Economic Development and Logistics Performance: The Impact of Human Development and Economic Growth on a Country's Logistics Performance: Evidence from the EU Member States

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Abstract
Our study aims to identify the influence that both economic growth and human development have on the logistics performance of the EU member states. When discussing the economic development of a country, the human and economic growth components tend to be separated. This research aims to fill this gap by integrating both perspectives into the comprehensive variable of economic development. Utilising a linear regression model, the study uses as independent variables, the human development index and the GDP per capita (as the main indicator for economic growth), while the logistics performance index (LPI) is considered the dependent variable. Based on the results, both independent variables of the model explain up to 54% of the variation of the LPI in the EU member states (plus Switzerland). Furthermore, the results of the research indicate that the strongest correlation is identified between the human development index and logistics performance index (0.73). The study explores how economic growth and advancements in human development metrics enhance the efficiency and effectiveness of national logistics systems. Findings suggest that broader economic and human development conditions are associated with stronger logistics performance, as reflected in the composite LPI measure. Furthermore, human development – assessed via education, health, and social welfare – arises as a crucial factor influencing logistics performance, underscoring the importance of human capital in facilitating sustainable transportation and trade systems. The results highlight the significance of combining economic and social development strategies with logistics policies to improve competitiveness and connectivity in the EU.

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1. Introduction

Logistics is increasingly becoming one of the primary determinants of economic prosperity in the twenty-first century. Once relegated simply to the technical function of managing the physical movement of goods, logistics is increasingly viewed as a competitiveness and growth

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driver. Efficient logistics systems reduce trade frictions and strengthen export competitiveness (Ding et al., 2023; Zaninović et al., 2021). They also enable economies to better withstand disruptions and recover faster from crises. In weak logistics system economies, the opposite occurs: countries incur higher transaction costs, have fewer opportunities for access to markets, and are less competitive across the board of the economic system. In a globalised world of supply chains, logistics has moved on from the fringes of economic policymaking to centre stage and affects not only economic growth but also other social outcomes.

The European Union is a quintessential representation of high economic interdependence. The world's most integrated economic region relies on seamless logistics activity to sustain the free movement of individuals, goods, and services. Transnational infrastructure, trade facilitation, and convergence of policies have all been strengthened by the EU (Cigu et al., 2019; Taylor, 2023). Performance, however, is uneven across member countries. Germany and the Netherlands remain world logistics performance frontrunners with a combination of strengthened infrastructure, functional institutions, and a highly educated labour force. Conversely, some Central and Eastern European countries persist with weak networks, insufficiently qualified personnel, and governance concerns. These differentials have significant implications for logistics performance that can no longer be measured by spending on infrastructure; rather, it is the cumulative impact of human development and economic growth.

Logistics development has long been considered an enabler of economic growth. Growth in GDP gives the government and companies the economic ability to support investments in modern highways and rail corridors, and information technologies that can increase the efficiency of international trade. In the EU, this relationship can be seen in the development models of the new and smaller member countries that correlate growth with logistics and transportation infrastructure improvement. Transport infrastructure and public-sector performance are closely associated with long-term economic growth and development across EU countries (Cigu et al., 2019). Physical investments alone, however, do not suffice. Without the institutional and human capacity for operation, maintenance, and adaptation of systems, the most advanced infrastructure may lead to disappointing results.

Human development is crucial in this scenario. Sophisticated logistics also demands physical capital, but also the ability of organisations and individuals to handle complexity. Competence of the workforce, education, innovation, and governance determine system performance. Research reveals that countries with stronger human development conditions tend to achieve better logistics performance, as education, technological readiness, and human capabilities support logistics efficiency (Magazzino et al., 2021). Human capital, therefore, is critical in mediating economic growth and sustainable logistics performance.

EU records reveal the ways through which economic growth fosters human progress. In Germany and the Netherlands, healthy economies have been supported by high-level educational systems, quality innovation, and effective institutions. Collectively, they have facilitated the maintenance of some of the best logistics platforms worldwide. Rather, many Central and Eastern European countries have achieved economic development without advancing their governance or competency capacities, and in subsequent years, persistent performance disparities between member states are documented in logistics performance rankings (Ulutaş & Karaköy, 2019).

Global shocks in the past years contributed to these dynamics, notably with the COVID-19 pandemic that reinforced the vulnerabilities of supply chains and reminded those economies that supply chain system failures have negative effects on the EU economy. There are

bottlenecks limiting capacity and slowing the recovery of trade. As can be seen from the studies, exporters embedded in global value chains were the most exposed to these disruptions, while the diversification of suppliers helped mitigate their impact (Lebastard & Serafini, 2023). Shocks also presaged an acceleration of digitalisation and the sustainability of supply chains.

The literature on topics regarding logistics in the EU fails to bridge the gap regarding correlations between economic and human development. Bibliometric research shows that supply chain management literature has increasingly focused on integration, performance, digital technologies, sustainability, and risk, while the specific intersection between human development indicators and national logistics performance remains comparatively underexplored (Fang et al., 2022; Kumcu & Özyörük, 2022). Understanding logistics against the twin context of economic development and human development yields richer analytic content for a variety of reasons.

Despite the growing body of literature on logistics and economic development, the existing research remains largely fragmented in terms of analytical perspective and variable integration. A substantial strand of the literature examines logistics performance and logistics infrastructure as determinants or moderators of economic growth (Khadim et al., 2021; Hayaloğlu, 2015; Sezer & Abasız, 2017), while, with notable exceptions (e.g., Wong & Tang, 2018), limited attention has been given to analysing logistics performance as an outcome variable influenced by broader development dimensions. Furthermore, the simultaneous integration of economic growth and human development into a unified analytical framework remains underexplored, particularly in the context of the European Union. Therefore, this study uses a different analytical perspective by adopting an alternative model orientation, in which logistics performance is treated as the dependent variable and by jointly examining the influence of GDP per capita and the Human Development Index on logistics performance, offering a more comprehensive and multidimensional understanding of development-driven logistics efficiency.

Taking logistics as a sub-theoretical aspect in the dual scenario of growth of the economy and human development provides a richer setting for a range of reasons. For scholars, the study broadens the theoretical analysis by linking macroeconomic spending on investment at the macro-level with the human and institutional aspects, and for policymakers, it suggests that interventions can neither be merely infrastructure-focused nor should they exclude the investment in people and governance, in line with the broader efforts of the EU to secure and strengthen its supply chains (Taylor, 2023). Integrated strategies linking growth at the macro-level with human development may therefore provide a more effective basis for efficient, robust, and flexible logistics systems throughout the EU for the long-term development of all the member states.

