly, undermining its pan-European uniformity and competitiveness. In addition, the limited availability of providers – especially in smaller or less developed financial markets – has contributed to slow implementation and limited access for potential savers. Regulatory uncertainty and the administrative

burden of cross-border compliance for financial institutions further complicate the expansion of the PEPP.

Future research could include PEPP holders from more countries. The conclusions drawn from the study of four countries where PEPP is offered by Finax are related to their macroeconomic situation, the development of their financial system, and their levels of pension awareness regarding voluntary retirement savings. These factors may differ in other countries where PEPP is introduced as more than just an additional product provider.

Hadad, Dimitrov, and Stoilova-Nikolova (2022) showed that the level of readiness to implement PEPP varies significantly across Member States, confirming the need for further institutional harmonization. According to Kochaniak et al. (2023), PEPP also has the potential for adaptation in EU candidate countries, although it encounters additional systemic and social barriers there. According to Poulle et al. (2024), while PEPP regulations at the EU level are relatively detailed, their effectiveness depends on consistent implementation across countries. An interesting point of reference is provided by Seth Khanna (2023), who analyzed micro-pensions in Africa as models adapted to societies with low levels of formal employment. These models could inspire the development of PEPP in less-developed EU economies.

Based on our findings, we recommend several EU-level policy adjustments. First, there are significant differences in how countries implement the PEPP, which undermines the product's core objective of cross-border portability and standardization. To address this, the EU could strengthen regulatory harmonization, particularly in supervisory frameworks and tax treatment, to ensure fair competition and consistency across the internal market.

The research also shows that national differences in tax incentives substantially affect the attractiveness of PEPP compared to local pension products. Introducing a coordinated EU-wide tax framework, or at least incentivizing Member States to align their regimes, could enhance the competitiveness and uptake of PEPP.

From a saver's perspective, the study reveals that expectations differ by country, especially regarding service preferences and return expectations. Therefore, the PEPP policy should keep a common structure but allow for flexibility to accommodate local preferences. Meanwhile, limited financial literacy and low awareness about PEPP are key barriers. Thus, the EU should invest in pan-European financial education campaigns and digital tools to empower citizens to make informed pension decisions.

Finally, from a provider's perspective, regulatory burdens and fragmented national rules complicate cross-border PEPP management. Therefore, simplifying compliance procedures and creating a more supportive environment for providers would help foster market development and consumer trust across the EU.

The implementation of the PEPP raises important ethical considerations that must be addressed to ensure the product's legitimacy, fairness, and societal impact. At the core of these concerns lies the question of equitable access to pension savings tools across different demographic groups and Member States. Although the PEPP is designed as a standardized and portable

product, there is a risk that its benefits may disproportionately favor more mobile, financially literate, or affluent individuals, thereby exacerbating existing inequalities in retirement preparedness.

A critical ethical issue is the potential exclusion of vulnerable populations, such as low-income workers, individuals with limited financial literacy, and those employed in informal sectors. The complexity of pension products, coupled with a lack of clear, accessible guidance, can leave these groups behind. Moreover, while the PEPP is regulated to ensure transparency and safety, the voluntary and individual nature of the product may shift responsibility for retirement security from the state to the individual, raising concerns about the erosion of the social contract and the principle of intergenerational solidarity.

Another ethical dimension involves the marketing and sale of PEPPs. Providers must ensure that the promotion of PEPPs adheres to high standards of truthfulness, relevance, and transparency. Financial institutions that offer these products have a duty to avoid exploiting information asymmetries or engaging in practices that could lead to mis-selling, especially to less informed savers. The harmonized disclosure requirements (e.g., PEPP KID and Benefit Statement) aim to mitigate this risk, but their actual impact depends on their clarity and the saver's ability to understand them.

Furthermore, ethical stewardship of the capital accumulated in PEPPs is essential. Investment decisions made on behalf of savers should align not only with risk-return considerations but also with broader societal values, such as environmental sustainability and social responsibility. As the funds collected under PEPPs may significantly impact capital markets and the real economy, incorporating Environmental, Social, and Governance (ESG) criteria into investment policy is both a prudent and ethically responsible approach.

Finally, from an intergenerational justice perspective, the development of PEPPs must consider the long-term implications for future retirees. Ensuring the financial sustainability of PEPPs while also safeguarding the rights and interests of younger generations demands a careful balance between cost efficiency, adequate returns, and regulatory protections. Policymakers and providers alike have an ethical obligation to avoid short-termism and design a pension framework that promotes dignity and security in old age for all EU citizens.

Conclusion

The PEPP was designed as a simple, safe, transparent, cost-effective, flexible, and competitive long-term savings product, subject to strict consumer protection rules. It is a funded voluntary private pension plan with an explicit objective to provide income on retirement. We confirm previous research (Hadad, Dimitrov, and Stoilova-Nikolova 2022) that the success of the PEPP will largely depend on the presence of an appropriate national regulatory regime, favorable tax treatment, and competitive fees and charges.

A qualitative study of PEPP managers in the four countries where it is currently offered (Poland, Slovakia, the Czech Republic, and Croatia) allowed us to compare managers' attitudes

and visions of the limitations and opportunities for PEPP development in each country. The quantitative survey of PEPP holders in Poland, Slovakia, and Croatia revealed differing expectations and assessments of future pension savers in each country, while a review of the literature and pension systems in the four countries highlighted differing solutions to PEPP implementation. This is confirmed by EIOPA's (2024) study of the overall friendliness of legal solutions for PEPP implementation across countries and the divergence rather than convergence in the single market.

The analyses and research presented in this article confirm hypotheses H1–H4. In contrast, hypothesis H5 – that the expectations of PEPP savers do not differ across countries but depend on the sociodemographic factors of savers – was not confirmed. These findings show that expectations of PEPP savers do differ across countries, but they also depend in part on the savers' sociodemographic characteristics.

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Paneuropejski Indywidualny Produkt Emerytalny – wyzwania dla zarządzających i oczekiwania oszczędzających

Paneuropejski Indywidualny Produkt Emerytalny (PEPP) to strategiczna inicjatywa Unii Europejskiej mająca na celu stworzenie zharmonizowanych, przenośnych ram oszczędności emerytalnych, które rozwiążą problemy związane ze starzeniem się populacji, zwiększoną mobilnością siły roboczej i rosnącą luką emerytalną w państwach członkowskich. W artykule zbadano wdrożenie i funkcjonowanie PEPP w czterech krajach UE – Polsce, Słowacji, Chorwacji i Czechach – poprzez projekt badawczy z zastosowaniem mieszanych metod.

Badanie łączy analizę prawną i porównawczą krajowych systemów emerytalnych z jakościowymi wywiadami przeprowadzonymi z menedżerami funduszy PEPP i ilościowymi badaniami oszczędzających w ramach PEPP. Wyniki ujawniają znaczne rozbieżności w podejściach regulacyjnych, traktowaniu podatkowym i ramach nadzorczych między krajami, co wpływa zarówno na atrakcyjność, jak i funkcjonalność PEPP. Pomimo wspólnych zasad projektowych przejrzystości, bezpieczeństwa i efektywności kosztowej, oczekiwania oszczędzających różnią się znacząco w zależności od kraju – zwłaszcza w odniesieniu do obsługi klienta, dostarczania informacji i oczekiwań dotyczących minimalnego zwrotu – a jednocześnie są kształtowane przez czynniki społeczno-demograficzne.

Badania jakościowe podkreślają, że zarządzający funduszami stoją przed wyzwaniami, takimi jak fragmentacja regulacyjna, wysokie obciążenia administracyjne i konkurencja ze strony produktów krajowych z korzystniejszym traktowaniem podatkowym lub zachętami opartymi na pracodawcach. Jednocześnie narzędzia cyfrowe i pasywne strategie inwestycyjne są postrzegane jako kluczowe dla zwiększenia skalowalności i wydajności PEPP.

Artykuł kończy się wnioskiem, że aby PEPP odniósł sukces jako prawdziwie paneuropejski produkt, niezbędna jest dalsza harmonizacja przepisów, spójne zachęty podatkowe i kompleksowe działania edukacyjne w zakresie finansów. Autorzy proponują również, że zwiększona konkurencja dostawców i adaptacyjna polityka krajowa mogłyby przyspieszyć wdrażanie produktu. Badanie oferuje praktyczne spostrzeżenia dla decydentów politycznych UE, krajowych organów regulacyjnych i instytucji finansowych, których celem jest promowanie inkluzywnych i zrównoważonych oszczędności emerytalnych na całym kontynencie.

Słowa kluczowe: system emerytalny, prywatne programy emerytalne, PEPP

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The Saving–Investment Relationship Re-visited: Capital Mobility and Current Account Deficit Sustainability

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Abstract

The study examines the degree of current account deficit (CAD) sustainability and capital mobility for a panel of 97 countries over the period 1980–2020. To this end, the study adopts a novel interpretation of the Feldstein–Horioka coefficient in the context of CAD sustainability and examines the relationship between savings and investment using the Dynamic Common Correlated Effects Mean Group (DCCEMG) estimator. The findings reveal that all country groups exhibit "weakly" sustainable CADs. The estimates of the short-run coefficients reveal that short-run capital mobility is high in all country groups, whereas long-run capital mobility is relatively moderate or low. The rolling-window analysis shows that the 2007–2008 global financial crisis caused a significant drop in both capital mobility and CAD sustainability. In the post-crisis period, short-run capital mobility and CAD sustainability remained on a downward trend in most regions, whereas long-run capital mobility started slowly recovering. By providing a comprehensive regional analysis across six major world regions, this study contributes to the literature by shedding light on the evolving dynamics of international capital flows and regional variations in external balance sustainability.

Keywords: saving–investment relationship, capital mobility, current account sustainability, Feldstein–Horioka puzzle, DCCEMG

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Introduction

Capital mobility and current account deficits (CAD) are critical macroeconomic issues that significantly impact policymaking, investment strategies, and financial stability. Investment, a key driver of economic growth, relies heavily on savings as its primary source of funding. In a closed economy, domestic investment relies solely on domestic savings, whereas in an open economy, it is financed by both domestic and international savings. The degree of capital mobility influences how easily countries can fund domestic investment and address external imbalances, shaping their ability to sustain consumption and implement effective fiscal and monetary policies (Dash 2019). High levels of capital mobility enable countries to tap into international savings to finance investment, mitigating concerns about crowding out private investment during periods of expansionary fiscal policy. Conversely, low capital mobility amplifies the risks associated with prolonged CADs, such as capital flight or currency crises (Pata 2018).

A key framework for assessing capital mobility is the saving–investment relationship introduced by Feldstein and Horioka (1980). Their empirical study of OECD countries found a surprisingly strong correlation between domestic savings and investment, contradicting the expectation that higher capital mobility would weaken this link. This paradox sparked extensive research into the implications of the saving–investment coefficient. More recent studies, including Yersh (2024), have reinterpreted this coefficient within the context of CAD sustainability, arguing that it serves as both a measure of solvency and an indicator of the sustainability of external imbalances. Building on this approach, this study employs a unified framework to assess both capital mobility and CAD sustainability, utilizing the Dynamic Common Correlated Effects Mean Group (DCCEMG) estimator (Chudik and Pesaran 2015). This methodology accounts for cross-sectional dependence and allows for heterogeneous short- and long-run dynamics across regions.

This study contributes to the literature in three ways. First, it utilizes Chudik and Pesaran's DCCEMG estimator, which produces consistent estimation results in the presence of cross-sectional dependence. This method also allows for heterogeneous short- and long-term dynamics across different cross-sections. Second, the study evaluates both CAD sustainability and the degree of capital mobility in diverse country samples grouped by region. Third, it conducts a sub-period analysis to trace how capital mobility and CAD sustainability have evolved over time.

The findings indicate that CADs are weakly sustainable in most regions, with high short-run capital mobility but moderate long-run mobility in developed economies and lower mobility in less developed ones. The 2007–2008 global financial crisis significantly disrupted both capital mobility and CAD sustainability. Long-run mobility showed gradual recovery post-crisis, while short-run mobility and CAD sustainability remained on a declining trend in many regions.

The remainder of this study is organized as follows. A brief overview of related literature is presented in Section 2. Section 3 lays out the econometric methodology, while Section 4 describes the data. The results, including sub-period analysis and policy implications, are summarized in Section 5. The final section concludes the study.

