Differentiated macroeconomic drivers of sustainable logistics: evidence from selected advanced and transition economies in the European Union

Magdalena Kowalska[1], Anna Misztal[1]

[1]University of Lodz,
Poland

***Abstract*— Sustainable development in logistics involves integrating economic, social, and environmental goals within transport and storage. In practice, it means reducing greenhouse gas emissions through eco-friendly fleets and green storage solutions. In the context of the EU Green Deal and the "Fit for 55" package, analyzing macroeconomic factors influencing sustainable logistics (SDLog) is crucial. This study compares six EU countries between 2008–2023: three developed (France, Germany, the Netherlands) and three transition economies (Czech Republic, Poland, Romania). A synthetic SDLog index was built from 18 variables covering environmental, economic, and social dimensions. The analysis followed two stages: OLS regression for each country and fixed-effect panel models for the two groups. Results show GDP has a universally positive effect on sustainable logistics. In developed economies, inflation and growth dynamics also matter, while in transition economies, wages and trade balance are more significant. The findings underline the importance of tailoring public policies and logistics strategies to country-specific macroeconomic conditions. Future research should expand the analysis to include institutional and technological factors, as well as apply dynamic models to capture long-term development paths.**

Keywords— sustainable development, logistics sector, macroeconomic conditions

I. INTRODUCTION

The logistics sector plays a important role in economic growth in the European Union (Malkowska &Malkowski, 2021; Trishch et al., 2023). At the same time, due to the substantial emissions generated by transport and storage activities, the sector has an important place in the goals of the EU's climate policy and sustainable development programs (Moreno et al., 2024). The European Green Deal places particular emphasis on decarbonization and improving the efficiency of logistics processes. Implementing environmental goals requires technological modernization and better recognition of the impact of macroeconomic conditions on the development of sustainable logistics in EU countries (Stefanis et al., 2024; Ozdemir et al., 2024).

Macroeconomic conditions have a major impact on the sustainable development of the logistics sector (Binsuwadan, 2024; Wani et al., 2024). They determine the conditions in which companies make decisions about investments, employment, innovation and environmental protection activities. GDP growth increases the demand for transport and storage services. The situation in the labour market affects wages and labour productivity. Inflation and interest rates determine investment opportunities. The trade balance and exchange rates affect the flow of goods and, thus, the intensity of logistics activities (Chen et al., 2025). In countries with stable economies, companies more easily plan long-term activities and implement green investments. In countries in transition, however, macroeconomic uncertainty may limit such activities (Skordoulis et al., 2025; Barakat & Gerged, 2025).

Despite the growing interest in regulatory and technological aspects of the logistics sector, there is still a lack of in-depth quantitative analyses considering the impact of macroeconomic variables on its sustainable development, especially using panel data models (Barathi, et al., 2025; Rodionov, 2025). This paper offers new insights by analyzing a comparative empirical analysis of the impact of selected macroeconomic indicators – including GDP, wages, HICP, unemployment rate and the balance of goods trade – on sustainable logistics (SDLog) development in six EU countries from 2008 to 2023.

The study covered three highly developed economies

ASEJ - Scientific Journal of Bielsko-Biala School of Finance and Law
Volume 29, No 4 (2025), pages 8
https://doi.org/10.19192/wsfip.sj4.2025.4
Received: September 2025 Accepted: December 2025,
Published: December 2025

(France, Germany and the Netherlands) and three countries with the character of transition economies (Czech Republic, Poland and Romania), which allows for a structural comparison of macroeconomic effects in different institutional and development conditions.

The paper's contribution is using a two-pronged approach – combining individual OLS regression models for individual countries with fixed-effects panel models for selected groups of countries. This solution allows for the identification of both stable and differentiated patterns of the impact of macroeconomic conditions on the development of a sustainable logistics sector in countries with different economic development trajectories.

The paper is structured as follows: Section 2 presents the theoretical framework, and Section 3 explains the data and methodology. Section 4 gives empirical results, Section 5 shows discussion, and conclusions are in Section 6.

II. THEORETICAL BACKGROUND

Sustainable logistics incorporates environmental, social and economic goals in the transport and storage area (Hoang et al., 2025; Okyere et al., 2025). It means reducing greenhouse gas emissions, energy and raw material consumption, and improving supply chain management efficiency. Sustainable logistics also strives to enhance economic and financial indicators (Sikder et al., 2024). The concept is based on balancing the company's profitability and care for the environment and society (Rosário & Figueiredo, 2024).

Sustainable logistics is an essential element of recent European sustainable development policy and occurs in the European Green Deal and the Sustainable and Smart Mobility Strategy (Turan et al., 2024). According to the European Commission, the logistics sector must reduce emissions significantly and maintain supply chain efficiency and reliability (Scriosteanu & Criveanu, 2024). Logistics is an activity requiring systemic and structural changes in this context. More and more attention is being paid to logistics and macroeconomic policy links (de Abreu et al., 2022). Internal and external factors affect sustainable logistics (Susanty et al., 2022; Alam, 2023).