Current trends in logistics, especially in the EU, show the need to integrate sustainable solutions to ensure specific SDG achievements such as carbon neutrality. While aiming to implement green logistics, there is a significant need for allocation of funds to developing technologies. The main factors that can drive logistics performance should be identified, as they might represent the first areas in which strategic resource allocation is needed. Therefore, the current paper aims to assess whether human development and economic growth can be utilised as main predictors for logistics performance. While previous research tends to focus on the influence that logistics might have on the overall economic growth of countries, the current study shifts the perspective and considers logistics performance as a dependent variable in a multivariate analysis. The separation between human development and economic growth was considered

necessary to identify the stronger influence variable between the two variables on a country's ability to innovate and optimise its logistic systems. By conducting the analysis within the EU member states, the wide range of economic development stages of the countries helps in capturing the real fluctuation of all variables while also providing valuable insights for potential future analyses.

This study addresses an important gap in the literature by combining the influence of socioeconomic aspects on the overall logistics performance of a country across the EU member states between 2012 and 2023. The analysis utilises secondary data from databases such as the World Bank, Eurostat and UNDP's Human Development Reports, testing hypotheses on significance, link direction and the relative strength of these links. The findings of the research can provide important information for the investment prioritisation of human capital and economic infrastructure enhancement in order to increase logistics performance across the EU. Ultimately, increased logistics performance can lead to trade costs and can delay reductions, increasing export competitiveness, enhancing EU market integration and increasing the resilience against global disruptions.

2. Literature review

While logistics and supply chain areas might lack specific indicators that can holistically quantify and assess the current performance of a country in this particular sector, the logistics performance index (LPI), published by the World Bank, ranks 139 countries based on their performance in the area of logistics. However, there are also critics (Beysenbaev & Dus, 2020) who highlight that the relevance of the LPI is questionable as it relies heavily on surveys from logistics experts, which can lead to subjective rankings of countries. Therefore, the proposal of Beysenbaev and Dus (2020) is to create the integrated LPI (ILPI), which also integrates quantitative data from international statistical publications into the qualitative surveys. The existing proposal can contribute to a more balanced approach to the logistics performance assessment.

Building on this measurement perspective, a substantial body of the literature suggests that logistics performance is not an isolated outcome but is significantly shaped by a country's broader development environment (Wong & Tang, 2018; Khadim et al., 2021). In particular, public governance efficiency is closely intertwined with macroeconomic stability (Bilan et al., 2019), and macroeconomic conditions are important determinants of logistics performance. GDP growth, trade openness, and urbanisation have been found to exert positive effects on logistics performance, whereas inflation and exchange-rate volatility may negatively affect it (Ohakwe & Wu, 2025). These factors influence not only the regulatory environment in which logistics operations take place but also the efficiency of customs procedures and the reliability of supply chains. In the 2023 Logistics Performance Index, Singapore ranked first, Finland second, while Denmark, Germany, and the Netherlands shared third place. Their high rankings reflect strong performance across customs, infrastructure, logistics competence, tracking and tracing, and timeliness (World Bank, 2023). These logistics outcomes may also be supported by effective institutional and regulatory environments, although governance is not directly measured by the LPI. In this context, strong regulatory quality and low levels of corruption are associated with highly efficient customs procedures, reduced trade delays, and superior supply chain coordination.

Similarly, infrastructure development like roads, ports, and digital connectivity has been widely recognized as a foundational driver of logistics competitiveness across both developed and developing economies. Efficient transport networks and advanced ICT systems facilitate faster movement of goods, reduce transaction costs, and enhance overall supply chain integration. Human development and technological innovation, alongside urbanisation and trade openness, play an important role in enhancing logistics performance (Magazzino et al., 2021). Evidence from Sub-Saharan Africa suggests that digital technologies can help reduce logistics bottlenecks and improve the speed, efficiency, transparency, and traceability of supply chains, provided that digital adoption is supported by investments in infrastructure, human capital, and institutional capacity (Kuteyi & Winkler, 2022). Taken together, these findings indicate that logistics performance is embedded within a broader socio-economic system, where improvements in education, technology, and institutional quality collectively contribute to logistics efficiency.

Recent evidence from 43 African countries suggests that greater trade openness does not automatically improve logistics performance. Mumin and Yakubu (2025) identify a significant negative association between trade openness and LPI, indicating that expanding trade volumes may strain existing logistics systems when they are not accompanied by adequate infrastructure investment and institutional capacity. Open economies tend to invest more in logistics infrastructure and adopt advanced technologies to remain competitive in global markets. Political instability can discourage foreign direct investment. Previous research results indicate that socio-political instability significantly reduces total FDI and several sector-specific investment inflows, particularly in manufacturing and services (Usubaliev, 2024). This reduction may indirectly limit the resources available for infrastructure and logistics development. Political and security instability can also increase logistics costs and operational risks, particularly in regions characterised by weak infrastructure and institutional capacity (Kuteyi & Winkler, 2022). This evidence highlights that logistics performance is a multidimensional outcome shaped by economic, institutional, technological, and human development factors rather than a single determinant. This multidimensionality reinforces the need for comprehensive analytical frameworks when examining the determinants of logistics performance.

Despite the growing recognition of these determinants, the existing research and studies highly focus on the impact that logistics enhancements have on the overall economic development of a country. An increase in the logistics performance of a country can lead to an increase in overall trade as the country has more access to other markets, contributing to overall economic development. Using static panel-data analysis for 32 OECD countries, Hayaloğlu (2015) shows that the relationship between logistics-sector development and economic growth is heterogeneous and depends on the particular transport, infrastructure, or telecommunications indicator employed. Sezer and Abasız (2017) analyse 34 OECD countries over the 1970–2014 period, using transport and communication indicators as proxies for logistics-sector development. Their findings are heterogeneous: transportation variables generally display limited statistical effects, whereas telecommunications investment and internet use are positively associated with GDP per capita. These findings collectively support the argument that logistics performance is a key driver of economic growth, particularly through its role in facilitating trade and enhancing competitiveness.