Literature review

Feldstein and Horioka (1980) introduced the idea that the saving–investment relationship reflects capital mobility, hypothesizing that with high capital mobility, domestic savings and investment should be unrelated, as international savings would fill any gap. They tested this by regressing the ratios of gross domestic capital formation to GDP on the ratios of gross domestic savings to GDP for 16 OECD countries. The coefficient on savings was interpreted as the share of domestic savings financing domestic investment. A coefficient close to zero would indicate perfect capital mobility, while a coefficient near one would suggest limited mobility. Contrary to expectations, the results showed a strong saving–investment correlation, indicating low capital mobility.

This finding, dubbed "the mother of all puzzles" (Obstfeld and Rogoff 2000), sparked extensive debate and generated a large body of literature. The prevailing explanation, based on the intertemporal current account approach, views the saving–investment relationship as reflecting the solvency condition rather than capital mobility. Scholars argue that the current account, defined as the difference between savings and investment, must be stationary in the long run to prevent debt accumulation. This implies that savings and investment should form a cointegrating vector, with coefficients close to (1; –1) (Coakley, Kulasi, and Smith 1996). Numerous studies provide evidence of the binding solvency condition (Nasiru and Haruna 2013; Drakos et al. 2017; Murthy and Ketenci 2020a), though some authors continue to interpret deviations from unity as evidence of long-run capital mobility (Drakos, Kouretas, and Vlamis 2018; Kaur and Sarin 2018; Pata 2018; Tursoy and Faisal 2019; Murthy and Ketenci 2020b; Patra and Mohanty 2020; Camarero, Muñoz, and Tamarit 2021; Yilanci and Kilci 2021). This study avoids the ambiguous interpretation of the saving–investment coefficient by focusing on CAD sustainability as proposed by Yersh (2024).

Taylor (2002) argued that a sustainable current account is a stationary process, meaning that a country can satisfy its solvency constraint in the long run without drastic policy intervention. Conversely, a non-stationary current account implies that the CAD is unsustainable and, consequently, a country runs a risk of defaulting on its international borrowing. CAD sustainability analyses typically rely on unit root testing or cointegration analysis of exports and imports. However, unit root tests are often criticized for their inconclusive results, while cointegration tests fail to fully account for current account dynamics (Dash 2020).

In a recent study, Dash (2020) pointed out that the main limitation of existing approaches for studying CAD sustainability is their inability to account for current account dynamics. He overcomes this limitation by estimating an error-correction model that allows for studying short- and long-run dynamics of the current account along with its speed of convergence to the long-run equilibrium. For this purpose, the study applies the Pooled Mean Group (PMG) estimator introduced by Pesaran, Shin, and Smith (1999). The findings revealed that while exports and imports are non-stationary, they are cointegrated, indicating that CADs are weakly sustainable across the analyzed panels of countries. However, the study's primary drawback is the PMG estimator's reduced estimation power when the residuals are characterized by cross-sectional dependence.

Yersh (2024) overcame this limitation by adopting the DCCEMG estimator, which accounts for cross-sectional dependence and captures heterogeneous dynamics. Similar to Yersh's (2024) study, this paper utilizes the DCCEMG estimator to analyze CAD sustainability across various regions, focusing on both short- and long-run capital mobility, as well as the degree of CAD sustainability.

Research methodology

Background and methodological approach

According to Husted (1992), the intertemporal budget constraint for a given country is represented by the following equation:

$$X_t = \alpha_0 + \alpha_1 M_t + \varepsilon_t, \tag{1}$$

where X_t and M_t are exports and imports, respectively. Under the null hypothesis, the intertemporal budget constraint is satisfied. Therefore, α_1 should be equal to 1 ($\alpha_1 = 1$), and ε_t should be a stationary process. Alternatively, X_t and M_t should be non-stationary and cointegrated, forming a cointegrating vector of (1, –1).

Following Dash (2017) and Yersh (2022; 2024), this study employs an alternative definition of the intertemporal budget constraint based on the saving–investment relationship. Similar to the conventional model, the economy satisfies its intertemporal budget constraint when β_1 is equal to 1, and the error term is a stationary process. Alternatively, (I/Y) and (S/Y) should be non-stationary processes and form a cointegrating vector of (1, –1).

Most studies on CAD sustainability use Dynamic OLS (DOLS) or Fully Modified OLS (FMOLS) estimators (e.g., Wu, Chen, and Lee 2001), but these fail to capture short- and long-term dynamics or convergence rates. Dash (2020) addresses this by using an error-correction model with the PMG estimator. However, as previously mentioned, the PMG estimator has a significant limitation in that it performs poorly when residuals are cross-sectionally dependent. Therefore, this study employs the DCCEMG estimator, which offers several advantages over these estimators. First, it explicitly accounts for unobserved common factors, providing consistent estimates even in the presence of cross-sectional dependence. Second, the DCCEMG estimator captures both short-run and long-run relationships while allowing for complete parameter heterogeneity across countries. This is particularly relevant given the heterogeneous nature of the regional sub-samples.

The DCCEMG estimator relies on several key assumptions. First, the estimator assumes that cross-sectional dependence arises through unobserved common factors, which can be approximated using cross-sectional averages of the dependent and independent variables, given that the asymptotic properties are met. Second, the method also requires that individual time series are integrated of order one, that a cointegrating relationship exists between saving and investment, and that the error-correction term is stationary. Third, the approach assumes weak exogeneity of regressors, meaning they may be correlated with current-period innovations but not with future ones.

Estimation model

Following Pesaran (2006), the relationship between national investment and saving is modeled as:

$$\left(I/Y\right)_{it} = \beta_{0i} + \beta_{1i}\left(S/Y\right)_{it} + u_{it}, \tag{2}$$

$$u_{it} = \gamma_i^{'}\boldsymbol{f}_t + \varepsilon_{it}, \tag{3}$$

where $\boldsymbol{f}_t$ are the unobserved common factors and $\gamma_i^{'}$ are the heterogenous factor loadings. Cross-sectional dependence may arise if these factors correlate with the explanatory variable. To address this, Pesaran (2006) suggests approximating unobserved factors using the cross-sectional means of the explained and explanatory variables and incorporating them into the model.

After augmenting equation 2 with the cross-sectional means of saving ($\overline{S/Y_t}$) and investment ($\overline{I/Y_t}$), the following error-correction model is constructed to evaluate the short- and long-run dynamics simultaneously:

$$\Delta\left(\frac{I}{Y}\right)_{it} = \lambda_i((I/Y)_{i,t-1} - \beta_{0i} - \beta_{1i}\left(S/Y\right)_{i,t-1} - \sum_{I=0}^{p_T}\gamma_{i,I}^{LR}\overline{Z}_{t-I}\right) + \delta_i\Delta(S/Y)_i + \sum_{I=0}^{p_T}\gamma_{i,I}^{SR}\overline{Z}_{t-I} + \varepsilon_{it}, \tag{4}$$

where λ_i is the speed of convergence of the current account to the long-run equilibrium or the indicator of long-run capital mobility, β_{1i} is the measure of current account sustainability, and δ_i is the measure of short-run capital mobility. $\overline{Z}_t$ includes the cross-sectional averages of domestic saving as a share of GDP, ($\overline{S/Y_t}$), and domestic investment as a share of GDP, ($\overline{I/Y_t}$). The lagged dependent variable is not strictly exogenous and, thus, correlated with the residuals. Consequently, the model estimates are no longer consistent. However, as noted by Chudik and Pesaran (2015), consistency of the estimates can be achieved when the number of lags for the cross-sectional averages is set according to the equation: $p_I = \sqrt[3]{T}$.

The convergence parameter λ_i indicates the degree of capital mobility in the long run. If the degree of capital mobility is perfect, the imbalance of the current account or the difference between saving and investment should persist for a longer period without immediately reversing to its long-run value of zero; in other words, the coefficient λ_i should be close to zero. If capital mobility is low, the current account will quickly revert to its long-run value of zero; in other words, the coefficient λ_i should be equal or close to minus one.

The degree of CAD sustainability is measured by β_{1i}. If β_{1i} is estimated to be equal to one, then the saving and investment series are cointegrated with a vector of (1, –1). In this case, it can be concluded that the current account is a stationary process, oscillating around its long-run value of either β_{0i} (if β_{0i} is statistically different from zero) or zero (if β_{0i} is not statistically different from zero). In both cases, the economy satisfies its intertemporal budget constraint, and the CAD is strongly sustainable.

If β_{1i} is estimated to be different from one, then the saving and investment series form a cointegrating vector of $(1, -\beta_{1i})$. Consequently, it can be concluded that the current account is a non-stationary process, meaning the country is unable to meet its solvency constraint, and the CAD is weakly sustainable. The closer β_{1i} is to zero, the more weakly sustainable the CAD is. If β_{1i} is found to be equal to zero, it can be concluded that the CAD is strongly unsustainable.

The coefficient δ_i measures short-run capital mobility and represents adjustments to various short-run shocks in the economy. A coefficient near zero indicates high short-run mobility, while values closer to one suggest low short-run mobility.

Data

The data set consists of 97 countries spanning the period 1980–2020. The data on both gross domestic saving as a percentage of GDP (S/Y) and gross capital formation as a percentage of GDP (I/Y) come from the World Bank's World Development Indicator database. For ease of reading, this study will address gross domestic saving as a percentage of GDP as "saving" and gross capital formation as a percentage of GDP as "investment".

Following the World Bank classification, the data set is split into sub-samples based on countries' regions. The list of regions, along with the countries included in each region, is summarized in Table 1. While the classification is geographic, the use of these groupings also had an economic rationale. Countries within each region often share similar institutional structures, trade linkages, exposure to common shocks, and common policy challenges. Regional groupings also reflect stronger spillovers and contagion effects, as seen during the 2007–2008 financial crisis.

Table 1. Regions' description

Region	Countries
East Asia and Pacific (EAP)	Australia, China, Hong Kong, Indonesia, Japan, South Korea, Malaysia, Mongolia, New Zealand, Philippines, Singapore, Thailand, Vietnam. *Number of countries = 13.*
Europe and Central Asia (ECA)	Albania, Austria, Belgium, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Italy, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Turkey, United Kingdom. *Number of countries = 22.*
Latin America and Caribbean (LAC)	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay. *Number of countries = 19.*
Middle East and North Africa (MENA)	Algeria, Bahrain, Egypt, Israel, Jordan, Kuwait, Malta, Morocco, Oman, Saudi Arabia, Tunisia. *Number of countries = 11.*
South Asia (SA)	Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka. *Number of countries = 6.*

Region	Countries
Sub-Saharan Africa (SSA)	Angola, Benin, Botswana, Burkina Faso, Cameroon, Comoros, Democratic Republic of the Congo, Eswatini, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Mauritania, Niger, Nigeria, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Uganda. *Number of countries = 26.*

Source: World Bank, World Development Indicators 2022a; 2022b.

The statistical properties of saving, investment, and CAD for each group are presented in Appendix A. The Middle East and North Africa (MENA), together with East Asia and the Pacific (EAP), show the highest current account surpluses of 1.32% and 0.86% of GDP, respectively, whereas Sub-Saharan Africa (SSA), along with Latin America and the Caribbean (LAC), shows the highest CADs of 6.48% and 4.01% of GDP, respectively. Additionally, the cross-sectional averages have been plotted against time and are shown in Figure 1. LAC, along with SSA, exhibit persistent CADs, whereas EAP have been experiencing a persistent current account surplus since 1997. Saving and investment in the other three regions move in tandem with each other, and the current account is characterized by short periods of surplus followed by short periods of deficit and vice versus.

Figure 1. Average gross domestic saving and investment, as a percentage of GDP

Source: own calculations, World Bank, World Development Indicators 2022a; 2022b.

Results

Diagnostic tests

Before proceeding to panel estimation, the saving and investment series are checked for the presence of cross-sectional dependence and unit roots. To this end, the study estimates the cross-sectional dependence (CD) statistic developed by Pesaran (2014) for the former and Pesaran's (2007) Cross-sectionally augmented Im-Pesaran-Shin (CIPS) test for the latter. The results are presented

in Table 2. The CD statistic strongly rejects the null hypothesis of weakly cross-sectionally dependent residuals in all the analyzed country groups. Since cross-sectional dependence has been detected, this study employs the CIPS unit root test, which produces unbiased and consistent results in the presence of cross-sectionally dependent error terms. While the results reveal that both saving and investment series are non-stationary in levels, they become stationary in first differences.