Among these determinants are macroeconomic changes that may affect the sector positively or negatively (Shang et al., 2021; Cai et al., 2023). Gross domestic product (GDP) growth usually increases demand for logistics services. Economic growth also leads to greater investment in infrastructure and new technologies (Kwilinski, 2025). In turn, wage levels affect labour costs in the sector, which may motivate companies to automate processes or change their operating model. Inflation affects the prices of fuels, energy and transport services, which translates into logistics costs. Unemployment affects the availability of workers in warehouses, distribution centres and road transport (Lehmacher, 2021). The balance of payments indicates the trade scale, which generates physical cargo flows and requires efficient logistics services. All these factors create a macroeconomic environment that can support or limit the implementation of sustainable development goals in logistics (Werner-Lewandowska & Golinska-Dawson, 2021).

The EU countries differ in their level of economic development, institutional maturity and sectoral structure. Western European countries such as France, Germany and the Netherlands have developed logistics systems, modern infrastructure and a stable regulatory environment (Gunn et al., 2023). In contrast, Central and Eastern European countries, including the Czech Republic, Poland and Romania, are still in the phase of economic transformation. Their logistics sector is developing dynamically but is more sensitive to external and internal changes (Gajdosikova & Vojtekova, 2024).

These differences mean that the impact of macroeconomic factors on the sustainable development of logistics may vary in particular groups of countries. Institutional, regulatory and innovation factors may play a greater role in developed economies. In transition economies, the effects of wages, foreign trade or labour availability may be more observable. Comparing these two groups allows a better understanding of how macroeconomics affects logistics in various development conditions (László, 2025).

In the scientific literature, sustainable logistics development is most often analyzed in the context of technological changes, regulatory frameworks and the impact of transport on the environment (Barut, et al., 2023; Nikseresht et al., 2024). Many studies focus on urban logistics, electromobility, CO_2 emissions and innovations in supply chains (Bell, 2021; Grzesiak & Sulich, 2023). The impact of macroeconomic factors on developing sustainable logistics practices is less discussed.

Studies usually focus on single countries or analyze cross-sectional data without considering institutional diversity (Sikder et al., 2024). There is a lack of comparisons between economies with different levels of development and analyses based on panel data that allow for capturing changes over time (Jomthanachai et al., 2024). This gap is particularly relevant for EU Member States, where policies are standard, but macroeconomic and structural conditions are significantly different. Research must show how these differences solve possibilities and limitations in achieving sustainable logistics goals.

The considerations presented so far show that sustainable logistics is evolving in strong connection with macroeconomic conditions (Bekun et al., 2022; Rokhadi & Setyawati, 2024). However, there is a lack of studies that systematically compare these relationships between developed and transforming countries within the European Union. Answers to these problems are pursued in the further part of the paper, based on the analysis of panel data and comparison of selected groups of countries.

III. RESEARCH METHODOLOGY

The research goal is to check the impact of macroeconomic variables on the logistics sector sustainable development in selected European Union countries from 2008 to 2023. The analysis covers three advanced economies (France, Germany,

and the Netherlands) and three transition economies (the Czech Republic, Poland, and Romania). The article identifies potential outcome differences based on the countries' economic and institutional development levels.

The main research hypothesis follows: "There are significant differences in the structure and strength of the impact of macroeconomic determinants of sustainable logistics development between advanced and transition economies. GDP growth and inflation are the main factors in developed countries, while labour costs and foreign trade balance play a greater role in transition economies". The following research questions were formulated:

- What macroeconomic variables significantly affected the sustainable development of the logistics sector in EU countries in 2008–2023?
- Does the impact of these variables differ significantly between the group of developed countries and countries in transition?
- Which factors most significantly determine the variability of the SDLog indicator from the national and group perspective?

Sustainable logistics development (SDLog) was measured using a synthetic index constructed based on 18 diagnostic variables. Variables used to construct the indicator:

- environmental: carbon dioxide (CO_2) emissions, methane (CH_4) emissions, nitrous oxide (N_2O) emissions, sulfur oxides (SO_2 eq.) emissions, ammonia (NH_3 eq.) emissions;
- economic: number of enterprises, turnover, production, value-added, operating surplus, total purchases, personnel costs;
- social: sector wages, social insurance contributions, number of employees, labour productivity, value added per employee.

Equation for the synthetic indicator of sustainable logistics development (SDLog):

$$SDLog_{it} = \frac{1}{n}\left(\sum_{j=1}^{s}\frac{x_{ijt}}{max\ x_{jt}} + \sum_{k=1}^{d}\frac{min\ x_{kt}}{x_{ikt}}\right) \quad (1)$$

Where:

$SDLog_{it}-$ synthetic index of sustainable logistics development for country iii in year ttt;

x_{ijt} – value of the jth stimulant variable for country i in year t;

x_{ikt} value of the kth destimulant variable for country i in year t;

$max\ x_{jt}$– maximum value of stimulant j in year t;

$min\ x_{kt}$ – minimum value of destimulant k in year t;

s = 13s – number of stimulants;

d = 5d – number of destimulants;

n = s + d = 18 – total number of diagnostic variables included in the index.

For each country, a separate OLS model was estimated with the SDLog index as the dependent variable and a set of macroeconomic variables as predictors:

$$SDLog_t = \propto_0 + \propto_1 GDP_t + \propto_2 Wage_t + \propto_3 HICP_t + \propto_4 UEMP_t + \propto_5 Balance_t + \varepsilon_t \quad (2)$$

- This general form was adapted per country depending on the statistical significance of variables;
- HAC (heteroskedasticity and autocorrelation consistent) standard errors were applied.