Kılıç *et al*. (2023) highlight, through their research, that the logistics area needs to be included as a main dimension of the human development index. Their results indicate that the infrastructure and timeliness sub-indicators of the logistics performance index have a significant effect on the HDI within the 154 countries analysed, leading the authors to propose

a logistics-augmented human development index (L-HDI). Le Caous and Huarng (2021) find that LPI moderates the relationship between economic complexity and HDI in both low- and high-HDI country groups. At lower LPI levels, logistics performance strengthens the positive contribution of economic complexity to human development; however, as LPI approaches its highest values, its marginal moderating effect becomes negative. These findings point to a nonlinear moderating role of logistics performance rather than to an unlimited positive effect of logistics improvements on human development.

However, while previous research focuses predominantly on the impact that logistics performance might have on economic growth (Hayaloğlu, 2015; Sezer & Abasız, 2017), relatively fewer studies have examined the reverse relationship. By considering the LPI as a dependent variable and including it in the analysis, significant factors arise that might contribute to the overall increase in the logistics performance area. However, even though the majority of the studies tend to analyse the logistical impact on growth, there are also studies such as the one performed by Tang & Abosedra (2019), that found that the export-led growth relationship is conditional on logistics performance. More efficient logistics systems facilitate trade and strengthen the contribution of exports to economic growth. Similarly, using data for 25 top-ranked logistics countries over the 2007–2018 period, Magazzino et al. (2021) find that technological innovation, HDI, urbanisation, and trade openness significantly improve logistics performance, whereas employment and gross fixed capital formation do not exhibit similarly favourable effects.

Another significant aspect integrated in the existing research related to the link between HDI, LPI and GDP is the feedback loop. In other words, the improvement in the HDI area and in the LPI can lead to an increase in GDP, which can further contribute to funding HDI and LPI improvements. Overall, the existing studies tend to indicate that HDI represents a more reliable driver of the LPI, while the GDP role can be influenced by strategic fund allocation.

2.1. Theoretical foundation

The performance of logistics systems has increasingly been recognised as a vital component of economic competitiveness and national development. Logistics has evolved from a supporting trade function into a strategic component of international trade and national competitiveness, while the LPI provides a macro-level instrument for assessing and comparing national logistics performance (Stević *et al.*, 2024). Logistics performance is normally measured on multiple dimensions such as customs efficiency, infrastructure quality, reliability of shipments, tracking and tracing, and institutional efficiency. The logistics performance index (LPI), which is currently the world's most widely used indicator, serves as a benchmarking tool to evaluate logistics efficiency at the national level. In the European Union, the LPI provides a common basis for comparing member states across customs, infrastructure, international shipments, logistics competence and quality, tracking and tracing, and timeliness (Ju *et al.,* 2024).

Theoretical analyses often underlie the connection between economic development and logistics based on trade theory and transaction-cost economics. Classical trade models emphasised the key role of tariff reduction in driving competitiveness, and the evidence from recent research suggests that transport and logistics costs play a decisive role in determining competitiveness. With very efficient logistics systems, market access barriers disappear, and firms gain access to global value chains and consequently their export markets. Logistics inefficiencies, however, consist of implicit non-tariff barriers to competition, limiting competitiveness despite openness policies. Ding *et al.* (2023) show that greater logistics efficiency reduces transport costs and export prices, thereby increasing foreign demand and export value; conversely, higher marginal logistics costs can reduce export volumes.

Previous studies also characterise logistics as a socio-technical mechanism that goes beyond infrastructure. Material networks call for an investment in supporting technology, governance, and human capital. It is inaccessible to achieve effectiveness in special operations without institutional openness and tracking facilities in digital form call for professional staff and management skills. This multidimensionality is highlighted by Kılıç et al. (2023), whose findings show that logistics performance is closely connected to education and innovation capacity and therefore to the overall potential of human development.

In addition, theoretical studies examine logistics both as a dependent and an independent variable within the context of economic development. From the reverse perspective, effective logistics performance is associated with economic development. Saini and Hrušecká (2021) identify LPI as a core component in configurations linked to higher GDP per capita, whereas logistics costs and ease of doing business display more mixed effects. Its two-base approach has been of interest to economists, management, and regional analyses, as it places logistics right at the heart of the analysis, both as a developing industry and as a developed one.

This new theoretical framework can serve to further contextualise the holistic and nonlinear performance dynamics associated with logistics. Logistics can thus be understood as lying at the intersection of infrastructure, human capital, governance, and innovation, contributing both to market efficiency and to resilience, sustainability, and long-term growth.

2.2. The logistics performance under the EU framework

The EU, as a single market, is a champion of logistics integration, involving very high interconnectedness between its 27 member states. High investments have been undertaken in harmonisation initiatives, for instance, the Trans-European Transport Network (TEN-T), and investments in digitalisation and sustainability-driven competitiveness (Cigu *et al.*, 2019). The literature, however, tends to experience mixed performance outcomes within the Union.

According to Ulutaş and Karaköy (2019), LPI indicator surveys indicate big divides between Western-Northern and Central-Eastern member states. In the first case, the Western-Northern members, with deviations in the region such as the Netherlands, Belgium, and Germany, achieved global rankings as world leaders in logistics performance measures in using world-class infrastructural capacities, efficient institutions, and advanced systems. In contrast, the new member states are mainly held back by their less-developed infrastructure, which the same study identifies as the most important criterion of logistics performance. However, new members belong to the same umbrella of policy, where there have been diversions that still exist, which indicates the difficulty of achieving cohesion in an economic space that is extremely heterogeneous.

Recent research has questioned the equal-weighted used in conventional LPI rankings, showing that criterion weights and aggregation methods can affect country rankings. Alternative MCDM frameworks may therefore provide more robust logistics-performance assessments (Stević *et al*., 2024). Recent studies have proposed alternative MCDM frameworks for evaluating the logistics performance of EU member states, assigning differentiated weights to the LPI dimensions and testing how changes in criterion importance affect national rankings (Ju *et al*., 2024).

Post-pandemic research identifies a broad range of operational and disruption-related transport risks and emphasises that identifying, quantifying, and modelling their interdependencies can support more stable and resilient supply chains (Chodakowska *et al*., 2024). This perspective reinforces the need to complement infrastructure investment with systematic transport-risk assessment and resilience-oriented supply chain management.

2.3. Economic growth and logistics performance

Empirical evidence has strongly substantiated the link between economic growth and logistics performance. Effective logistics performance can support economic development by improving the conditions under which firms and international trade operate (Saini & Hrušecká, 2021). On the other hand, effective logistics cuts the cost of trade, induces investment, and fuels further growth so that a beneficial cycle can be created.