Table 2. Diagnostic test results

	S/Y	*I/Y*	*ΔS/Y*	*ΔI/Y*
Europe and Central Asia				
CD-statistic	8.78***	2.91***	4.53***	4.81***
$CIPS_{\mu}$	−2.41**	−2.32**	−2.86***	−2.86***
$CIPS_{\mu,t}$	−2.50	−2.25	−2.87**	−2.91**
East Asia and Pacific				
CD-statistic	6.39***	19.88***	15.36***	28.01***
$CIPS_{\mu}$	−1.46	−1.69	−2.63***	−3.04***
$CIPS_{\mu,t}$	−1.78	−2.19	−2.68***	−3.05***
Latin America and Caribbean				
CD-statistic	7.38***	11.78***	2.29**	15.92***
$CIPS_{\mu}$	−2.56***	−2.44***	−3.13***	−3.17***
$CIPS_{\mu,t}$	−2.55	−2.35	−3.17***	−3.14***
Middle East and North Africa				
CD-statistic	3.42***	7.38***	4.56***	2.12**
$CIPS_{\mu}$	−1.85	−1.72	−3.35***	−3.67***
$CIPS_{\mu,t}$	−2.49	−2.36	−3.31***	−3.68***
South Asia				
CD-statistic	4.75***	4.42***	0.27	0.96
$CIPS_{\mu}$	−2.01	−2.92***	−2.45**	−2.78***
$CIPS_{\mu,t}$	−1.58	−2.81*	−2.86**	−2.74*
Sub-Saharan Africa				
CD-statistic	4.96***	6.61***	0.39	2.27**
$CIPS_{\mu}$	−2.04	−2.20**	−3.18***	−3.37***
$CIPS_{\mu,t}$	−2.44	2.37	−3.31***	−3.48***

*, ** and *** denote 10%, 5% and 1% significance levels, respectively. Pesaran's (2014) CD test null hypothesis assumes weak cross-sectional dependence. $CIPS_{\mu}$ tests for a unit root with an intercept while $CIPS_{\mu,t}$ includes a trend. Lag length is set at $T^{1/3} \approx 3$.

Source: own calculations.

Since saving and investment are found to be non-stationary, the next step is to check for cointegration. To this end, this study estimates Westerlund's (2007) four panel cointegration tests, which

are found to produce consistent estimation results in the presence of cross-sectional dependence. The results are summarized in Table 3. The results indicate that the null hypothesis of no cointegration is strongly rejected in all the sub-samples. Thus, it can be concluded that there exists a long-run relationship between domestic saving and investment. In other words, the cointegration test results indicate that the current account is sustainable in the analyzed panels of countries.

Table 3. Westerlund's panel cointegration tests results

	Panel statistic		*Group-mean statistic*	
	P_τ-Statistic	P_α-Statistic	G_τ-Statistic	G_α-Statistic
Europe and Central Asia	– 7.79	– 10.24	– 2.69*	– 12.27*
East Asia and Pacific	– 10.49	– 9.55*	– 2.08*	– 9.94*
Latin America and Caribbean	– 14.73***	– 17.49***	– 3.43***	– 17.65***
Middle East and North Africa	– 9.68**	– 13.63**	– 2.84**	– 13.82**
South Asia	– 7.61	– 18.06***	– 2.81*	– 12.85
Sub-Saharan Africa	– 13.58**	– 11.92**	– 2.94***	– 14.23***

*, ** and *** denote 10%, 5% and 1% significance levels, respectively. Each test equation includes an individual intercept and trend.

Source: own calculations.

Panel estimation results

The DCCEMG panel estimation results for the analyzed groups of countries are presented in Table 4. The long-run coefficients are statistically significant and lie between 0.35 and 0.57, implying weakly sustainable CADs in the analyzed regions. Additionally, the Wald statistic has been estimated to check whether the long-run coefficients are statistically different from one. The estimates confirm the presence of a weakly sustainable CAD in four regions: Latin America and the Caribbean (LAC), Middle East and North Africa (MENA), Sub-Saharan Africa (SSA), and South Asia (SA). The results for LAC confirm the previous findings of Dash (2020) and Yersh (2024), who found a weakly sustainable CAD in the panels of Latin American and Caribbean countries. The findings for MENA are in line with the results of Bousnina, Redzepagic, and Gabsi (2021), who examined 12 countries from the MENA region using the DOLS approach. The authors obtained a long-run coefficient different from one, which they interpreted as weakly sustainable current balances. The results of this study also confirm the previous findings of a weakly sustainable CAD in the Sub-Saharan African region obtained by Dash (2020). However, for Europe and Central Asia (ECA) and East Asia and the Pacific (EAP), the Wald statistic fails to reject a unit coefficient, suggesting strongly sustainable CADs. There is a notable inconsistency between the long-run estimates and Wald statistic results in the ECA and EAP regions. For clarification purposes, individual coefficients have been estimated and reported in Appendix B. In both regions, the majority of long-run estimates are relatively low and lie below or close to the MG results. Only a few countries reveal a relatively high long-run coefficient, implying a strongly sustainable CAD. Therefore, one can conclude that in both regions, CADs are weakly sustainable, with a few exceptions among individual countries.

Table 4. DCCEMG panel estimation results

	Long-run coef. (β_1)		Short-run coef. (δ)		EC term (λ)		Intercept (β_0)	
	Value	*S.E.*	*Value*	*S.E.*	*Value*	*S.E.*	*Value*	*S.E.*
ECA	0.43***	0.18	0.20***	0.05	−0.28***	0.04	0.12	0.15
	(*WD* = 2.14)							
EAP	0.57**	0.25	0.08	0.12	−0.32***	0.04	0.0	0.17
	(*WD* = 2.95*)							
LAC	0.35***	0.09	0.18***	0.07	−0.46***	0.03	−0.04	0.08
	(*WD* = 47.26***)							
MENA	0.40***	0.09	0.06	0.08	−0.34***	0.06	0.07	0.11
	(*WD* = 44.93***)							
SA	0.39**	0.15	0.38**	0.18	−0.38***	0.08	0.04	0.06
	(*WD* = 43.87***)							
SSA	0.45***	0.13	0.26***	0.05	−0.41***	0.03	0.03	0.10
	(*WD* = 18.27***)							

*, ** and *** denote 10%, 5% and 1% significance levels, respectively. WD stands for the Wald statistic, which checks the following null hypothesis: β_1=1.

Source: own calculations.

While all regions exhibit weak sustainability, the underlying reasons for this are different. Developing and middle-income regions (LAC, MENA, SSA, and SA) face structural challenges stemming from limited export diversification, dependence on volatile commodity prices, and underdeveloped domestic financial markets (Mania and Rieber 2019; Zarach and Parteka 2023; Andreev et al. 2024). In contrast, the mixed results for developed economy regions (ECA and EAP) reflect heterogeneity within these groups. While some countries achieve strong sustainability through export competitiveness and financial market depth, others face cyclical imbalances.

Table 4 also summarizes the estimates of the short-run coefficients, which measure the degree of capital mobility in the short run. The coefficients reveal distinct regional patterns driven by different economic structures and institutional frameworks. At one extreme, EAP and MENA demonstrate perfect short-run capital mobility (coefficients statistically insignificant), though for different reasons. EAP's perfect short-run mobility reflects the region's status as a global manufacturing hub, which comprises complex production networks requiring flexible, short-term financing along with the region's developed financial markets, which enable rapid capital reallocation in response to global demand shocks (Huang and Guo 2006). In the case of MENA, perfect short-run mobility is likely driven by oil revenue volatility, which induces large and sudden capital flow reversals, as well as political and economic instability that triggers episodes of rapid capital flight. Alzoubi and Kasasbeh (2021) similarly report high capital flows in MENA, attributing their findings to the region's persistent economic and political volatility.

In contrast, ECA, LAC, and SSA exhibit similar short-run coefficients (0.20, 0.18, and 0.26, respectively), yet the underlying drivers are different. ECA's relatively high mobility reflects the region's

advanced financial market infrastructure and institutional frameworks, particularly the benefits of EU integration, which have eliminated barriers to capital flows and strengthened investor confidence (Camarero, Muñoz, and Tamarit 2023). LAC's short-run result likely stems from the region's financial market integration, constrained by higher sovereign risk premiums and periodic sudden stops in capital flows (Gomez-Gonzalez, Valencia, and Sánchez 2021). This finding is in line with the results of Murthy and Ketenci (2020a), who analyzed the degree of capital mobility in 20 Latin American and Caribbean countries using the DCCEMG estimator. SSA's high degree of short-run capital mobility is comparable with the results of Murthy and Ketenci (2020b), who also found a reasonable degree of short-run capital mobility in 27 African countries. However, our finding should be interpreted with caution as it might primarily reflect commodity price fluctuations and foreign aid inflows rather than sustained financial integration (Ilorah 2008; International Monetary Fund 2018). Finally, South Asia stands apart with a moderate level of short-run mobility (0.38), reflecting the region's persistent financial market constraints relative to other emerging market regions.

Table 4 also presents the values of the error-correction terms, which reflect the extent of long-run capital mobility. All the estimated coefficients are negative and statistically significant. The error-correction terms of –0.28 and –0.32 indicate that 28% and 32% of the disequilibrium are corrected within the first year in ECA and EAP countries, respectively. Interestingly, the relatively slower speed of adjustment implies higher long-run capital mobility. This reflects the ability of these economies to sustain external imbalances over extended periods, supported by access to deep and liquid international capital markets. In the MENA and SA regions, 34% and 38% of the disequilibrium are adjusted during the first period, respectively. The adjustment coefficients of –0.41 and –0.46 indicate that almost 50% of the disequilibrium is resolved within the first year in the SSA and LAC regions. The faster adjustment in these regions reflects lower long-run capital mobility due to financial market constraints that force quicker current account corrections when external imbalances become unsustainable. The estimates indicate that the longest adjustment process is in ECA and EAP countries, whereas the shortest correction period is found in the SSA and LAC regions. The results imply that the former two regions exhibit the highest degree of long-run capital mobility. This finding aligns with economic theory as these regions, comprising mostly developed economies, are characterized by lower capital constraints, better integrated financial markets, stronger institutional frameworks, and higher investor confidence (Younas and Chakraborty 2011; Ketenci 2013; Dash 2019).

The panel error-correction model has also been re-estimated using alternative approaches: Mean Group (MG), Pooled Mean Group (PMG), and Dynamic Fixed Effects (DFE) estimators. The results are presented in Appendix C. Given the results in Tables 4 and 7, it can be concluded that the coefficients estimated with the alternative approaches are generally higher than the coefficients obtained with the DCCEMG estimator. However, the former results should be treated with caution since the alternative approaches are not able to properly account for cross-sectional dependence. Table 8 summarizes the estimates of the CD test applied to the residuals of the four models estimated with the DCCEMG and three alternative approaches. The results indicate that none of the alternative approaches can account for cross-sectional dependence. On the other hand, the CD-statistic results for the DCCEMG model imply that the originally chosen estimator is able to account for cross-sectional dependence. Thus, the results further confirm the choice of the DCCEMG estimator over the traditional estimators.

Rolling-windows analysis

A rolling-window analysis was conducted to examine how both capital mobility and CAD sustainability have evolved over the analyzed period. Figure 2 presents DCCEMG panel estimation results with 30-year rolling windows. Both short- and long-run capital mobility follow a similar trend in the analyzed regions. Capital mobility decreases or remains relatively low in the 1980s, which is later followed by a steady increase in the 1990–2000s. This evolution reflects the era of financial globalization, which was characterized by capital account liberalization, financial innovation, and the development of new instruments that enabled better risk distribution (Quinn 2003). Both short- and long-run capital mobility reached their peaks prior to the financial crisis of 2007–2008. Moreover, regions comprising mostly developed economies (ECA and EAP) performed relatively better than the rest of the regions. This finding reflects their deeper financial markets, stronger institutional frameworks, and better integration into global financial networks (Nasreen et al. 2020; Nasreen, Mbarek, and Atiq-ur-Rehman 2020).