Based on diagnostic tests and statistical significance, a unified panel model was specified for both country groups, with only significant macroeconomic predictors retained:

$$SDLog_t = \begin{cases} \beta_0 + \beta_1 GDP_{it} + \beta_2 Wage_{it} + \beta_3 HICP_{it} + \mu_i + \varepsilon_{it};\ if\ i \in Advanced\ Economies \\ \gamma_0 + \gamma_1 Wage_{it} + \gamma_2 Balance_{it} + \mu_i + \varepsilon_{it};\ if\ i \in Transition\ Economies \end{cases} \quad (3)$$

Where:

i – country index;

t – time (year);

μi– country-specific fixed effect;

εit– idiosyncratic error term.

IV. RESEARCH RESULTS

Table 1 presents the SDLog for six selected EU countries from 2008 to 2023. The results show a clear upward trend in all cases, with the highest levels recorded in 2023. Advanced economies (France, Germany, Netherlands) display higher average SDLog values than transition economies (Czechia, Poland, Romania), indicating structural differences in logistics sustainability performance over time.

TABLE 1.: LOGISTICS SECTOR SUSTAINABLE DEVELOPMENT IN SELECTED EU COUNTRIES

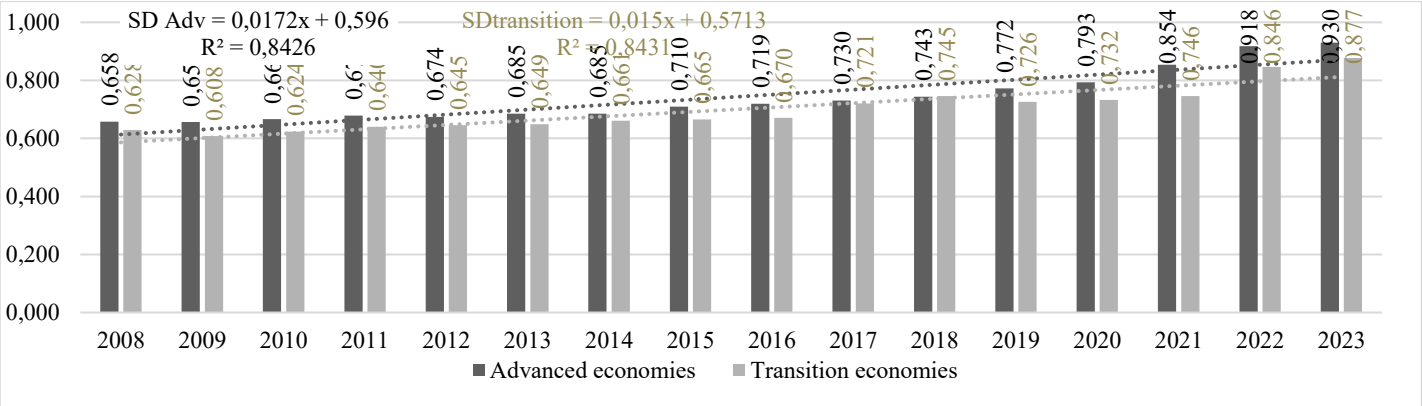
Years	Franc	German	Netherland	Czechi	Polan	Romani
2008	0,687	0,626	0,661	0,683	0,625	0,578
2009	0,689	0,622	0,658	0,663	0,593	0,568
2010	0,701	0,629	0,670	0,686	0,591	0,594
2011	0,704	0,646	0,685	0,704	0,612	0,606
2012	0,710	0,624	0,689	0,706	0,622	0,609
2013	0,716	0,636	0,702	0,706	0,624	0,618
2014	0,663	0,680	0,712	0,690	0,641	0,654
2015	0,691	0,689	0,750	0,701	0,635	0,658
2016	0,697	0,704	0,756	0,701	0,632	0,678
2017	0,696	0,723	0,772	0,723	0,728	0,711
2018	0,706	0,737	0,787	0,768	0,774	0,694
2019	0,733	0,772	0,811	0,791	0,682	0,704
2020	0,761	0,813	0,806	0,793	0,697	0,708
2021	0,824	0,882	0,856	0,824	0,664	0,749
2022	0,902	0,935	0,917	0,899	0,778	0,861
2023	0,902	0,946	0,942	0,929	0,808	0,894
Max	0,902	0,946	0,942	0,929	0,808	0,894
Min	0,663	0,622	0,658	0,663	0,591	0,568
Std.dev.	0,072	0,108	0,086	0,077	0,067	0,091
Median	0,705	0,697	0,753	0,706	0,638	0,668
Average	0,737	0,729	0,761	0,748	0,669	0,680

Source: own calculations based on https://ec.europa.eu/eurostat/databrowser/product/view/sbs_na_sca_r2?category=bsd.sbs.sbs_h.sbs_na_h.

Figure 1 illustrates the average values of the Sustainable Logistics Development Index (SDLog) for advanced and transition EU economies between 2008 and 2023. Both groups show a steady upward trend, with advanced economies maintaining a consistently higher SDLog level. The fitted linear trendlines reveal slightly faster growth in advanced economies (slope = 0.0172, R^2 = 0.8426) than in transition economies (slope = 0.0155, R^2 = 0.8431), indicating gradual convergence

in sustainable logistics performance across development levels.