Empirical evidence has substantiated the presence of the cycle within the EU context. Transport infrastructure development studies highlight the long-run growth advantages of ongoing investments in logistics systems by small economies striving for integration (Cigu et al., 2019). The improvement of logistics infrastructure directly reduces transaction costs, expands export ability, and boosts international market competitiveness. Zaninović *et al.* (2021) show that differences in LPI and its sub-indices help explain bilateral trade between EU15 and Central and Eastern European member states and the rest of the world, with heterogeneous effects across country groups and product classes.

Logistics performance also plays a key role in determining national competitiveness. Effective logistics systems can contribute to enhanced global competitiveness (Kabak *et al*., 2020). Results of research conducted by Saini & Hrušecká (2021) identify logistics performance as a core component associated with economic development.

Using data for more than 130 countries, Goel *et al*. (2021) find that improvements in aggregate logistics performance and delivery timeliness are associated with higher economic growth. Their simulations also show that supply chain disruptions can generate substantial and heterogeneous growth losses, particularly in low-growth economies. Disruptions to pandemic logistics resulted in measurable economic consequences and demonstrate the strategic importance of resilient supply chains (Jin *et al*., 2024).

In addition to the impact of immediate shocks, logistics influences long-term growth trajectories as a source of its influence on competitiveness. Hilmola *et al.* (2025) develop a strengths-and-weaknesses model for comparing EU-27 countries as manufacturing locations, incorporating LPI alongside demographic, labour-market, macroeconomic, geographic, and export-structure indicators. Their results generally favour larger member states—France, Germany, Italy, and Spain—although Ireland, Sweden, Luxembourg, and Finland also perform strongly.

Collectively, these findings indicate that logistics performance can support economic growth, while broader competitiveness conditions can, in turn, shape logistics performance (Kabak et al., 2020; Saini & Hrušecká, 2021).

2.4. Human development and logistics performance

While logistics infrastructure and economic development form a foundation for logistics performance, human development is equally crucial in determining logistical success. If we want to assess the importance of human development in logistics, we must look at elements such as education, workforce skills, and abilities for innovation, all contributing to an efficient management of logistics systems (Kılıç *et al*., 2023). In the EU countries, socio-economic conditions vary significantly, and human development emerges as a differentiating feature that influences logistics performance. Studies indicate that logistics performance is enhanced by well-developed human capital with significant innovation ability.

The COVID-19 crisis marked the ultimate role of human development. Resilience in logistics studies conducted in the European Union shows that the degree of adaptability and institutional capacity, not infrastructure, determined the effectiveness of the member states to deal with

disruptions. Human resources can add to the resilience of logistics systems if they possess the ability to adapt and operate under stress.

Similar patterns can also be observed at the global level. Cullinane and Haralambides (2021) show that the abrupt shifts in demand generated by the pandemic exposed shortages of equipment, truck drivers, and dock labour, contributing to congestion and longer turnaround times across port and transport networks.

A bibliometric analysis of Scopus-indexed publications from 2010 to 2021 indicates that human factors in logistics remain insufficiently researched, despite their importance for logistics-system performance and the continued expansion of automation and Industry 4.0 technologies (Kumcu & Özyörük, 2022).

Collectively, these findings support the dual aspects of the contribution of human development: it improves the efficiency of the use of logistics infrastructure and constructs the resilience of societies to disruption. Vast investments in infrastructure would hardly yield effective logistics systems without simultaneous gains in school attainment, worker skill, and institutional ability (Kılıç *et al*., 2023).

2.5. Research gaps and hypotheses

There is vast literature on logistics performance in the EU, but there are still gaps that can be addressed by further research. Predominantly, the vast number of studies take human development and economic growth as separate explanatory variables, though they ought to be taken conjointly. Existing studies often examine selected links between logistics performance and broader economic outcomes, including economic growth, international trade, competitiveness, and environmental quality, rather than jointly modelling economic and human development as determinants of LPI (Magazzino *et al.,* 2021; Zaninović *et al.,* 2021). However, few studies test the economic and human development nexus within a single framework, with a residual empirical question as to whether the two dimensions have a simultaneous effect on logistics performance across EU member nations.

Secondly, a few studies refer to interregional differentials and link them with underlying socio-economic and institutional contexts. Regional evidence for Central and Eastern European countries and the Western Balkans shows that logistics performance and its components have a positive and statistically significant effect on bilateral trade, although the available analysis is limited to the years 2007 and 2018 (Bugarčić *et al*., 2020). Conversely, few studies ascribe differentials to foundations such as school systems, innovation cultures, or governance that support long-term logistics sustainability. This narrow focus risks prescribing policy solutions that address physical infrastructure at the cost of social and institutional foundations for the long-term sustainability of logistics.

Thirdly, the large volumes of extant literature continue to be fixated on infrastructure, trade, and competitiveness with inadequate representation of social and human development aspects. Bibliometric surveys of logistics and supply chain literature also echo such imbalances (Fang *et al.,* 2022). This neglect is ironic given that the EU itself continues to be increasingly vested in digitalisation, inclusivity, and sustainability, with human capital as the very focus of policy formulation and execution.

Finally, while there has been a prominent post-COVID-19 thread on resilience that emerged within the literature, it is for short-term solutions towards coping with the crisis. While beneficial, such initiatives ignore long-term directions that incorporate human development, economic development, and logistics performance. The limitations of longitudinal viewpoints

also constrain both theoretical gains and the identification of predictive long-term policy directions.

The literature has established that logistics performance in the EU is driven by a complex interaction across a set of connected areas, comprising logistics infrastructure, economic growth, and human capital. Economic growth fosters investment in logistics infrastructure and trade competitiveness, while human capital helps to ensure adaptability, creativity, and resilience. Existing research offers useful evidence but in a fragmentary manner, since it frequently considers the growth and human development independently (Fang *et al.,* 2022). Overcoming these weaknesses necessitates the introduction of holistic approaches wherein logistics is treated as an economic and social system, more so in a region that is as heterogeneous and interdependent as the EU.

The hypotheses set were defined based on the following perspectives from the literature review: The high impact of the LPI on the overall economic growth of the country (Tang & Abosedra, 2019), the significant influence of HDI among other variables on the LPI variation (Magazzino et al., 2021) and results obtained by Le Caous & Huarng (2021). Our hypotheses are as follows:

H1: GDP per capita and HDI jointly have a statistically significant effect on LPI.

H2: HDI has a positive association with LPI.

H3: GDP per capita has a stronger effect on LPI than HDI.