The results are in line with the stylized facts formulated by Lane and Milesi-Ferretti (2007) and Milesi-Ferretti and Telli (2011), who examined the evolution of financial globalization for 145 economies over the period 1970–2004. They found that starting from the 1990s, there was a rapid increase in the scale of gross asset trade with a noticeable acceleration in the speed of financial deepening in the 2000s. Lane and Milesi-Ferretti (2007) further showed that developed economies experienced greater capital mobility intensity than developing economies. Drakos et al. (2017) and Khan (2017) arrived at a similar conclusion about the evolution of capital mobility over time. They found that the saving-retention coefficient declined prior to the crisis of 2007–2008, signaling an increase in the degree of capital mobility.

The rolling-window results for short-run coefficients and error-correction terms show a significant decrease in both short- and long-run capital mobility between 2008 and 2009. The decrease in capital flows can be attributed to the reduction in the proportion of assets invested abroad and a retrenchment towards domestic assets (Lane and Milesi-Ferretti 2018). In the post-crisis period, short-run capital mobility continued to decrease in all regions. The explanation for a continuous drop in capital flows lies in the increased risk aversion, which resulted in a stronger home bias and more capital controls (Lane and Milesi-Ferretti 2018). Similar findings by But and Morley (2017) and Duran and Ferreira-Lopes (2022) linked decreased short-run capital mobility with rising home bias in investor portfolios.

In contrast, the estimates of the error-correction term suggest that long-run capital mobility had started recovering by the end of the analyzed period, except for MENA and SA. These findings could reflect the effects of policy responses taken by domestic and international entities, including currency swaps between central banks, the use of foreign exchange reserves, and loans from multilateral organizations (Milesi-Ferretti and Telli 2011).

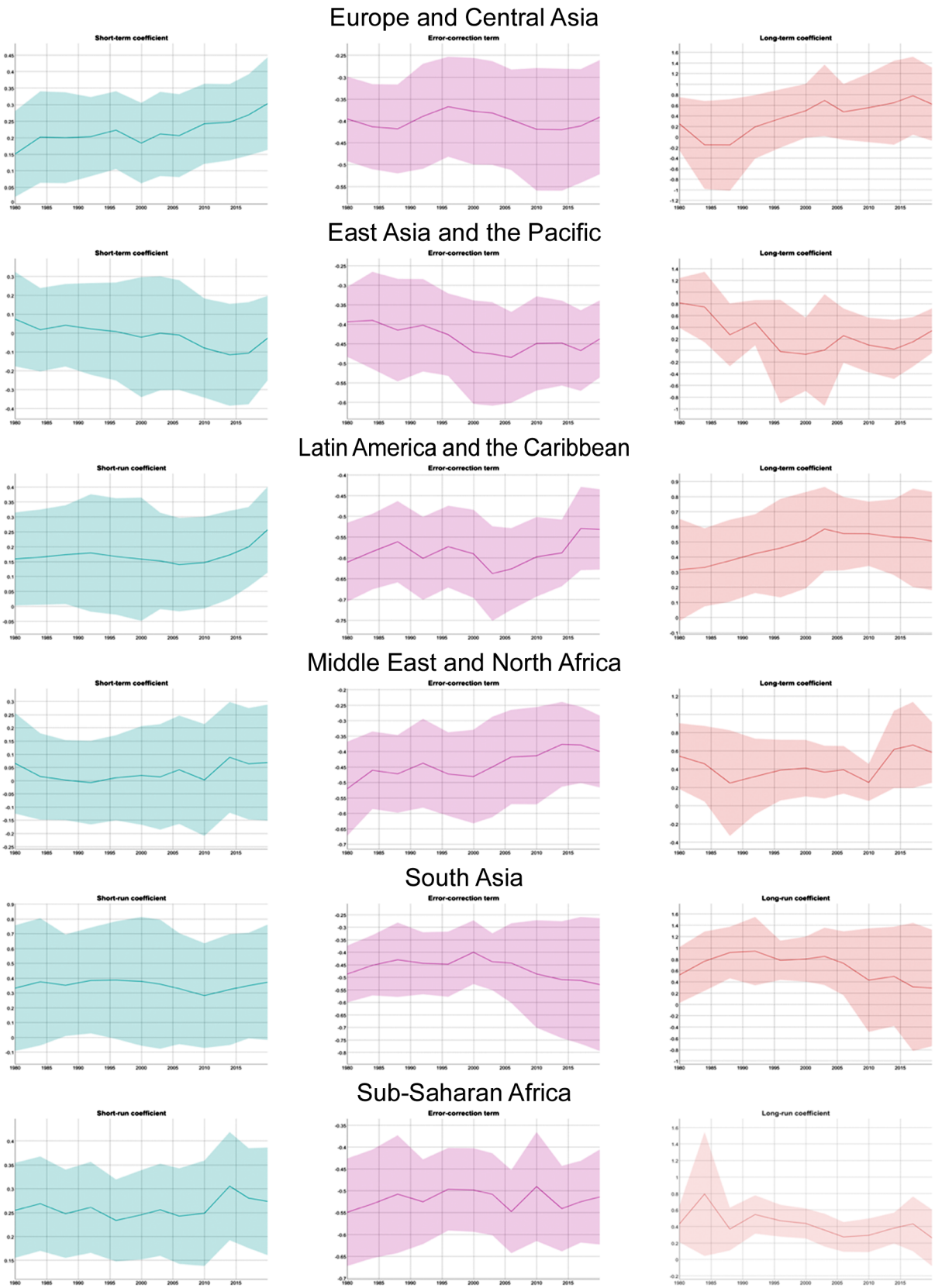

Figure 2. Rolling-window analysis

Source: own calculations.

The degree of CAD sustainability follows a similar trend to that of capital mobility. Prior to the financial crisis of 2007–2008, CAD sustainability steadily increased in all regions, reaching a peak in 2007–2008. Post-crisis, all country groups experienced a significant decrease in CAD sustainability, which was later followed by a moderate improvement in the long-run coefficient (ECA and EAP) or a continuous decline in CAD sustainability (LAC, MENA, SA, and SSA). This divergence could reflect the fact that advanced regions (ECA and EAP) have stronger institutional frameworks and diversified economies while developing regions face persistent constraints from limited export diversification, institutional weaknesses, and continued dependence on volatile external financing sources.

Policy implications

The prevalence of weak CAD sustainability across most regions, combined with varying capital mobility patterns, constrains macroeconomic policy space. Weak sustainability constrains policy space by limiting fiscal policy flexibility, as additional government borrowing could push external imbalances beyond sustainable levels, particularly in high-deficit regions like Sub-Saharan Africa and Latin America and the Caribbean (Reinhart and Rogoff 2010). It also forces central banks to balance domestic objectives with external stability concerns (Rey 2015).

Policy approaches should be regionally tailored, given the heterogeneous nature of sustainability and capital mobility patterns. Developed economies with high capital mobility (Europe and East Asia) should implement countercyclical capital buffers and flexible exchange rate frameworks while using selective capital controls during excessive inflow episodes (Ostry et al. 2010; Frost, Ito, and van Stralen 2020). Emerging markets in Latin America, the Middle East and North Africa, and South Asia should deepen domestic bond markets, improve governance structures to attract stable capital flows, and build adequate foreign exchange reserves as buffers during periods of stress (Milesi-Ferretti and Telli 2011; Filip, Momferatou, and Parraga Rodriguez 2025). Meanwhile, low-income regions like Sub-Saharan Africa should prioritize export diversification to reduce commodity dependence, selective capital account liberalization favoring foreign direct investment over volatile portfolio flows, and policies aimed at increasing domestic savings (McIntyre et al. 2018; Delechat et al. 2024).

Across all regions, improving CAD sustainability requires fiscal rules that incorporate external balance targets, managed exchange rate flexibility, and macroprudential tools to manage capital flow volatility (Ghosh, Ostry, and Qureshi 2015; Frost, Ito, and van Stralen 2020). Countries must diversify their exports to reduce the effects of commodity price fluctuations, develop domestic financial markets to boost local savings, and strengthen institutions to improve investor confidence (Kose et al. 2017; McIntyre et al. 2018; Tang, Zhou, and Liu 2020). Experience from past crises shows the importance of implementing macroprudential regulations to control volatile capital flows, maintaining sufficient foreign exchange reserves, and establishing early warning systems for emerging vulnerabilities (Lane and Milesi-Ferretti 2018; Frost, Ito, and van Stralen 2020).

Conclusions

This study investigated the degree of capital mobility and current account sustainability across six regional groups of countries using the DCCEMG estimator. The findings reveal that current account deficits are only weakly sustainable in all regions, with long-run coefficients ranging from 0.35 to 0.57. In the short run, capital mobility is perfect in the East Asia and Pacific and Middle East and North Africa regions, while it is only moderate in others. Over the long run, capital mobility is highest in Europe and Central Asia, along with East Asia and the Pacific.

The rolling-window analysis reveals that the 2007–2008 global financial crisis significantly reduced both capital mobility and current account sustainability across all regions. The post-crisis recovery has been uneven: while long-run capital mobility has gradually improved in developed regions, it remains weak in emerging markets, and short-run capital mobility has continued to decline overall.

Given these heterogeneous patterns, policy implications need to differ across regions. High-mobility economies (Europe and East Asia) should use countercyclical capital buffers and flexible exchange rates. In contrast, emerging markets (Latin America, the Middle East, and South Asia) would benefit from deeper domestic bond markets and higher foreign exchange reserves. Low-income regions (Sub-Saharan Africa) should diversify exports and prioritize foreign direct investment over volatile portfolio flows.

Building on these findings, future research should extend the analysis to conduct country-specific studies within regions to explain intra-regional heterogeneity. Additionally, it should explore the effectiveness of specific capital control measures on the estimated coefficients.

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Appendix A

Table 5. Properties of saving, investment and CAD (% of GDP) for each category

Categories	S/Y	I/Y	CAD/Y
East Asia and Pacific (EAP)	29.92%	29.06%	0.86%
Europe and Central Asia (ECA)	22.24%	23.22%	– 0.98%
Latin America and Caribbean (LAC)	17.54%	21.55%	– 4.01%
Middle East and North Africa (MENA)	26.43%	28.21%	1.32%
South Asia (SA)	26.34%	28.06%	– 1.72%
Sub-Saharan Africa (SSA)	15.29%	21.77%	– 6.48%

Source: own calculations, World Bank, World Development Indicators 2022a; 2022b.

Appendix B

Table 6. Individual long-run coefficients results

Country	Value	Country	Value	Country	Value	Country	Value
Europe and Central Asia							
Albania	0.65	Finland	0.12	Italy	0.14	Romania	0.45
Austria	0.24	France	0.77	Netherlands	0.48	Spain	0.37
Belgium	0.40	Germany	0.44	Norway	0.33	Sweden	0.75
Bulgaria	0.75	Greece	0.53	Poland	0.47	Turkey	0.63
Cyprus	0.43	Hungary	0.02	Portugal	0.52	United Kingdom	0.11
Denmark	0.12	Iceland	0.14				
East Asia and Pacific							
Australia	0.47	Japan	0.80	Mongolia	1.09	Singapore	0.56
China	0.88	South Korea	0.44	New Zealand	0.72	Thailand	0.64
Hong Kong	0.52	Malaysia	0.68	Philippines	0.01	Vietnam	0.09
Indonesia	0.53						
Latin America and Caribbean							
Argentina	0.11	Costa Rica	0.52	Haiti	0.53	Panama	0.38
Bolivia	0.12	Dominican Republic	0.23	Honduras	0.54	Paraguay	0.02
Brazil	0.48	Ecuador	0.54	Jamaica	0.26	Peru	0.22
Chile	0.49	El Salvador	0.50	Mexico	0.17	Uruguay	0.43
Colombia	0.51	Guatemala	0.58	Nicaragua	0.04		
Middle East and North Africa							
Algeria	0.27	Israel	0.44	Malta	0.50	Saudi Arabia	0.29

Country	Value	Country	Value	Country	Value	Country	Value
Bahrain	0.58	Jordan	0.23	Morocco	0.71	Tunisia	0.57
Egypt	0.45	Kuwait	0.13	Oman	0.21		
South Asia							
Bangladesh	0.35	India	0.57	Pakistan	0.20	Sri Lanka	0.50
Bhutan	0.28	Nepal	0.46				
Sub-Saharan Africa							
Angola	0.25	Eswatini	0.31	Mali	0.58	South Africa	0.53
Benin	0.59	Gambia	0.57	Mauritania	0.46	Sudan	0.63
Botswana	0.38	Ghana	0.42	Niger	0.25	Tanzania	0.52
Burkina Faso	0.61	Guinea	0.26	Nigeria	0.62	Togo	0.40
Cameroon	0.59	Guinea-Bissau	0.43	Senegal	0.32	Uganda	0.36
Comoros	0.30	Kenya	0.38	Seychelles	0.44		
Congo	0.42	Madagascar	0.47	Sierra Leone	0.55		

Source: own calculations.