FIGURE 1. AVERAGE SUSTAINABLE LOGISTICS DEVELOPMENT INDEX (SDLOG) IN ADVANCED AND TRANSITION EU ECONOMIES, 2008–2023



Source: own calculations based on https://ec.europa.eu/eurostat/databrowser/product/view/sbs_na_sca_r2?category=bsd.sbs.sbs_h.sbs_na_h.

The OLS estimation results (Table 2) confirm that GDP has a statistically significant and positive effect on SDLog in all analyzed countries. In France, in addition to GDP, both the unemployment rate (negative) and inflation (positive) significantly influence SDLog. In Germany, the trade balance has a significant negative impact alongside GDP. In the Netherlands, unemployment positively affects SDLog, complementing the strong influence of GDP. Among transition economies, Czechia shows a marginally significant positive effect of unemployment. In Poland, only GDP is significant, while in Romania, GDP and trade balance (positive) are statistically relevant. Model fit is strong in all cases (R^2 from 0.76 to 0.98), and diagnostic tests indicate acceptable specification, although some models exhibit mild autocorrelation (e.g., Netherlands: DW = 0.79).

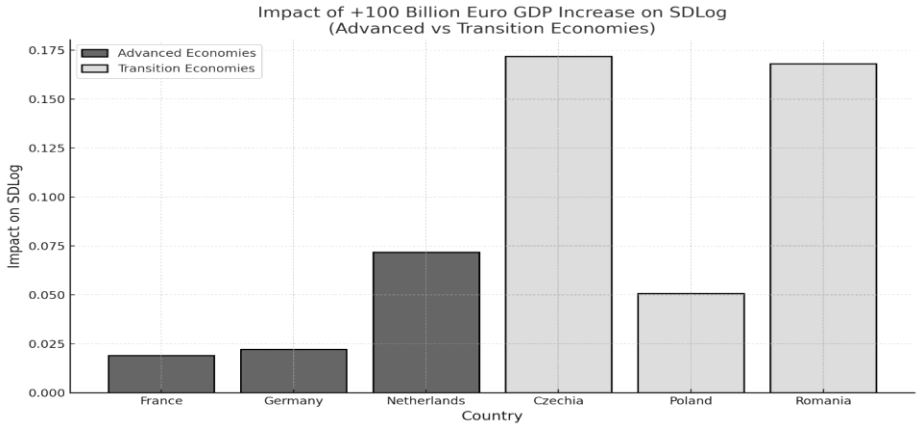
TABLE 2.: THE OLS ESTIMATION RESULTS FOR THE SUSTAINABLE LOGISTICS DEVELOPMENT INDEX (SDLOG) IN SELECTED EU COUNTRIES (2008–2023)

Country		Coefficient	Std.	t-ratio	p-value
France	const	0,3787	0,0789	4,7990	0,0004
	GDP	0,0000	0,0000	5,4450	0,0001
	uemp	−0,0378946	0,0102	−3,706	0,0030
	HICP	0,0110	0,0045	2,4720	0,0294
		R-squared	0.889314	D-W	1.306528
	LM = 15.431 with p-value = P(Chi-square(9) > 15.431) =				
	Chi-square(2) = 2.07732 with p-value = 0.353928				
	LMF = 2.75883 with p-value = P(F(1, 11) > 2.75883) =				
Germany	const	0,1169	0,0390	3,0000	0,0102
	GDP	0,0000	0,0000	21,8600	<0,0001
	balance	−5,41783e-07	0,0000	−6,790	<0,0001
		R-squared	0.961359	D-W	1.257737
	LM = 7.95644 with p-value = P(Chi-square(5) > 7.95644) =				
	Chi-square(2) = 1.79879 with p-value = 0.406815				
	LMF = 2.24454 with p-value = P(F(1, 12) > 2.24454) =				
Holand	const	0,1897	0,0263	7,2050	<0,0001
	GDP	0,0000	0,0000	22,1200	<0,0001
	uemp	0,0173	0,0041	4,1770	0,0011
		R-squared	0.984588	D-W	0.788011
	LM = 7.74174 with p-value = P(Chi-square(5) > 7.74174) =				
	Chi-square(2) = 1.45784 with p-value = 0.482431				
	LMF = 7.69535 with p-valu(F(1, 12) > 7.69535) = 0.016835				
Czechia	const	0,3907	0,0253	15,4200	<0,0001
	GDP	0,0000	0,0000	19,6000	<0,0001
	uemp	0,0090	0,0047	1,9270	0,0762
		R-squared	1.430845	D-W	0.760914
	LM = 3.9689 with p-value = P(Chi-square(2) > 3.9689) =				
	Chi-square(2) = 0.20702 with p-value = 0.901667				
	LMF = 0.930525 with p-value = P(F(1, 12) > 0.930525) =				
Poland	const	0,4308	0,0148	29,0400	<0,0001
	GDP	0,0000	0,0000	13,7500	<0,0001
		R-squared	0.760914	D-W	1.712796
	LM = 3.9689 with p-value = P(Chi-square(2) > 3.9689) =				
	Chi-square(2) = 6.36397 with p-value = 0.0415032				
	LMF = 0.26679 with p-value = P(F(1, 13) > 0.26679) =				
Romania	const	0,3868	0,0136	28,3500	<0,0001
	GDP	0,0000	0,0000	19,9900	<0,0001
	balance	0,0000	0,0000	2,5390	0,0247
		R-squared	0.951517	D-W	1.507990
	LM = 10.5561 with p-value = P(Chi-square(5) > 10.5561) =				
	Chi-square(2) = 2.21607 with p-value = 0.330208				
	LMF = 0.776315 with p-value = P(F(1, 12) > 0.776315) =				

Source: own calculations based on https://ec.europa.eu/eurostat/data/database.