3. Research methodology

The current research focuses on examining the associations between country-level development indicators and medium-term logistics performance profiles across the EU (and Switzerland). To assess this influence, we use a linear regression model with one dependent variable (LPI) and two independent variables (GDP/capita and HDI). The main reason for utilising the selected variables is based on the fact that, in past research, the human and economic components of the overall development of a country tend to be treated separately. Therefore, as logistics represents a sector with a high need for flexibility and constant improvement in terms of technology integration and cost reduction (especially while trying to also incorporate sustainable practices such as lowering the carbon footprint), quantifying the influence of the economic and human development on the logistics performance evolution represents an important perspective provided by the current analysis. The study employs a cross-sectional design based on country-level arithmetic means calculated over the 2012–2023 period, across 27 EU countries plus Switzerland, utilising datasets from the World Bank (2023), Eurostat (2024) and United Nations Development Programme (2024) (Table 1). The model examines whether medium-term differences in GDP per capita and HDI are associated with differences in LPI across countries.

Table 1. Variable description

Variable	Notation	Conceptualisation	Level used in regression	Data source
Logistics performance index	LPI	Interactive index containing 3 main dataset sections: Global logistics performance, country score card (across 139 countries) and supply chain tracking data	Country-level mean of all available LPI editions between 2012 and 2023	World Bank. (2023). Logistics Performance Index (LPI). Years: 2012-2023 (excluding 2020)
Real gross domestic product per capita	GDP per capita	Inflation-adjusted economic output per inhabitant, used as a proxy for material living standards; it does not directly measure household income or income distribution.	Country-level mean of annual observations, 2012–2023	Eurostat (2024). Real GDP per capita Years: 2012-2023
Human development index	HDI	Composite index measuring average achievement in three dimensions: a long and healthy life, knowledge, and a decent standard of living; calculated as the geometric mean of the corresponding normalised dimension indices	Country-level mean of annual observations, 2012–2023	United Nations Development Programme (2024). Human development index (HDI) Years: 2012-2023

Source: Authors' research

Firstly, considering the linear regression and the included variables, the model has the following format:

$$LPI = \alpha + \beta_1 * GDPpc + \beta_2 * HDI$$

As mentioned above, the total number of observations for all three variables of the model is 28 (the number of countries included in the analysis, 27 EU member states plus Switzerland – considered in the model as it is part of the single market).

For each EU member state, the values of LPI, GDP per capita and HDI were aggregated over the 2012–2023 period by calculating the arithmetic mean of the annual/ available observations. The method of aggregation for GDP and HDI involved calculating the arithmetic mean of all available annual observations. The reason behind the aggregation method utilized in the study relies both in the methodological and substantive reasons, as it generates the possibility to obtain a single, stable cross-sectional observation per country, while also reducing temporary fluctuations caused by business cycles, external shocks or data volatility. Additionally, the final result of the data provides a reliable representation of each country's medium term development profile and logistics capability, aligning with the comparative nature of the analysis. Therefore, the final dataset used in the regression is cross-sectional, with one aggregated observation per country. Because LPI data are not available for every year in the period, only years with available observations were included in the country-level aggregation. This aggregation approach is appropriate because the objective is not to estimate year-to-year dynamics, but to

compare medium-term country-level development profiles and their association with logistics performance across EU member states. However, this approach does not capture within-country temporal variation; future research could extend the analysis using panel-data methods.

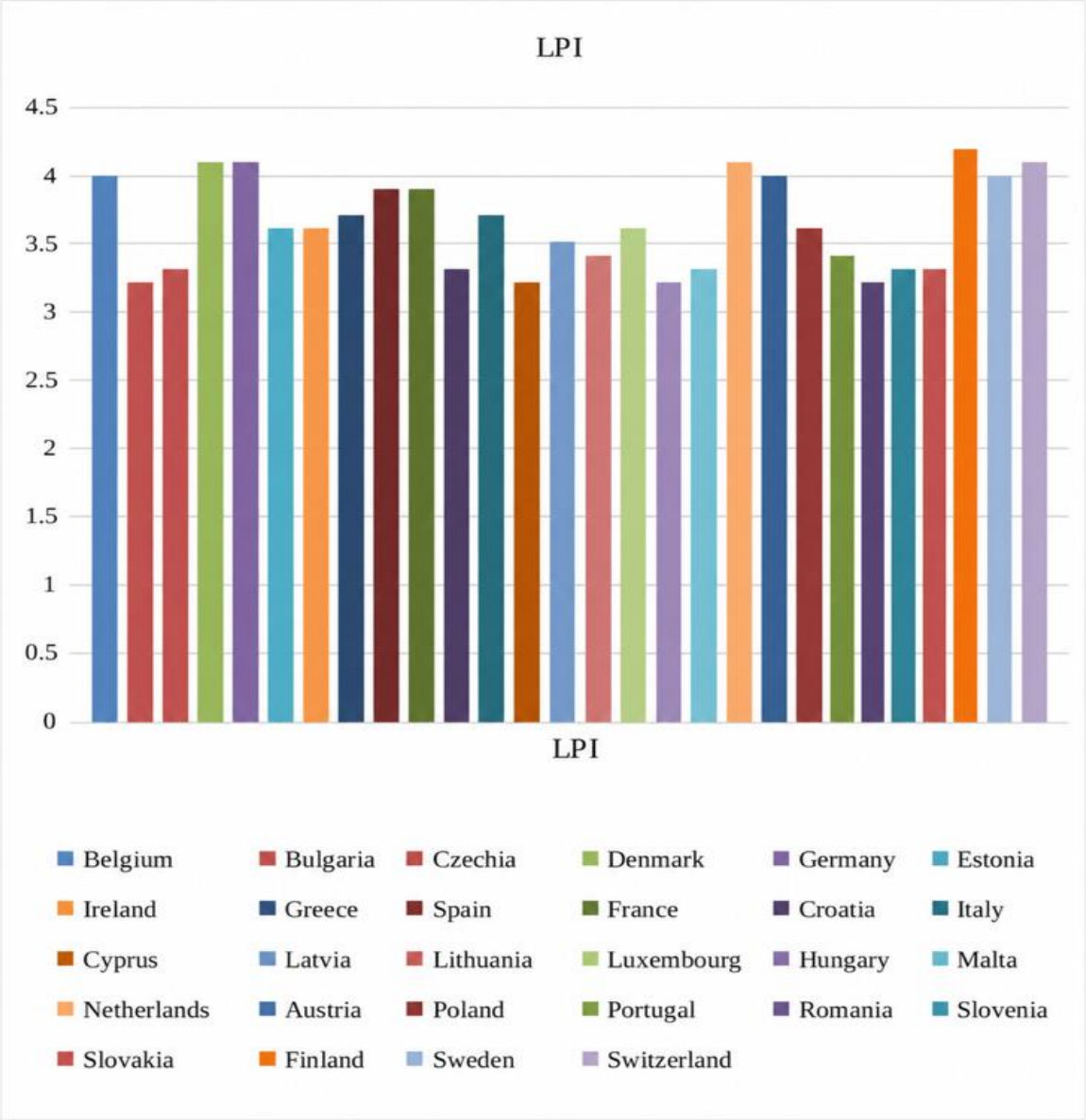
The regression model is based on a cross-sectional dataset containing one aggregated observation per country. For each country, the dependent variable represented by the LPI and the two independent variables (GDP per capita and HDI) were introduced into the model as arithmetic means calculated over 2012-2023 period, utilizing all available annual observations (for LPI the available years). Even if from an economic perspective, income is considered to be one of the three dimensions of human development index, both independent variables were retained in the study, because they capture complementary aspects of development (economic size and material prosperity versus a broader measure of human development, incorporating health and education outcomes). From an analytical standpoint, the calculated value of VIF between the two independent variables is 2.05, which does not indicate severe multicollinearity, which means that the degree of overlap does not influence significantly the stability of interpretation of the estimates.