Appendix C

Table 7. Robustness check: MG, PMG and DFE panel estimation results

	MG	PMG	DFE
Europe and Central Asia			
Long-run coef. (β_1)	0.67*** (*WD* = 0.5)	0.67*** (*WD* = 22.9***)	0.64*** (*WD* = 25.9***)
Short-run coef. (δ)	0.34***	0.33***	0.29***
EC term (λ)	−0.21***	−0.19***	−0.21***
Intercept (β_0)	0.01	0.02***	0.03***
East Asia and Pacific			
Long-run coef. (β_1)	0.50*** (*WD* = 12.6***)	0.70*** (*WD* = 13.8***)	0.40*** (*WD* = 15.8***)
Short-run coef. (δ)	0.19***	0.21***	0.15***
EC term (λ)	−0.23***	−0.20***	−0.17***
Intercept (β_0)	0.03***	0.02***	0.03***
Latin America and Caribbean			
Long-run coef. (β_1)	0.48*** (*WD* = 29.9***)	0.48*** (*WD* = 124.8)	0.46*** (*WD* = 0.7)
Short-run coef. (δ)	0.22***	0.21***	0.22***
EC term (λ)	−0.40***	−0.35***	−0.36***
Intercept (β_0)	0.05***	0.05***	0.05***

	MG	PMG	DFE
Middle East and North Africa			
Long-run coef. (β_1)	0.49*** (*WD* = 21.2***)	0.34*** (*WD* = 162.5***)	0.06 (*WD* = 435.0***)
Short-run coef. (δ)	0.1	0.08	−0.06***
EC term (λ)	−0.34***	−0.30***	−0.30***
Intercept (β_0)	0.04	0.05***	0.07***
South Asia			
Long-run coef. (β_1)	0.69*** (*WD* = 5.9**)	0.68*** (*WD* = 27.6***)	0.49*** (*WD* = 27.9***)
Short-run coef. (δ)	0.46***	0.44***	0.36***
EC term (λ)	−0.30***	−0.25***	−0.27***
Intercept (β_0)	0.03*	0.03***	0.04***
Sub-Saharan Africa			
Long-run coef. (β_1)	0.47*** (*WD* = 20.5***)	0.86*** (*WD* = 10.4***)	0.54*** (*WD* = 41.9***)
Short-run coef. (δ)	0.26***	0.29***	0.21***
EC term (λ)	−0.37***	−0.27***	−0.30***
Intercept (β_0)	0.05***	0.02***	0.04***

*, ** and *** denote 10%, 5% and 1% significance levels, respectively. WD stands for the Wald statistic, which checks the following null hypothesis: β_1=1.

Source: own calculations.

Table 8. CD test results

	DCCEMG	MG	PMG	DFE
ECA	1.21*	15.87***	15.92***	16.43***
EAP	−0.78	6.83***	7.41***	6.45***
LAC	−0.65	11.50***	11.55***	11.71***
MENA	−0.67	2.12**	1.99**	2.16**
SA	1.83*	2.87***	2.86***	2.36**
SSA	−0.88	1.12	1.70*	2.21**

*, ** and *** denote 10%, 5% and 1% significance levels, respectively. Pesaran's (2014) test for cross-sectional dependence (CD) follows a standard normal distribution and checks the null hypothesis of weakly cross-sectionally dependent errors.

Source: own calculations.

Związek oszczędności i inwestycji na nowo: mobilność kapitału a trwałość deficytu na rachunku obrotów bieżących

Celem artykułu jest analiza trwałości deficytu na rachunku obrotów bieżących oraz mobilności kapitału na podstawie danych z panelu obejmującego 97 krajów w latach 1980–2020. W badaniu przyjęto nowatorską interpretację współczynnika Feldsteina-Horioki w kontekście oceny trwałości deficytu, jednocześnie analizując relację między oszczędnościami a inwestycjami przy użyciu estymatora Dynamic Common Correlated Effects Mean Group (DCCEMG). Wyniki wskazują, że we wszystkich analizowanych grupach krajów deficyt na rachunku obrotów bieżących cechuje się jedynie „słabą" trwałością. Szacunki krótkookresowych współczynników sugerują wysoką mobilność kapitału w krótkim okresie, podczas gdy w perspektywie długookresowej mobilność ta pozostaje umiarkowana lub niska. Analiza z wykorzystaniem metody okna ruchomego wykazała, że w trakcie kryzysu lat 2007–2008 nastąpił istotny spadek zarówno mobilności kapitału, jak i trwałości deficytu. W okresie pokryzysowym krótkookresowa mobilność kapitału oraz trwałość deficytu wykazywały tendencję spadkową w większości regionów, podczas gdy mobilność kapitału w długim okresie stopniowo się odbudowywała. Przeprowadzona analiza regionalna, obejmująca sześć głównych obszarów świata, wnosi istotny wkład do literatury, ukazując zmieniające się uwarunkowania międzynarodowych przepływów kapitałowych oraz różnice regionalne w zakresie równowagi zewnętrznej.

Słowa kluczowe: zależność między oszczędnościami a inwestycjami, mobilność kapitału, trwałość rachunku obrotów bieżących, zagadka Feldsteina-Horioki, DCCEMG

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Enhancing Resilience in International Supply Chains: The Role of Sustainable Development in a VUCA World

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Abstract

In today's VUCA (Volatility, Uncertainty, Complexity, Ambiguity) world, which exerts strong pressure on international and global supply chains, academia and business are actively seeking new strategies to foster their sustainable and uninterrupted development. The results of our study, using statistical methods such as analysis of variance, show that the implementation of sustainable development principles in supply chain management positively affects the resilience of supply chains to sustainability risk across the pre-disruption, during-disruption and post-disruption phases. This, however, is contingent on a process-based approach to supply chain management and a high level of managerial awareness of the various types of risks to supply chains. Furthermore, our findings confirm that the key organizational characteristics are significant determinants of this resilience. Specifically, we observed that company size, the origin of the capital, and the degree of internationalization all affect supply chain resilience across the three disruption phases. Sustainable and resilient (SUS-RES) supply chains, which employ proactive, concurrent, and reactive approaches, are particularly noticeable in the supply chains of large enterprises with foreign capital or foreign branches. This suggests that managing international supply chain sustainably can also improve their resilience.

Keywords: sustainability risk, sustainable resilience, international supply chain, process orientation, SCRES, SUS-RES supply chain, VUCA world

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Introduction

Every day, companies face challenges that test their ability to operate effectively under volatile and uncertain conditions. The international environment, which is often linked to the volatility of external factors such as economic, political, legal, social, and environmental influences, increases this uncertainty. The level of risk is also heightened by the number and nature of supplier-customer relationships, which determine the complexity of the supply chain structure. Decisions made within this network often lead to uncertain outcomes and unpredictable costs. The VUCA (volatility, uncertainty, complexity, ambiguity) world presents a challenging environment in which existing strategies, practices, and traditional thinking in businesses often prove ineffective (Sinha and Sinha 2020). Therefore, understanding the operational context and adopting a tailored approach to building supply chain resilience (SCRES) is essential (Kazancoglu et al. 2022; Hong et al. 2023).

Supply chain risk management (SCRM) has become an urgent challenge for many companies, especially in terms of sustainability risk management. Risk management in a value chain can be seen as a burden for companies, but sustainable development in supply chains can enhance their resilience. There are clear interdependencies between resilience and sustainability. Combining both areas can transform supply chain management. Therefore, researchers are investigating the relationship between sustainable development and SCRES (Jabbarzadeh, Fahimnia, and Sabouhi 2018; Negri et al. 2021). Numerous studies confirm that resilience positively impacts sustainability. For instance, Jabbarzadeh, Fahimnia, and Sabouhi (2018) found that resilience strategies can minimize expected costs and maximize overall sustainability performance during disruptions.

Although studies on the reverse relationship are less common, interest in them is growing. Sabouhi, Jabalameli, and Jabbarzadeh (2021) developed a methodology for designing a sustainable supply chain resilient to random disruptions, while Eggert and Hartmann (2023) observed the positive effects of sustainable supply chain management on readiness and recovery post-disruptions. Research on the impact of sustainability on resilience still does not sufficiently address sustainable supply chain management from a process-oriented and international perspective, nor does it consider resilience to sustainability risks before, during, and after disruptions.

Enhancing resilience in the context of sustainable development and the VUCA world is critically important in the current global context. Therefore, this article is an important contribution to the discussion on the relationships between sustainability and resilience and on the possibilities of building sustainable and resilient (SUS-RES) supply chains. The aim of this paper is to examine the impact of sustainability on international SCRES in the context of sustainability risk and three disruption phases. To achieve this objective, the paper discusses specific relationships formulated in four research hypotheses. Mainly, it analyzes whether and how the implementation of sustainability principles in supply chain processes affects SCRES to sustainability risks in three phases of disruption. Furthermore, the study considers how specific company characteristics, such as size, origin of capital, and degree of internationalization, can affect this resilience.

To verify our hypotheses, we conducted a quantitative study among manufacturing enterprises in the Polish market with a national or international supply chain. Statistical analysis led to significant conclusions, offering both theoretical and practical implications for building SUS-RES supply chains in the international context.

The article constitutes a significant contribution to the ongoing discourse for three main reasons. Firstly, sustainable development is a strategy of global importance, as emphasized by the United Nations 2030 Agenda for Sustainable Development, which defines 17 Sustainable Development Goals. This underscores the need for international enterprises to increasingly integrate sustainability aspects into supply chain management.

Secondly, legal, political, economic, and social factors – including non-financial reporting and ESG requirements – strongly drive the adoption of sustainability principles. It is essential to explore whether and how this implementation positively influences business operations and the development of resilient supply chains. Research that identifies and highlights the impact of implementing sustainability principles is crucial for building resilient and sustainable supply chains in the VUCA world. A novel aspect of this study is its focus on the impact of sustainability on SCRES, particularly before, during, and after disruptions occur.

Thirdly, the research was conducted between September 5 and 16, 2022 – a critical period for both the economy and society, as well as for the development of resilient international supply chains – shortly after the COVID-19 pandemic and the outbreak of the war in Ukraine. These events had a profound impact on the stability of supply chains, especially those of international manufacturing companies, whose operations depend on global access to resources and markets. The findings may support enterprises in making strategic decisions related to implementing sustainability to build resilient and sustainable supply chains. Existing research does not sufficiently account for the perspective of building SUS-RES supply chains across pre-, during- and post-disruption phases, specifically among manufacturing companies within the period studied.

The article comprises a theoretical and an empirical part. The first section presents the theoretical background, drawing on findings from the existing literature on SUS-RES supply chains. The subsequent sections outline the hypotheses development and the research methodology, and present and discuss the results of the study.

Theory background

Sustainable development principles in international supply chains

Sustainability principles are being implemented in business, in the context of innovation and improved stakeholder relations (Laszlo and Zhexembayeva 2011). Supply chain management models are being developed to meet competing needs, reduce Zhexembayeva negative environmental impacts, and ensure positive impacts on stakeholders and beneficiaries, which is explicitly linked to the implementation of sustainability principles. The integration of sustainability principles in supply chains is becoming increasingly common (Feng, Zhu, and Lai 2017). Supply chain

management has the potential to reduce resource consumption while sustainability principles are consistently implemented as part of business strategies (Yakovleva, Frei, and Murthy 2019).