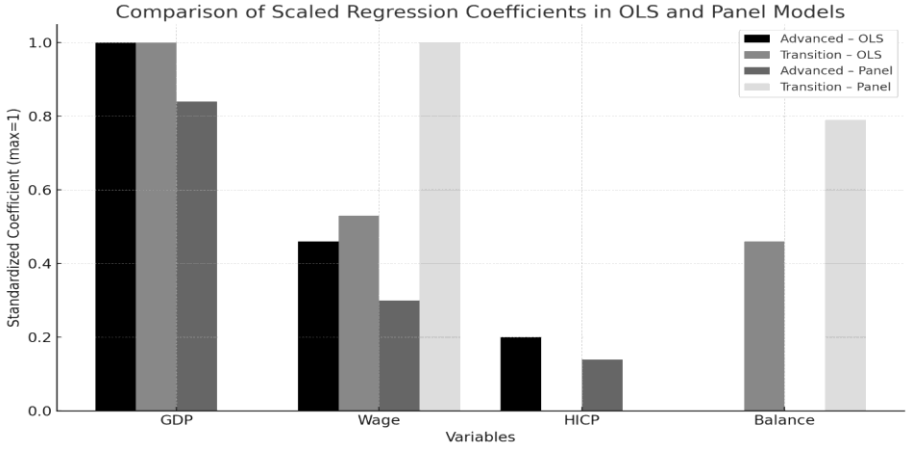
Figure 2 compares the magnitude of GDP's influence on SDLog across advanced (dim grey) and transition (light grey) economies. Values represent the product of the GDP regression coefficient and a 100 billion euro increase in national output (GDP measured in millions of euros). The results indicate that transition economies, notably Czechia and Romania, exhibit stronger responsiveness of SDLog to GDP growth than most advanced economies. This suggests that economic growth may have a more direct or less institutionally moderated effect on sustainable logistics outcomes in less mature economies. Fixed effect estimation results indicate a significant positive impact of GDP on sustainable logistics development (coefficient = 4.65e-07; p = 0.0025), alongside a positive effect of inflation measured by HICP (β = 0.0077; p = 0.0327) (Table 3). Wages show a weakly negative influence (β = −5.28e-07; p = 0.0763), possibly reflecting cost pressure in mature logistics systems. The model exhibits strong explanatory power (R^2 = 0.842), a highly significant joint F-test (F(3, 42) = 72.37; p < 0.0001), and significant fixed effect variation between countries (F(2, 42) = 52.51; p < 0.0001). However, residual autocorrelation is present, as indicated by a low Durbin–Watson statistic (DW = 0.64).

FIGURE 2. ESTIMATED IMPACT OF A 100 BILLION EURO INCREASE IN GDP ON SUSTAINABLE LOGISTICS DEVELOPMENT (SDLOG) IN SELECTED EU COUNTRIES (2008–2023)



Source: own calculations based on https://ec.europa.eu/eurostat/databrowser/product/view/sbs_na_sca_r2?category=bsd.sbs.sbs_h.sbs_na_h.

FIGURE 3. COMPARISON OF REGRESSION RESULTS FOR ADVANCED AND TRANSITION ECONOMIES



Source: own calculations based on https://ec.europa.eu/eurostat/databrowser/product/view/sbs_na_sca_r2?category=bsd.sbs.sbs_h.sbs_na_h

For transition economies, the model reveals a different structure of key drivers. Wages emerge as the strongest positive determinant (β= 2.70e-06; $p < 0.0001$), likely supporting the professionalization and modernization of the logistics activities. However, the external balance has a strong negative effect (β = −2.14e-06; p = 0.0038), suggesting the sector is open to external trade imbalances. The model demonstrates good fit ($R^2 = 0.808$), strong joint significance of regressors ($F(2, 43) = 71.98$; $p < 0.0001$), and notable heterogeneity in fixed effects ($F(2,43) = 79.07$; $p < 0.0001$). The Durbin–Watson statistic (DW = 0.67) indicates moderate autocorrelation in residuals.