Although GDP per capita and HDI capture different dimensions of development, they are not fully independent conceptually, because the HDI includes a standard-of-living component. Therefore, the correlation between GDP per capita and HDI was examined before regression estimation. The positive correlation between GDP per capita and HDI suggests a degree of association, but not perfect overlap, allowing both variables to be retained while interpreting coefficients cautiously.

4. Results and discussion

The cross-country distribution of the aggregated values of the variables (between 2012 and 2023) can be observed in Figure 1. The evolution of the LPI contains a range between 3.2 (registered in Bulgaria, Cyprus, Romania and Hungary) and 4.2 (registered in Finland). The countries with a high LPI level are mostly Nordic countries such as Denmark (4.1) or Finland (4.2), suggesting strong infrastructure, high value of investments and potential trade policy enhancement. On the opposite side, Romania and Bulgaria registered the lowest score for the LPI, triggered by economic instability and the high need for infrastructure development.

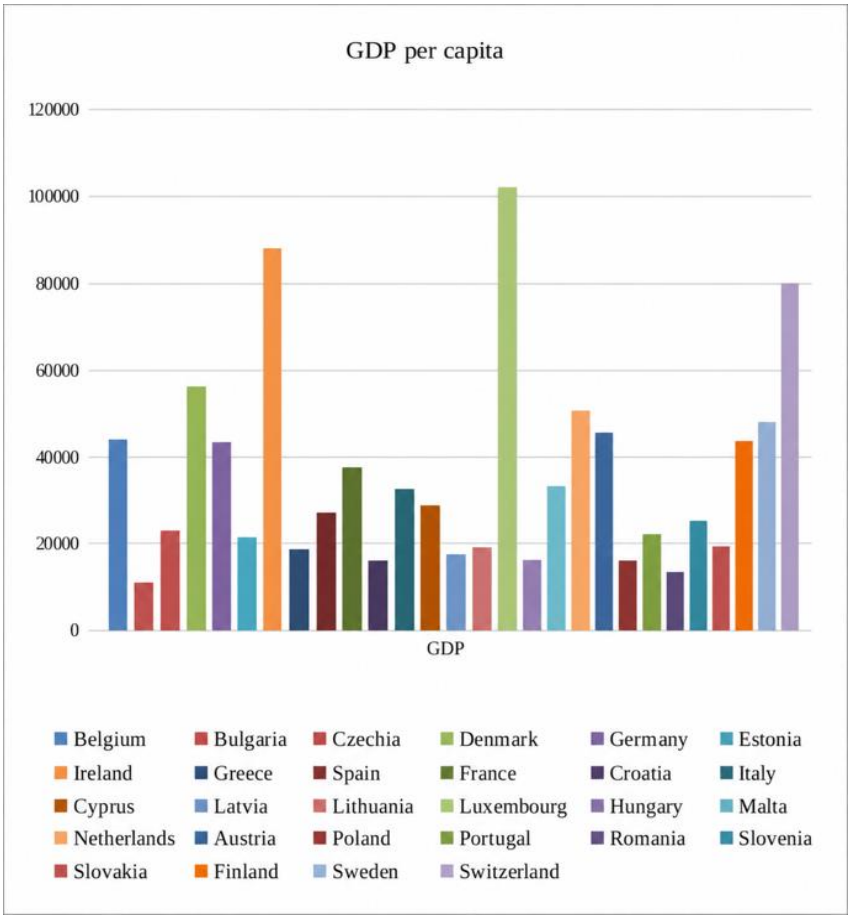
Figure 1. Country-level aggregated values of LPI, across EU member states (plus Switzerland), 2012–2023



Source: Authors' interpretation, based on data from World Bank (2023)

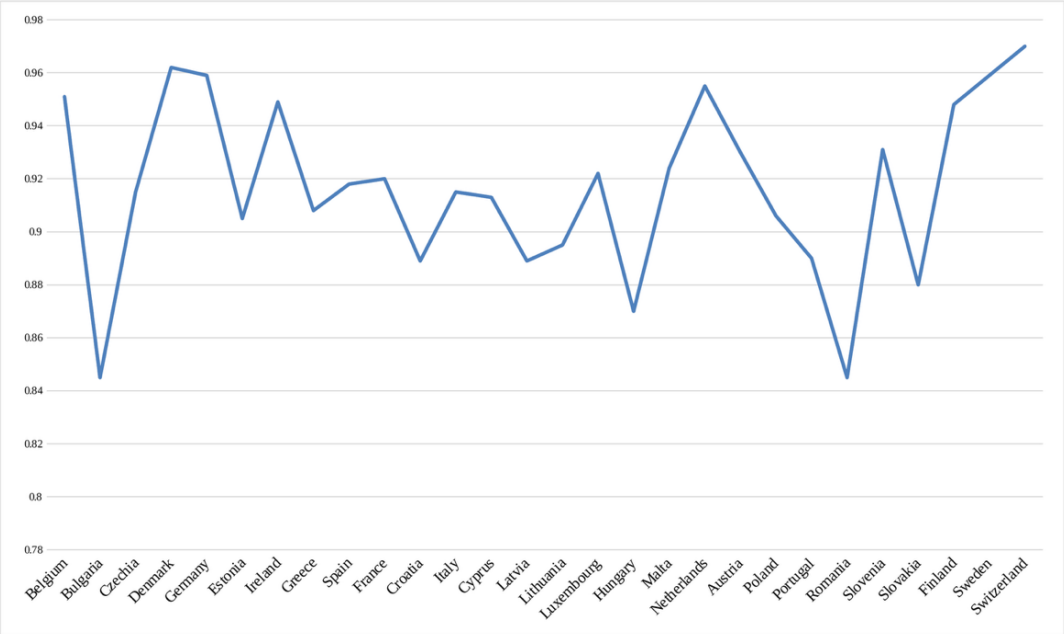
Differences in development levels are also reflected in the country-level aggregated values of GDP per capita and HDI presented in Figures 2 and 3, with Romania and Bulgaria recording among the lowest values in the analysed sample.