Sustainable supply chain management has been a key area of focus due to growing environmental concerns, regulatory pressures, and stakeholder expectations (Maghsoudi et al. 2023). A sustainable supply chain strategy is defined in relation to the triple-bottom line (TBL) end result and its three elements: economic, environmental, and social (Vergara, Martínez, and Salais-Fierro 2023). It is increasingly important to create a business that is based on the principles of sustainability while remaining resilient to disruptions that occur (Bals et al. 2019). The supply chain contributes to economic development while maintaining business profitability (Dahlsrud 2008), caring for the environment, and ensuring proper ecological balance (Sufiyan et al. 2019). It also considers the relationship between business and society (Dahlsrud 2008). These dimensions are not merely theoretical; they are a consequence of growing social pressure from governments and competitors, as well as political conditions. This clearly indicates that in logistics operations, supply chain links must prioritize social and environmental impacts (Al-Swidi, Hair, and Al-Hakimi 2023).

Key areas include optimizing energy consumption, reducing emissions, ethical working practices, the principles of the circular economy, and managing stakeholder relationships throughout the value chain (Hofstetter et al. 2021). A genuine commitment to sustainable development involves adopting strategies that deliver economic, social, and environmental benefits, and responsibly using resources for future generations (Rahimi, Maghsoudi, and Shokouhyar 2024). Sustainable business models are increasingly recognized as sources of competitive advantage (Ebinger and Omondi 2020). Sustainable supply chains support resilience building and help deal with uncertainty (El Sayed and Baky 2023). The risk of disruption in supply chain networks requires considering risk and variability throughout the design of resilient systems (Lee 2022). Addressing these challenges is essential to continue developing the sustainability aspect of international supply chains. Organizations need to be proactive in this context. There is also a growing awareness among companies, indicating that sustainable business practices support effective risk management while meeting growing customer expectations (Mirzaei and Shokouhyar 2023).

Sustainable supply chain risk and resilience

Risks to the sustainable development of supply chains encompass environmental, social and economic dimensions (Xu et al. 2019). Each of the triple bottom line dimensions can be related to both exogenous and endogenous events (Giannakis and Papadopoulos 2016). The general classification of sustainable supply chain risks can also be broadened to include operational risk (Christopher and Gaudenzi 2015), institutional risk, and technical risk (Moktadir et al. 2021), or even more risk categories (Wang and Rani 2022). Regardless of the scope, the predictability of the probability and effects of environmental, social, and economic risks can vary widely, from "known knowns," for which traditional statistical models can be applied, to black swan events and "unknowable unknown" scenarios that go beyond the knowledge of managers.

Sustainability risks can disrupt information, goods and financial flows, negatively impacting internal and external supply chain stakeholders. Therefore, a comprehensive risk management process becomes a key approach for achieving supply chain sustainability (Giannakis and Papadopoulos 2016). Sustainable supply chain risk management involves identifying events that may hinder the achievement of sustainable development goals, as well as risk measurement, risk evaluation, risk treatment, risk monitoring, and control (Tundys et al. 2024, p. 96). Nowadays, cooperative risk management, particularly cultivating a risk-aware culture, is one of the most important elements of supply chains that aim to be resilient to effectively operate in the VUCA world (Hohenstein et al. 2015).

SCRES is "the supply chain's ability to be prepared for unexpected risk events, responding and recovering quickly to potential disruptions to return to its original situation or grow by moving to a new, more desirable state in order to increase customer service, market share, and financial performance" (Hohenstein et al. 2015). In recent years, the interplay between sustainability and SCRES has become increasingly evident. For example, research confirms the positive impact of resilient strategies on economic and environmental sustainability (Singh, Hamid, and Garza-Reyes 2023). Likewise, sustainable development practices have also been shown to have a positive impact on SCRES (Tundys et al. 2024, pp. 137–142). Thus, building SUS-RES supply chains can yield significant benefits for companies.

Hypothesis development

Supply chain processes, sustainability risk, and supply chain resilience

The process approach to supply chain management is recognized as a best practice and is embodied in two main supply chain management reference models: the Global Supply Chain Forum (GSCF) framework (Lambert and Cooper 2000; Croxton et al. 2001) and the Supply Chain Operations Reference (SCOR) framework (APICS 2017). Research suggests that applying these models can have significant sustainable economic and environmental benefits, particularly in collaborative manufacturing networks (Siong Kuik, Verl Nagalingam, and Amer 2011).

The characteristics of the VUCA world underscore the critical need for robust and adaptable supply chain processes. Managing these processes in volatile and uncertain environments requires not only efficiency but also a proactive approach to understanding potential risks, where sustainability becomes an important framework for building more resilient supply chains (Malindretos and Binioris 2014; Negri et al. 2021; Shishodia et al. 2023). Eggert and Hartmann's (2023) detailed study confirmed that higher intensity in sustainable supply chain management increases readiness for disruptions, and that greater experience with sustainable supply chain management leads not only to increased readiness but also faster recovery after disruption.

Furthermore, the extensive literature on the subject indicates that risk management awareness and culture are important elements of building both proactive and reactive SCRES strategies (Hohenstein et al. 2015; Ali, Mahfouz, and Arisha 2017; Um and Han 2021). Some research also suggests that the risk management process is crucial for effective, sustainable supply chain management (Giannakis and Papadopoulos 2016; Wang, Cheng, and Wang 2022; Tundys et al. 2024, p. 96).

Against the background of previous research, it is valuable to see how implementing sustainable development principles in specific supply chain management processes affects SCRES, particularly in proactive, concurrent, and reactive strategies.

Therefore, the following hypothesis is proposed:

H1: Implementing the principles of sustainable development in supply chain processes affects supply chain resilience to sustainability risks in the pre-disruption, during-disruption and post-disruption phases.

Company size and supply chain resilience

Significant differences in supply chain management approaches between Small and medium-sized enterprises (SMEs) and large companies have been noted, primarily related to awareness and the feasibility of implementing similar solutions (Ramakrishna 2016). SMEs tend to focus less on planning and control methods than large companies, which may hinder their ability to address supply chain challenges (Vaaland and Heide 2007).

In the context of a VUCA world, the impact of company size on SCRES becomes even more pronounced. While large enterprises might have more resources to invest in resilience and sustainability, SMEs may have greater flexibility in adapting to external changes. As companies grow and become increasingly internationalized and global (Di Paola, Cosimato, and Vona 2023), their external environment changes and the complexity of their supply chains increases, making managing risk and uncertainties more demanding.

Research has identified differences between small, medium and large companies in areas such as risk awareness, supplier and customer relationship management, and the types of risk controls implemented (Wieteska 2011a; 2011b). For SMEs, collaboration is a key capability to deal with supply chain risk (Alzate et al. 2022). However, comparative research on supply chain management between small, medium, and large companies remains limited (Ramakrishna 2016). Thus, further analysis of these differences in relation to resilience and sustainability is warranted.

Therefore, the following hypothesis is proposed:

H2: Company size affects supply chain resilience to sustainability risks in the pre-disruption, during-disruption and post-disruption phases.

Company internationalization and supply chain resilience

The need to enhance the resilience of international supply chains is increasingly being captured in the concept of the VUCA world. A VUCA environment, which is characterized by unpredictable and rapid changes spreading to different countries, profoundly impacts global operations. Global supply chains are particularly vulnerable to the variability of a diverse international environment (Di Paola, Cosimato, and Vona 2023). However, global supply chains also offer better opportunities for effective risk management through strategies such as diversification and flexibility (Manuj and Mentzer 2008; Chu, Park, and Kremer 2020). Um and Han (2021) further observed that resilient strategies can efficiently mitigate global supply chain risks.

The challenges inherent in a VUCA world, such as geopolitical risks, climate-related events, and pandemics, require international supply chains to not only become resilient but also to proactively implement sustainability to manage multifaceted threats (Cavusgil et al. 2021; Wieland 2021). Therefore, international and global supply chains are expected to lead in implementing risk and resilience management. Thus, enterprises that are part of international corporations are often the source of best practices in SCRM (Tang, Zimmerman, and Nelson 2009).

However, following the COVID-19 pandemic, supply chain managers began to consider returning to domestic and local supply networks and manufacturing systems (Ivanov 2021). Additionally, the severity of the war in Ukraine has shown that having foreign suppliers and customers is risky, potentially disrupting the continuity of manufacturing processes and delivering products and services (Tundys et al. 2004, pp. 108–113). The consequences of such disruptions may be exacerbated by single sourcing strategies and locating suppliers in one geographical area (Norrman and Jansson 2004; Haraguchi and Lall 2015).

In light of the concerns regarding whether the supply chains of domestic or international companies achieve better resilience today, the following two hypotheses are proposed:

H3: The origin of capital affects supply chain resilience to sustainability risks in the pre-disruption, during-disruption and post-disruption phases.

H4: Internationalization affects a company's supply chain resilience to sustainability risks in the pre-disruption, during-disruption and post-disruption phases.

Methodology

To operationalize the designed approach, each of the three research areas was expressed through appropriate variables (Figure 1). The measurement of sustainable supply chain management using a process approach was developed based on supply chain business processes outlined in the GSCF model (Croxton et al. 2001). Five types of sustainable development risk, as presented by Moktadir et al. (2021), were adopted, and we followed Ali, Mahfouz, and Arisha (2017) understanding of SCRES and the SCRES framework. The framework is based on proactive, concurrent and reactive strategies that require the development of several supply chain capabilities to achieve SCRES: the ability to anticipate in the pre-disruption phase, to adapt and respond during the disruption phase, and to recover and learn in the post-disruption phase.

The study employed a proprietary questionnaire, with items developed by the authors and inspired by a review of the relevant literature. The questionnaire underwent validation through a pilot study conducted prior to the main survey, with feedback and revisions resulting from the pilot phase incorporated into the final version.

This study introduces a novel, process-oriented analytical framework that integrates sustainable supply chain management (SSCM) principles with resilience capabilities across the entire disruption lifecycle: the pre-disruption, during-disruption, and post-disruption phases. Unlike prior research that predominantly emphasizes either readiness or recovery, our approach enables

a multidimensional assessment of resilience that is rooted in the operationalization of sustainability across core supply chain processes.

The empirical design is based on a large-scale, stratified sample of 550 international and domestic manufacturing firms in Poland. It incorporates capital origin and internationalization dimensions, which remain underexplored in the extant literature. Furthermore, by aligning the GSCF process model with sustainable development risk typologies and SCRES capabilities, the study offers a unique methodological synthesis that bridges conceptual gaps between sustainability and resilience. This integrative perspective contributes to the international discourse by empirically substantiating how embedded sustainability practices condition resilience-building mechanisms in global supply chains operating under VUCA pressures.

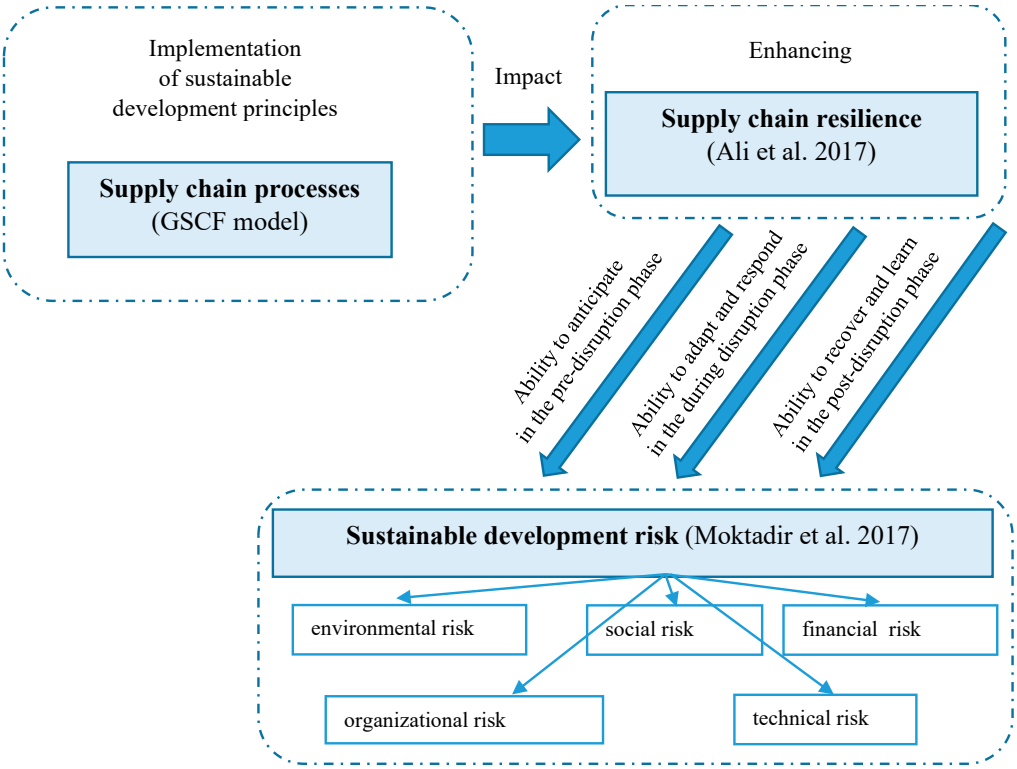

Figure 1. Research framework

Source: own study.