TABLE 3.: FIXED EFFECTS IN ADVANCED AND TRANSITION ECONOMIES (2008–2023)

Group of		Coefficien	Std. Error	t-ratio	p-value
Advanced economies (France, Germany, Holand)	const	0,203779	0,0636006	3,204	0,0026
	GDP	4,65E-07	1,44E-07	3,22	0,0025
	wage	−5,27747	2,90E-07	−1,817	0,0763
	HICP	0,0077292	0,0034984	2,209	0,0327
	LSDV R-kwadrat= 0,841527				
	D-W= 0,642425				
	F(3, 42) = 72,3658; p = P(F(3, 42) > 72,3658) =				
	F(2, 42) = 52,512; p = P(F(2, 42) > 52,512) = 3,74183e-				
	const	0,456196	0,0214328	21,28	<0,0001
Transition economies (Czechia, Poland, Romania)	balance	−2,14398	7,01E-07	−3,057	0,0038
	wage	2,70E-06	2,35E-07	11,5	<0,0001
	LSDV R-kwadrat 0,807557				
	D-W= 0,674280				
	F(2, 43) = 71,9831; p = P(F(2, 43) > 71,9831) =				
	F(2, 43) = 79,0741; p = P(F(2, 43) > 79,0741) =				

Source: own calculations based on https://ec.europa.eu/eurostat/databrowser/product/view/sbs_na_sca_r2?category=bsd.sbs.sbs_h.sbs_na_h.

Figure 3 shows a normalized cross-comparison of the most significant regression coefficients from fixed effects panel models and country-level OLS models for advanced (France, Germany, Netherlands) and transition economies (Czechia, Poland, Romania). For the developed economies, GDP always has a strong and positive coefficient in SDLog for both OLS and panel models, confirming its real status as a macroeconomic growth indicator. Wages, however, have

a negative coefficient in the panel model and remain statistically insignificant in OLS estimations. Inflation (HICP) is found to have a positive and statistically significant effect in the panel model, while it has been included in the French OLS specification only, where its effect is also positive and significant.

In the OLS models, the impact of GDP is always positive and robust for Romania and Poland. However, in the panel model, GDP is excluded in favour of trade balance (balance) with a negative and statistically significant effect, which could suggest exposures in external trade dynamics. Wages have a positive and strong effect in the panel model versus their less strong and ambiguous role in single-country OLS models. Overall, the panel model detects more consistent and generalizable influence patterns in each group. It highlights the structural differences in macroeconomic drivers of SDLog between transition and advanced EU economies. GDP, in general, presents itself as a more general driver in advanced economies, whereas labour cost dynamics and trade balance are more determinant in transition economies.

V. .DISCUSSION

The empirical analysis results show the various effects of macroeconomic factors on the SDLog in developed and transition countries in the European Union. This confirms the validity of the adopted research hypothesis, according to which the structure and strength of the impact of macroeconomic variables differ significantly depending on countries' economic and institutional development. The analysis is also entitled to deliver exact answers to the research questions.

The most universal indicator that positively impacted SDLog was gross domestic product (GDP). Its growth stimulates the evolution of logistics infrastructure, new technologies and the quality of transport services. It is worth noting that other variables suggested various significance levels for each country. For example, the unemployment rate hurt SDLog in France, which can be interpreted as demand rules and insufficient use of labour resources. A different effect was observed in the Netherlands and the Czech Republic, where higher unemployment could be associated with the sector's restructuring. HICP positively impacted the SDLog in the panel model's entire group of developed countries. This may indicate the adaptive capabilities of logistics companies to increase costs and implement savings measures. In the transition countries, wages were of key importance, the increase of which had a positive impact on SDLog, most likely through the professionalization of the sector and its modernization. The balance of payments is also significant. However, it negatively impacted Germany and the panel model for transition countries, which may be due to the increasing sensitivity of the logistics sector to imbalances in international trade.

OLS and fixed-effects panel models confirmed that differences between developed and transition countries significantly impact the relationship between macroeconomic determinants and SDLog. In developed countries, the effects related to the pace of economic growth and price adjustments dominate, while in transition countries, variables reflecting labour costs and trade openness become more important. Panel group models consistently captured these differences. It indicates that GDP and inflation are pivotal in developed countries. Wages and the trade balance are crucial in developing countries. The strength of the impact of macroeconomic factors on SDLog depends on the country's economic and institutional development stage.

From a theoretical perspective, the study shows that macroeconomic conditions significantly impact the sustainable development of logistics. Until now, many studies have focused on technology, regulations and emissions. This analysis shows that factors such as GDP, inflation and wages also play a key role. Using the synthetic SDLog indicator and comparing countries provides new knowledge.

The conclusions also have practical significance. Public policies should be adapted to the specifics of countries. It is worth supporting innovation and efficiency in developed countries while in transition countries - the development of the labour market and foreign trade. Logistics companies can use knowledge about the impact of macroeconomic factors to better plan investments and reduce risks. The findings underscore that shared sustainable development objectives should consider structural disparities between nations.

Nevertheless, the research has several limitations. To begin with, the SDLog indicator is not sensitive to all significant qualitative determinants, i.e., institutions' quality or the usefulness of regulations. Second, the analysis covers only six countries, limiting the possibility of fully generalizing the results. Third, relationships between variables were not studied; for example, GDP can simultaneously be affected and shaped by SDLog. Fourth, variables such as green investments, digitalization or innovation, which may be of growing importance for logistics, were not included.

Future research will expand the range of the study to additional countries and institutional and technological factors. It is also worth using dynamic panel models because they allow the capture of lagged macroeconomic effects, reduce the problem of endogeneity and better reflect the dynamic nature of changes in the sustainable development of logistics.