Figure 2. Country-level aggregated values GDP per capita, across EU member states (plus Switzerland), 2012–2023



Source: Authors' interpretation based on data from Eurostat (2024)

Figure 3. Country-level aggregated values HDI, across EU member states, 2012–2023



Source: Authors' interpretation based on data from UNDP (2024)

The distribution of the LPI is nearly symmetrical (skewness 0.08) and slightly platykurtic (kurtosis-1.34), indicating a relatively balanced spread of the values for this variable, without extreme outliers (see Table 2).

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. error	Median	Mode	St. dev.	Kurtosis	Skewness	Min	Max
LPI	28	3.66	0.06	3.60	3.60	0.33	(1.34)	0.08	3.20	4.20
GDP/ capita	28	38,598.93	4,481.27	32,960	16,060	23,712.67	0.80	1.11	10,970	102,250
HDI	28	0.92	0.01	0.92	0.85	0.04	(0.29)	(0.49)	0.85	0.97

Source: Authors' research

Among the country-level averages, Ireland combines a very high GDP per capita with an LPI that is not proportionally high. Polyak (2022) attributes Ireland's comparatively strong pandemic-era macroeconomic performance to several country-specific features, particularly its close economic ties with the United States and its specialisation in pharmaceutical manufacturing and digital services. The author also cautions that multinational accounting practices can inflate headline economic indicators and that the gains generated by these sectors do not necessarily spread to the broader domestic economy. Accordingly, the Irish case may partly reflect the exceptional sectoral and statistical structure of its multinational-dominated economy. In a strong contrast with the LPI, the GDP per capita exhibits substantial variation, being positively skewed (skewness 1.11), reflecting the presence of high-income outliers (example: Luxembourg, Ireland or Switzerland).

In the case of Greece, the divergence between a relatively stable HDI and a fluctuating LPI suggests that omitted variables may be relevant. Given the country's exposure to maritime transport, global shipping and port disruptions represent one plausible mechanism, although this interpretation is not directly tested either in the present model or by Notteboom *et al.* (2021). Therefore, despite having knowledgeable employees, the evolution of logistics performance can be impacted by other factors not included in the current study. This conclusion can lead to potential future research ideas that can incorporate the identified gap. Additionally, the HDI presents the highest degree of uniformity, with a slightly negatively skewed (skewness -0.49) and platykurtic (kurtosis -0.29) distribution of the values.

The relationship between the variables included in our dataset was measured using the Pearson correlation indicator (see Table 3). The results show that the LPI and HDI have the strongest positive correlation (0.73), which indicates that countries with higher mean HDI values tend to display higher mean LPI values. The relationship between the two variables can be logically interpreted, as the increase in human development, especially in the knowledge section, can translate into improved skills that enable employees to identify optimal solutions and achieve an increase in overall logistics performance. Similarly, the correlation between GDP/capita and HDI is also strong and positive, indicating that, with an increase in GDP per capita, the HDI will also increase. In this particular case, the economic implications relate more to the HDI dimensions that measure wealth and decent living conditions. Therefore, these aspects will improve once the GDP per capita increases (as a main indicator of the economic development of a country). Lastly, the correlation between the LPI and GDP/capita, although positive, registers the lowest intensity across the dataset (0.48), indicating that these indicators are not that sensitive to each other's fluctuations. However, even if the correlation is moderate, overall, the increase in GDP per capita is associated with an increase in the LPI. In the economic environment, this relationship can be explained by the fact that the economic development of a

country can influence the faster integration of technology in the logistics sector, leading to an increase in the LPI.

Table 3. Pearson correlation coefficient results

Statistic	Value
Pearson correlation coefficient between LPI and GDP/capita	0.48
Pearson correlation coefficient between LPI and HDI	0.73
Pearson correlation coefficient between GDP/capita and HDI	0.71

Source: Authors' research

The results of the model coefficients are in line with the correlation results for only the LPI and HDI variables, meaning that the value of the β2 coefficient indicates a positive relationship between these two variables, similar to the Pearson coefficient (see Table 4). More specifically, A one-unit increase in HDI is associated with a 7.39-unit increase in LPI, holding GDP per capita constant. On the other hand, the situation related to the LPI and GDP/capita based on the model coefficients indicates that the relationship between these two variables is negative and extremely low in intensity (-0.0000012). In other words, for a one-unit increase in GDP per capita, the LPI will decrease by 0.0000012 units. The direction and intensity of the relationship between the variables is different from the one indicated by the Pearson correlation coefficient, whose value of 0.48 indicates a positive medium relationship. The negative value of the model coefficient β1 could indicate that, after accounting for the HDI's strong positive effect on LPI, the remaining unique contribution of GDP/capita is negatively associated with LPI, possibly determined by other factors not included in the model. However, it is important to mention that while the Pearson coefficient measures a bivariate relationship (only between GDP/capita and LPI), the model coefficients measure the impact within the context of a multivariate analysis (in our case, the model has two independent variables: HDI and GDP/capita).