The survey covered 550 manufacturing companies operating in Poland, spanning a range of sizes and sectors, and active in both domestic and international markets. The ownership structure of the participating enterprises was diverse: 69% were domestically owned, 21% had foreign ownership, and 10% had mixed capital. Additionally, 32% of the companies reported having foreign branches, while 68% operated solely within Poland.

The sample was selected using a quota-based sampling method supported by purposive selection, reflecting the structural characteristics of the target population. Recruitment was conducted in collaboration with a professional research agency that maintains an extensive B2B contact database. Key eligibility criteria – including company size (more than 50 employees) and engagement in SSCM practices – were verified through a pre-screening process conducted by the agency, based on proprietary and validated internal databases. Further, emphasis was placed on ensuring

respondent competence. Only individuals holding top management positions, i.e., CEOs, board members, company owners, or managers responsible for purchasing and supply chain management, were invited to participate. Data collection was conducted using the Computer-Assisted Telephone Interviewing (CATI) method between September 5th and 16th, 2022, with operational support provided by the external research company.

The research instrument addressed all three research areas: sustainable development in supply chain processes, sustainability risk categories, and SCRES to the sustainability risk. The questionnaire was constructed so that each area was represented by statements derived from previous studies, with each statement corresponding to an observable variable measured on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The survey was preceded by preliminary research on a small sample of companies from the relevant sector. The pilot phase aimed to assess the questionnaire's content and clarity of structure and variables. Feedback from this stage was included in the final version of the questionnaire.

Research results

The initial analysis examines how the implementation of sustainable development principles, using a process-oriented approach to supply chain management, affects SCRES to sustainability risks across the pre-disruption, during-disruption and post-disruption phases (hypothesis H1).

To assess this effect, responses from the questionnaire on the impact of implementing sustainability principles in supply chain management processes were analyzed. Responses on a 5-point Likert scale were grouped as follows: 1 and 2 (group NO), 3 (group MODERATE), 4 and 5 (group YES). For the classification of risks to sustainability, we adopted the five categories defined by Moktadir et al. (2021). In the survey, all responses for each risk were averaged to determine resilience for each of the three phases of disruption. The average Likert scale responses for each group are presented in Table 1.

Table 1. Average Likert scale response values in the pre-disruption (anticipate), during-disruption (adapt and respond), and post-disruption (recover and learn) phases, grouped by level of sustainable development implementation

		Supply chain resilience to sustainability risks		
The enterprise implements the principles of sustainable development in the process		ability to anticipate	ability to adapt and respond	ability to recover and learn
Supplier relationship management	YES	3.73	3.83	3.84
	MODERATE	2.87	3.11	3.24
	NO	2.58	3.19	3.29
Customer relationship management	YES	3.82	3.86	3.86
	MODERATE	2.97	3.19	3.25
	NO	2.54	3.22	3.41

		Supply chain resilience to sustainability risks		
The enterprise implements the principles of sustainable development in the process		ability to anticipate	ability to adapt and respond	ability to recover and learn
Customer service management	YES	3.87	3.90	3.90
	MODERATE	3.03	3.14	3.21
	NO	2.50	3.25	3.43
Demand management	YES	3.78	3.89	3.91
	MODERATE	3.00	3.27	3.37
	NO	2.65	3.04	3.11
Order fulfilment	YES	3.79	3.84	3.83
	MODERATE	3.02	3.39	3.49
	NO	2.45	2.93	3.08
Production flow management	YES	3.67	3.85	3.89
	MODERATE	3.03	3.31	3.38
	NO	2.82	2.84	2.83
Returns management	YES	3.92	3.95	3.93
	MODERATE	2.60	3.14	3.28
	NO	3.14	3.32	3.41

Source: own study.

Table 1 shows that companies that implemented sustainability in their processes (the YES group) showed greater resilience to sustainability risks in the pre-disruption, during disruption, and post-disruption phases, as evidenced by higher average response values compared to the MODERATE and NO groups.

To test whether these differences are significant, an analysis of variance (ANOVA) was conducted. ANOVA tests whether there are statistically significant differences between the means of two or more groups (Keselman et al. 1998). However, it does not provide insight into effect sizes or indicate which groups caused the differences to be significant (Murphy, Myors, and Wolach 2003). The groups analyzed are significantly different from each other if the calculated value of the F statistic is greater than the corresponding theoretical F value from the Snedecor distribution for the appropriate number of degrees of freedom at a given level of significance. The results of the ANOVA calculation are shown in Table 2.

Table 2. Results of the analysis of variance for differences between groups with varying levels of sustainable development implementation in terms of their ability to anticipate sustainability risk, adapt and respond, and recover and learn

The enterprise implements the principles of sustainable development in the process	Supply chain resilience to sustainability risks	F	*p*-value
Supplier relationship management	ability to anticipate	81.03794	0.000000
	ability to adapt and respond	51.68529	0.000000
	ability to recover and learn	34.25919	0.000000
Customer relationship management	ability to anticipate	111.1931	0.000000
	ability to adapt and respond	50.9276	0.000000
	ability to recover and learn	33.7942	0.000000
Customer service management	ability to anticipate	134.1918	0.000000
	ability to adapt and respond	63.0524	0.000000
	ability to recover and learn	41.4162	0.000000
Demand management	ability to anticipate	75.00932	0.000000
	ability to adapt and respond	60.44688	0.000000
	ability to recover and learn	48.06144	0.000000
Order fulfilment	ability to anticipate	92.69357	0.000000
	ability to adapt and respond	49.19146	0.000000
	ability to recover and learn	30.75715	0.000000
Production flow management	ability to anticipate	37.68646	0.000000
	ability to adapt and respond	56.23200	0.000000
	ability to recover and learn	55.67761	0.000000
Returns management	ability to anticipate	121.8485	0.000000
	ability to adapt and respond	65.5251	0.000000
	ability to recover and learn	39.3853	0.000000

Source: own study.

Table 2 shows that the F-value is higher than the theoretical value of the test for all the groups studied, while the *p*-value is low (less than 0.05) in each case. This indicates that there are statistically significant differences between companies that implement sustainability in particular processes in their ability to anticipate, adapt and respond, and recover and learn. Thus, hypothesis H1 has been positively verified.

When considered alongside the average results presented in Table 1, it can be concluded that companies with a higher degree of sustainability implementation are capable of managing sustainability risks in the pre-, during- and post-disruption phases. Additionally, Table 2 reveals that, in most cases, the implementation of sustainability principles has the greatest impact on risk anticipation, as indicated by the highest *F* values.

In-depth analyses were conducted to examine the characteristics of the surveyed companies, such as the number of employees, origin of capital, and ownership of foreign affiliates (hypotheses H2–H4). The analyses explored the differences among groups in their ability to anticipate sustainability risks, adapt and respond, and to recover and learn in the post-disruption phase. The average response results for each group are presented in Table 3.

Table 3. Average Likert scale response values in the pre-disruption (anticipate), during-disruption (adapt and respond), and post-disruption (recover and learn) phases by enterprise characteristics

		Supply chain resilience to sustainability risks		
Feature		Ability to anticipate	Ability to adapt and respond	Ability to recover and learn
Number of employees	51–250	3.27	3.47	3.52
	251–500	3.50	3.73	3.78
	over 500	3.66	3.80	3.84
Origin of capital	domestic and foreign	3.32	3.52	3.56
	domestic	3.30	3.49	3.55
	foreign	4.05	4.35	4.34
Ownership of foreign affiliates	Yes	3.52	3.78	3.81
	No	3.32	3.49	3.55

Source: own study.

Table 3 indicates that a company's internationalization influences its resilience to sustainability risks. Specifically, companies with foreign capital, as well as those with foreign affiliates, report higher average responses across all disruption phases compared to companies with domestic or mixed capital. The number of employees also affects SCRES to sustainability risks, with the largest companies demonstrating higher average responses in all three categories. These relationships are further illustrated in the graphs presented in Figure 2, which included 95% confidence intervals.

To confirm the significance of this impact, an analysis of variance was performed. The results are presented in Table 4.

Table 4 shows that, for all groups examined, the F value is higher than the theoretical value of the test, with a low p-value (below 0.05), indicating statistically significant differences between companies in terms of company size, origin of capital, and ownership of foreign affiliates. These findings statistically confirm the results in Table 3 and Figure 2, which highlighted differences in the surveyed companies according to these characteristics. Thus, hypotheses H2, H3 and H4 have been positively verified.

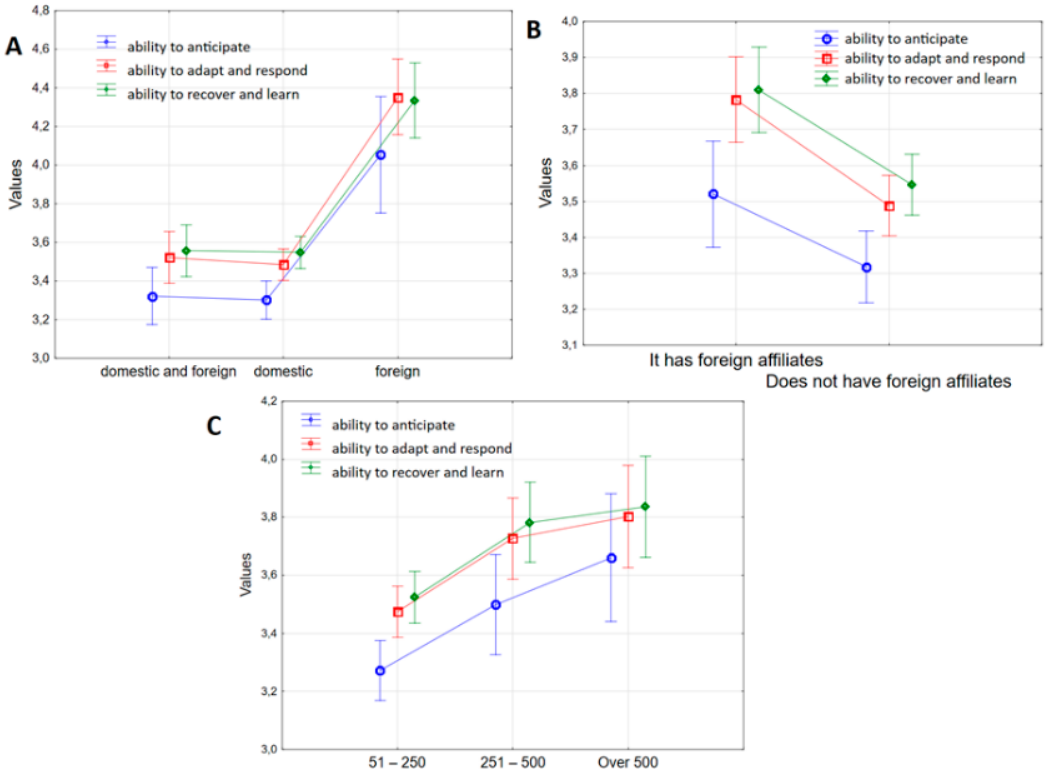

Figure 2. Mean values and 95% confidence intervals for responses in the pre-disruption (anticipate), during-disruption (adapt and respond), and post-disruption (recover and learn) phases by (A) origin of capital, (B) ownership of foreign affiliates, and (C) number of employees.