VI. CONCLUSIONS

This paper analyzes the impact of selected macroeconomic factors on sustainable logistics development in six European Union countries from 2008 to 2023. The study covered three developed countries (France, Germany, the Netherlands) and three transition countries (Czech Republic, Poland, Romania). A comparative approach was applied using OLS regression and panel models with fixed effects.

The results confirmed that GDP is the most important factor supporting the sustainable development of logistics in all the countries studied. At the same time, other variables, such as inflation, wages, unemployment, or foreign trade balance, play different roles. It depends on the country's economic situation. GDP and inflation were more important in developed countries, while wages and trade balance were crucial in transition countries.

The analysis showed that the macroeconomic conditions of sustainable development of logistics are not uniform across the European Union. The impact of variables depends on local

institutional, economic and social conditions. Therefore, the policy supporting the logistics sector should be tailored to the specifics of a given country or group of countries.

The study results can be helpful to both public policymakers and logistics companies. They show which factors should be monitored to effectively support the sector's sustainable development. The article also makes a theoretical contribution by pointing out the need to include macroeconomics in logistics and sustainable development analyses.

In the future, it is worth extending the analysis to more countries, including institutional and technological variables and using dynamic models. This will allow for a better understanding of the long-term relationships and changes in logistics in the context of economic and environmental transformations in Europe.

VII. REFERENCES

Alam, S. Factors influencing sustainable logistics: Sustainability in logistics. South Asian Journal of Operations and Logistics 2023, 2(1), 48–62. https://doi.org/10.57044/SAJOL.2023.2.1.2304

Barakat, M.; Gerged, A. M. Does logistics performance foster sustainable development? A moderated mediation effect. International Journal of Social Economics 2025, ahead-of-print. https://doi.org/10.1108/IJSE-05-2024-0392

Barathi, G.; Murugesan, R.; Murugesan, S. Analysing the drivers for implementing smart supply chain management in Indian industries by using the analytic hierarchy process. International Journal of Advanced Manufacturing Technology 2025. https://doi.org/10.1007/s00170-024-14946-1

Barut, A.; Citil, M.; Ahmed, Z.; et al. How do economic and financial factors influence green logistics? A comparative analysis of E7 and G7 nations. Environmental Science and Pollution Research 2023, 30, 1011–1022. https://doi.org/10.1007/s11356-022-22252-0

Bekun, F. V.; Adedoyin, F. F.; Lorente, D. B.; et al. Designing policy framework for sustainable development in Next-5 largest economies amidst energy consumption and key macroeconomic indicators. Environmental Science and Pollution Research 2022, 29, 16653–16666. https://doi.org/10.1007/s11356-021-16820-z

Binsuwadan, J. Transport sector emissions and environmental sustainability: Empirical evidence from GCC economies. Sustainability 2024, 16(23), 10760. https://doi.org/10.3390/su162310760

Cai, L. Macroeconomic determinants and their impact on environmental sustainability: The role of cultural and creative product prices. Environmental Science and Pollution Research 2023, 30, 75908–75924. https://doi.org/10.1007/s11356-023-27425-z

Chen, M.; Tan, X.; Zhu, J.; et al. Can supply chain digital innovation policy improve the sustainable development performance of manufacturing companies? Humanities and Social Sciences Communications 2025, 12, 307. https://doi.org/10.1057/s41599-025-04601-9

de Abreu, V. H. S.; Santos, A. S.; Monteiro, T. G. M. Climate change impacts on the road transport infrastructure: A systematic review on adaptation measures. Sustainability 2022, 14(14), 8864. https://doi.org/10.3390/su14148864

Gajdosikova, D.; Vojtekova, S. Comparative analysis of business environment dynamics in Central and Eastern Europe: A multi-criteria approach. Economies 2024, 12(12), 320. https://doi.org/10.3390/economies12120320

Grzesiak, S. S.; Sulich, A. Electromobility: Logistics and business ecosystem perspectives review. Energies 2023, 16(21), 7249. https://doi.org/10.3390/en16217249

Gunn, S.; Butler, R.; De Block, G.; Høghøj, M.; Thelle, M. Cities, infrastructure and the making of modern citizenship: The view from north-west Europe since c. 1870. Urban History 2023, 50(3), 565–583. https://doi.org/10.1017/S0963926821000882

Hoang, T. H.; Tran, T. T.; Huynh, L. N. T.; et al. Advances and barriers in promoting green logistics 4.0 from a multi-stakeholder perspective: A systematic review. Environmental Systems and Decisions 2025, 45, 14. https://doi.org/10.1007/s10669-025-10006-5

Jomthanachai, S.; Wong, W. P.; Khaw, K. W. An application of machine learning to logistics performance prediction: An economics attribute-based of collective instance. Computational Economics 2024, 63, 741–792. https://doi.org/10.1007/s10614-023-10358-7

Kwilinski, A. GDP per capita vs foreign direct investment: Key drivers of a country's technological leadership. Technological and Economic Development of Economy 2025, 1–25. https://doi.org/10.3846/tede.2025.22857

László, T. Economic convergence of Central and Eastern European countries in the European Union. Political Research Exchange 2025, 7(1). https://doi.org/10.1080/2474736X.2025.2507633

Lehmacher, W. (2021). Digitizing and automating processes in logistics. Disrupting Logistics 2021, 15-30. https://doi.org/10.1007/978-3-030-61093-7_2