Table 4. Model coefficients

Coefficient	Value	P-value
Intercept (a)	-3.102	0.06142
GDP/capita (β1)	-0.0000012	0.0468187
HDI (β2)	7.39	0.0000372

Source: Authors' research

Based on the results of the linear regression model obtained utilising SPSS, the model can be written as follows:

$$LPI = -3.1 - 0.0000012 * GDPpc + 7.39 * HDI$$

The value of the determination coefficient (R-square) of 0.54 indicates that up to 54% of the variation of the LPI can be explained by the fluctuation of GDP per capita and HDI (see Table 5). For a linear regression model with two independent variables, the result of the determination coefficient is representative; however, it emphasises the possibility to improve the model in future research by including additional independent variables. The created regression model is also representative, based on the value of the significance F (0.0058%), which is below the significance level of 5%. Additionally, both independent variables are statistically significant, considering the p-values calculated in the regression model (p-value β1 = 0.047; p-value β2 = 0.001), which confirms that both income and human development can be considered predictors of logistics performance across the EU countries.

The negative coefficient of GDP per capita should not be interpreted as evidence that higher income reduces logistics performance. The bivariate correlation between GDP per capita and

LPI is positive, while the negative regression coefficient appears only after HDI is included in the model. This suggests that part of the development effect captured by GDP per capita may overlap with HDI. In EU countries, logistics performance may depend less on income levels alone and more on how economic resources are translated into human capital, institutional capacity, infrastructure quality, and technological readiness.

Table 5. Model statistical results

Statistic	Value
R2	0.54
Significance F	0.000058

Source: Authors' research

Based on the regression results, H1 is supported, as the overall model is statistically significant. H2 is also supported, as the HDI coefficient is positive and the Pearson correlation between HDI and LPI is strong and positive. Therefore, a 0.01 increase in HDI is associated with an approximately 0.0739 increase in LPI, holding GDP per capita constant. H3 is not supported, since GDP per capita has a weaker association with LPI than HDI and its regression coefficient is negative after controlling for HDI.

5. Conclusion

Our research aimed to examine the key factors influencing logistics performance across the European Union (EU) by utilising a linear regression model with the logistics performance index (LPI) as the dependent variable and gross domestic product per capita (GDP/capita) and the human development index (HDI) as independent variables. The empirical analysis is based on country-level aggregated values for EU member states over the 2012–2023 period. Therefore, the findings should be interpreted as cross-sectional evidence on medium-term development profiles rather than as year-by-year panel dynamics. Our findings indicate a significant positive correlation between HDI and LPI, as evidenced by a Pearson correlation coefficient of 0.73. This result is in line with other studies (Magazzino et al., 2021), concluding that the logistics performance of a country can be enhanced by improvements in human development, particularly in knowledge, skills and innovation abilities. According to our results, HDI has a strong positive impact on the variation in LPI across EU countries, and therefore, we can accept hypothesis H2 as true. This underscores the importance of investing in human capital and education as critical drivers of logistics efficiency and performance.

Based on our results, both the HDI and GDP per capita can be integrated as predictors for the LPI, addressing an important gap identified in other research, where human and economic aspects often tend to be treated separately. Furthermore, by adopting an alternative model orientation and focusing on how socioeconomic factors influence logistics performance, rather than the other way around, our study fills an empirical gap in understanding the key influences on LPI, particularly in the EU member states, where no prior research has combined these variables across all countries. The focus on EU member states also addresses the gap in previous research, as most of the studies focus on OECD countries (Hayaloğlu, 2015; Sezer & Abasız, 2017), on top-performing logistics economies (Magazzino *et al*., 2021) or on global samples (Jayathilaka *et al*., 2022).

Our results also reveal some inconsistencies in specific cases, such as those of Ireland and Greece, that appear not to follow fully the general cross-country pattern observed in the full sample. These country-specific divergences suggest that logistics performance is shaped by factors beyond GDP per capita and HDI, including economic structure, infrastructure, institutional conditions, and exposure to sector-specific or external shocks.

Our result regarding the relation between the GDP per capita and LPI correlates with the results obtained by Magazzino *et al.* (2021), where economic growth aspects (such as gross fixed capital formation) register insignificant effects on LPI compared with HDI, emphasising the need for the strategic allocation of resources. By addressing these research gaps, the present study adopts a broader development perspective that is consistent with the 'Beyond GDP' agenda. Jansen et al. (2024) argue that GDP alone is insufficient for assessing societal progress and propose a multidimensional dashboard for measuring sustainable and inclusive wellbeing. In the present study, the joint use of GDP per capita and HDI represents a narrower operationalisation of this broader principle, rather than a specific indicator combination proposed or validated by Jansen et al. (2024). While our research confirms the significant influence of HDI on logistics performance across the EU, the unexpected results regarding GDP/capita point towards the need for a multidimensional analysis that considers other influences on logistical effectiveness. The overall results emphasise the need for resource allocation within the EU countries towards education and human development, as it can directly trigger a positive impact on the logistics performance and indirectly on the overall trade balance of member states.

From a methodological and theoretical perspective, the negative coefficient of GDP per capita can also be interpreted through the lens of diminishing marginal returns and multicollinearity-adjusted effects, as the HDI already captures a significant portion of the institutional educational and infrastructural foundations that support both economic and logistic performance efficiency. In this regard, any additional increase in the GDP per capita beyond what is already captured in the HDI can represent resource allocation towards sectors with lower logistic content.

By correlating the research findings with the existing studies, we can clearly identify that there is a strong conclusion that logistic performance is more strongly associated with broad-based human capital accumulation than with pure income levels (Magazzino et al., 2021). Additionally, several countries from the dataset of the research that have significant levels of GDP per capita (example: Luxembourg and Switzerland) can generate high-value services in sectors with substantial value added while involving modest requirements for physical logistics infrastructure.

The main novelty of the study is the shift from the dominant view of logistics performance as a driver of economic growth toward an alternative perspective in which logistics performance is analysed as an outcome of broader development conditions. By jointly examining GDP per capita and HDI, the study shows that human development may be more relevant than income alone for explaining logistics performance differences across EU member states.

This study has several limitations. First, the use of aggregated country-level values limits the ability to capture annual changes and causal dynamics. Second, the model includes only two predictors, while logistics performance may also be influenced by infrastructure quality, institutional quality, digitalisation, trade openness, urbanisation, and political stability. Third, the possible overlap between GDP per capita and HDI requires cautious interpretation.

Future research perspectives include the possibility to create a new regression model to capture specific variables that are part of the economic development area (such as inflation rate, employment rate, and unemployment rate) to identify the components of the GDP that can

negatively influence the LPI development. Additionally, the current model can be improved to obtain a higher value of the determination coefficient (currently at 54%). Future research could also use panel-data models, include additional institutional and infrastructure variables, and test robustness through alternative logistics indicators.

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