Source: own study in Statistica software (Statsoft v.13).

Table 4. Results of the analysis of variance examining differences in company size and internationalization on the ability to anticipate sustainability risk, adapt and respond, and recover and learn

Feature	Supply chain resilience to sustainability risks	*F*	*p*-value	Verification of the hypothesis
Number of employees	ability to anticipate	6.427 104	0.001 742	H2 positive
	ability to adapt and respond	7.973 873	0.000 386	
	ability to recover and learn	7.587 000	0.000 562	
Origin of capital	ability to anticipate	15.22 130	0.000 000	H3 positive
	ability to adapt and respond	30.18 192	0.000 000	
	ability to recover and learn	24.27 710	0.000 000	
Ownership of foreign affiliates	ability to anticipate	5.02 982	0.025 313	H4 positive
	ability to adapt and respond	15.60 007	0.000 088	
	ability to recover and learn	12.21 267	0.000 513	

Source: own study using Statistica software (Statsoft v.13).

Discussion

The research results show that implementing sustainability principles enables companies to demonstrate a greater ability to proactively anticipate, adapt to and address crises, and become more resilient to the sustainability risk in the phases before, during and after disruption. This confirmation of H1 aligns with the growing body of literature that underscores the general relationship between sustainability and SCRES (Malindretos and Binioris 2014; Negri et al. 2021; Shishodia et al. 2023).

In line with earlier findings (Shabbir et al. 2021), overlooking the risk of supply chain disruption can result in planning and actions that lack resilience and the ability to deal effectively with disruption, posing a significant risk to the overall supply chain sustainability strategy. Additionally, resilience can be compromised when companies fail to effectively manage supply chain disruptions (Queiroz et al. 2024), which can, in turn, impact the organization's performance. The literature underscores that the connection between resilience and sustainability is essential for long-term success (Ewuga and Adesi 2023; Abdelaziz, Chen, and Dey 2024). This suggests that knowledge and the effective implementation of sustainability principles may be a critical success factor in today's dynamically changing economic environment.

Risk management awareness and a strong organizational culture are crucial for building resilience strategies in the VUCA world (Hohenstein et al. 2015; Ali, Mahfouz, and Arisha 2017; Um and Han 2021). Our findings suggest that integrating sustainability principles into supply chain management fosters such an environment. In stable environments, sustainability measures, such as energy efficiency, resource recycling and environmental management, can help shape and prepare organizations for internal change (Lin and Fan 2024).

However, businesses are increasingly operating in dynamic environments where complex and unforeseen situations, such as sudden changes in environmental pressures, unexpected disruptions to the global supply chain, or changes in market demand (Ekanayake, Shen, and Kumaraswamy 2023), are more likely to arise, requiring appropriate responses. Responding dynamically and effectively to such situations requires stronger resilience and the ability to anticipate, adapt, respond, recover and learn. This can be done by building resilience through practices such as diversifying suppliers, increasing redundancy capacity, and adopting flexible logistics solutions (Silva, Pereira, and Hendry 2023; Li et al. 2025).

Our findings also show that a higher degree of implementation of sustainability principles correlates with greater resilience to sustainability risks for each disruption phase. This finding is particularly significant as it extends the observations of Eggert and Hartmann (2023), who confirmed that greater experience with SSCM translates into faster recovery. While they also noted that greater experience with SSCM translates into faster recovery, our study also demonstrates a comprehensive impact across all disruption phases directly linked to the degree of sustainability implementation. This suggests that the risk management process, deemed crucial for effective SSCM by Giannakis and Papadopoulos (2016), Wang, Cheng, and Wang (2022), and Tundys et al. (2024), is indeed enhanced by sustainability, leading to more robust resilience across the entire disruption lifecycle.

This contrasts with Eggert and Hartmann (2023), who found that the impact of sustainable supply chain management intensity mainly affects readiness, not recovery after disruption.

Sustainability practices in the supply chain aim to minimize negative environmental impacts, improve social conditions and ensure economic efficiency in delivering products and services. These practices include reducing packaging, using recyclable materials, adopting composting, and investing in renewable energy, which limit the need for new resources within the supply chain or allow consumers to upgrade or dispose of products responsibly. In supply management, this extends to sustainable supplier selection (Cui, Wu, and Dai 2023), reducing carbon footprints (Dubisz, Golinska-Dawson, and Kolinski 2023), and minimizing logistics waste (Roozkhosh et al. 2024). Equally important are the use of renewable raw materials, the implementation of a closed-loop economy, and the use of renewable energy sources.

Social responsibility (Zhang et al. 2018) refers to fair labor practices, transparency, and supporting local communities. Technological advances and digitalization, such as blockchain, RFID, and other technologies, also contribute to process optimization and sustainability, allowing tracking and transparency in the chain. Sustainability practices also include obtaining environmental certification and upholding ethical standards (Bubicz, Barbosa-Póvoa, and Carvalho 2019; Zimon, Tyan, and Sroufe 2020; Khan et al. 2021; Abualigah et al. 2023; Nikseresht, Golmohammadi, and Zandieh 2024).

The research also revealed statistical differences between companies that implement sustainability principles in individual processes and their ability to anticipate, adapt and respond, and recover and learn in the different phases of risk analysis. Our findings support the notion that a process-oriented approach to supply chain management (Lambert and Cooper 2000) provides a solid foundation. Specifically, embedding sustainability within these specific processes, as advocated by Siong Kuik, Verl Nagalingam, and Amer (2011) for collaborative manufacturing networks, indeed translates into tangible resilience benefits, particularly in risk prediction in a VUCA world. The results clearly show that implementing sustainability principles has the greatest impact on risk prediction.

Numerous practical examples and cases in the literature have highlighted poor sustainability in SCRM (Reshad et al. 2023). This has increased the pressure on companies to manage and measure social and environmental issues more effectively. Activities of this type influence the performance of supply chain processes positively or negatively (Kumar and Garg 2017). Risks are associated with unforeseen events that may have negative consequences (Hajmohammad and Vachon 2016), and sustainable supply chain risks can significantly affect organizations' sustainability principles (Zarbakhshnia et al. 2023). This situation consequently creates both challenges and opportunities to be sustainable. Therefore, it is crucial to mitigate risks that may impact individual supply chain processes, such as supply disruptions, delivery delays, price and demand fluctuations, exchange rate volatility, as well as mitigate systemic risks such as information infrastructure failures, forecasting risks due to inaccuracies, procurement and inventory risks, capacity constraints, and intellectual property risks (Chopra and Sodhi 2004; Reshad et al. 2023).

The confirmation of H2, indicating that company size affects SCRES to sustainability risks, is consistent with the existing literature. Additionally, our analysis of internationalization and capital

origin (H2 and H4) shows that companies with foreign capital are more effective at managing risks related to sustainable development. Companies with a significant proportion of foreign capital respond better to risk, with significant differences when comparing large companies with the smallest companies in the sample. This complements the results of both Vaaland and Heide (2007) and Ramakrishna (2016), who noted significant differences in awareness and feasibility of implementing SCM solutions between SMEs and large companies. It also confirms Vaaland and Heide's (2007) findings that SMEs are less focused on planning and control methods. Our results further align with Wieteska (2011a; 2011b), who identified differences in risk perception and control types based on company size. The results reveal that large companies are better at coping with supply chain challenges, such as building resilience to risks for sustainable development in the VUCA world.

A major limitation of this study is the focus on medium-sized and large companies. The exclusion of small enterprises means that insights into their unique characteristics, such as a potential reliance on collaboration to manage supply chain risk (Alzate et al. 2022), are missing from the analysis. Our study reveals that companies with foreign capital and greater internationalization manage risks and implement sustainability principles better than those with only Polish capital and a domestic focus. This aligns with the expectation that multinational corporations are often sources of best practices in SCRM (Tang, Zimmerman and Nelson 2009) and may have better opportunities for effective risk management through strategies like diversification and flexibility (Manuj and Mntzer 2008; Chu, Park, and Kremer 2020). Um and Han (2021) also observed that resilient strategies can effectively mitigate risk in global supply chains.

It is therefore necessary to consider how organizational size and capital structure influence performance, especially given that medium-sized companies respond differently to risk compared to large companies. There is no doubt that large, often multinational companies with foreign capital face greater exposure to the pressures of a VUCA world (Cavusgil et al. 2021) and the inherent vulnerabilities of global supply chains (Di Paola, Cosimato, and Vona 2023). This exposure may stem from factors like single sourcing, geographic concentration of suppliers (Norrman and Jansson 2004; Haraguchi and Lall 2015), or geopolitical events like the war in Ukraine (Tundys et al. 2024, pp. 108–113). Nevertheless, these companies typically possess the skills and resources necessary to develop better mechanisms for guaranteeing resilience (Garrido-Moreno, Martín-Rojas, and García-Morales 2024).

In summary, the research clearly indicates that companies with foreign capital and greater internationalization demonstrate greater resilience to sustainability risks. The prerequisite for this resilience, as our study confirms, is the integration of sustainability principles into supply chain processes.

Conclusions

This study contributes to the discourse on sustainable development and supply chain resilience by addressing key gaps identified in systematic literature reviews. By exploring three disruption phases and five sustainability risk categories, it demonstrates how a process-oriented approach to supply chain management strengthens resilience through proactive, concurrent, and reactive

strategies. This theoretical contribution highlights the positive impact of sustainability principles on effective risk management.

A comparative analysis of national and international supply chains reveals that large and internationalized companies are more resilient to sustainability risks across all disruption phases, suggesting that they can serve as a source of best practices. The research also underscores the need for smaller enterprises, which face financial challenges such as rising energy and raw material costs, to adopt resilience-enhancing practices. This is especially relevant in Poland, where SMEs constitute 99.8% of businesses but often lack the resources to match the resilience of larger or foreign-owned companies. The findings encourage internationally active firms and global supply chain participants to adopt sustainable principles across their processes. Simultaneously, they urge Polish companies to investigate why their resilience levels differ from those of mixed or foreign-capital companies.

Despite its contributions, the study has limitations, primarily its focus on a specific geographic context and organizational size – areas that future research should expand upon. Incorporating details on supply chain partners, raw material suppliers, and end customers would provide a deeper understanding of international dynamics. Further research should also distinguish between local and global supply chains, identify best practices for sustainable and resilient supply chains across industries and maturity levels, and incorporate emerging areas like artificial intelligence and ESG risk reporting. These efforts would help bridge gaps in the field and offer actionable strategies for enhancing SCRES in a rapidly globalizing and sustainability-focused world.

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Wzmacnianie odporności międzynarodowych łańcuchów dostaw: rola zrównoważonego rozwoju w świecie VUCA

W dzisiejszym świecie VUCA (*Volatility* – zmienność, *Uncertainty* – niepewność, *Complexity* – złożoność, *Ambiguity* – niejednoznaczność), wywierającym silną presję na międzynarodowe i globalne łańcuchy dostaw, świat nauki i biznesu intensywnie poszukuje nowych szans, które pozwolą na ich trwały i niezakłócony rozwój. Wyniki przedstawionego badania, w którym autorzy wykorzystali metody statystyczne, m.in. analizę wariancji, pokazują, że implementacja zasad zrównoważonego rozwoju w zarządzanie łańcuchem dostaw może przełożyć się na kluczowe zdolności odpornego łańcucha dostaw. Jest to możliwe w warunkach procesowego podejścia do zarządzania łańcuchem dostaw oraz świadomości menedżerów co do występowania różnych rodzajów ryzyka dla łańcuchów dostaw. Dodatkowo zrównoważone i odporne (*sustainable and resilient* – SUS-RES) łańcuchy dostaw, wykorzystujące proaktywną, równoległą i reaktywną optykę, zostały zaobserwowane szczególnie w przypadku łańcuchów dostaw przedsiębiorstw dużych, z kapitałem zagranicznym oraz z zagranicznymi oddziałami. Oznacza to, że zarządzanie międzynarodowymi łańcuchami dostaw w podejściu zrównoważonym stanowić może jednocześnie szansę na wzmacnianie ich odporności.

Słowa kluczowe: ryzyko dla zrównoważonego rozwoju, zrównoważona odporność, międzynarodowy łańcuch dostaw, orientacja procesowa, SCRES, łańcuch dostaw SUS-RES, świat VUCA