Malkowska, A.; Malkowski, A. International trade in transport services between Poland and the European Union. Sustainability 2021, 13(1), 424. https://doi.org/10.3390/su13010424

Bell, M. G. H. City logistics and the urban environment. Urban Form and Accessibility 2021. https://doi.org/10.1016/B978-0-12-819822-3.00021-3

Moreno, J.; Campagnolo, L.; Boitier, B.; et al. The impacts of decarbonization pathways on Sustainable Development Goals in the European Union. Communications Earth & Environment 2024, 5, 136. https://doi.org/10.1038/s43247-024-01309-7

Sikder, M.; Wang, C.; Rahman, M. M.; Yeboah, F. K.; Alola, A. A.; Wood, J. Green logistics and circular economy in alleviating CO_2 emissions: Does waste generation and GDP growth matter in EU countries? Journal of Cleaner Production 2024, 449, 141708. https://doi.org/10.1016/j.jclepro.2024.141708

Nikseresht, A.; Golmohammadi, D.; Zandieh, M. Sustainable green logistics and remanufacturing: A bibliometric analysis and future research directions. The International Journal of Logistics Management 2024, 35(3), 755–803. https://doi.org/10.1108/IJLM-03-2023-0085

Okyere, S.; Yang, J.; Adams, C. A. Optimizing the sustainable multimodal freight transport and logistics system based on the genetic algorithm. Sustainability 2022, 14(18), 11577. https://doi.org/10.3390/su141811577

Ozdemir, S.; Demirel, N.; Zaralı, F.; et al. Multi-criteria assessment framework for evaluation of Green Deal performance. Environmental Science and Pollution Research 2024, 31, 4686–4704. https://doi.org/10.1007/s11356-023-31370-2

Rodionov, O. Ways to successfully develop and manage a business in the transport sector in a competitive environment. American Journal of Industrial and Business Management 2025, 15, 1–13. https://doi.org/10.4236/ajibm.2025.151001

Rokhadi, Setyawati, H. T.; Novida, D. R.; Hariyanti; Mariyani, D. Infrastructure governance and economic dynamics: Enhancing national competitiveness from a macroeconomic perspective. Journal of Contemporary Administration and Management (ADMAN) 2024, 2(1), 458–463. https://doi.org/10.61100/adman.v2i1.173

Rosário, A. T.; Figueiredo, J. Sustainable entrepreneurship and corporate social responsibility: Analysing the state of research. Sustainable Environment 2024, 10(1). https://doi.org/10.1080/27658511.2024.2324572

Scriosteanu, A.; Criveanu, M. M. Green and reserve logistics of packaging and plastic packaging waste under the conditions of circular economy at the level of the European Union member states. Energies 2024, 17(12), 3015. https://doi.org/10.3390/en17123015

Shang, H.; Su, F.; Yüksel, S.; Dinçer, H. Identifying the strategic priorities of the technical factors for the sustainable low carbon industry based on macroeconomic conditions. SAGE Open 2021, 11(2). https://doi.org/10.1177/21582440211016345

Sikder, M.; Wang, C.; Yeboah, F. K.; et al. Driving factors of CO_2 emission reduction in the logistics industry: An assessment of the RCEP and SAARC economies. Environment, Development and Sustainability 2024, 26, 2557–2587. https://doi.org/10.1007/s10668-022-02840-3

Skordoulis, M.; Kavoura, A.; Stavropoulos, A.-S.; Zikas, A.; Kalantonis, P. Financial stability and environmental sentiment among millennials: A cross-cultural analysis of Greece and the Netherlands. International Journal of Financial Studies 2025, 13(2), 64. https://doi.org/10.3390/ijfs13020064

Stefanis, C.; Stavropoulos, A.; Stavropoulou, E.; Tsigalou, C.; Constantinidis, T. C.; Bezirtzoglou, E. A spotlight on environmental sustainability in view of the European Green Deal. Sustainability 2024, 16(11), 4654. https://doi.org/10.3390/su16114654

Susanty, A.; Puspitasari, N. B.; Jati, S.; Selvina, O. Impact of internal and external factors on halal logistics implementation. Journal of Islamic Marketing 2022, 13(5), 1143–1170. https://doi.org/10.1108/JIMA-09-2020-0293

Trishch, R. M.; Sichinava, A.; Bartoš, V.; Stasiukynas, A.; Schieg, M. Comparative assessment of economic development in the countries of the European Union. Journal of Business Economics and Management 2023, 24(1), 20–36. https://doi.org/10.3846/jbem.2023.18320

Turan, B.; Hemmelmayr, V.; Larsen, A.; et al. Transition towards sustainable mobility: The role of transport optimization. Central European Journal of Operations Research 2024, 32, 435–456. https://doi.org/10.1007/s10100-023-00888-8

Wani, M. J. G.; Loganathan, N.; Mujalli, A. The impact of sustainable development goals (SDGs) on tourism growth: Empirical evidence from G-7 countries. Cogent Social Sciences 2024, 10(1). https://doi.org/10.1080/23311886.2024.2397535

Werner-Lewandowska, K.; Golinska-Dawson, P. Sustainable logistics management maturity—The theoretical assessment framework and empirical results from Poland. Sustainability 2021, 13(9), 5102. https://doi.org/10.3390/su13095102