

THE SUSTAINABLE DEVELOPMENT OF THE LOGISTICS SECTOR IN THE LARGEST EU ECONOMIES – COMPARATIVE ANALYSIS

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Purpose: The main aim of this paper is to assess the level and dynamics of sustainable development of the logistics sector in the ten largest economies of the European Union from 2008 to 2020.

Design/methodology/approach: We normalize diagnostic variables into synthetic indicators to verify the hypothesis. We created a synthetic sustainable development index and indicators describing its economic, social, and environmental pillars.

Findings: The results indicate a positive trend in the sustainable development of the logistics sector in the largest EU economies from 2008 to 2020. Moreover, in most cases, countries with a higher GDP level also have a higher level of sustainable logistics development.

Research limitations/implications: The availability of data, the choice of normalization method and the choice of research sample.

Practical implications: Managing the sustainable development of enterprises takes place and requires analyzing the external situation, including macroeconomic conditions.

Social implications: The social development of the logistics sector is visible, and it is necessary to take further actions to improve working conditions and quality.

Originality/value: The novelty in the paper is the creation of sustainable development indicators. The paper addresses many recipients interested in developing the logistics sector.

Keywords: sustainable development, logistics sector, EU economies.

Category of the paper: research paper.

1. Introduction

Implementing the concept of sustainable development requires the participation of states, international institutions and organizations as well as whole communities (Bose, Khan, 2022; Szychta, 2022). A special place is occupied by enterprises that are widely recognized as the entities that have contributed the most to environmental degradation (Brzezinski, Pyza, 2021; D'Angelo et al., 2022). Therefore, it is necessary for them to take active measures to combat climate change and protect natural resources (Pishdar et al., 2022; Keshavarz-Ghorabae et al., 2022). However, current scientific research does not show a statistically significant impact of the implementation of an ESG strategy by a company on its market performance (Naffa, Fain, 2021). The literature has repeatedly examined the impact of implementing an ESG strategy on the value and growth potential of a company (Hong, Kacperczyk, 2009; Liston, Soydemir 2010) and, as summarized by Cunha et al. (2021) and Kumar et al. (2022), the nature of this compound is not homogeneous (Lins et al., 2017). Yu et al. (2018) and Wong et al. (2021), as one of the reasons for this phenomenon, show external determinants related to the operation of a specific enterprise, i.e., the country in which the company operates or the sector/industry to which it belongs (Adams, Jiang, 2016). The research gaps indicated by Baji and Yurtoglu (2018) emphasize that the analysis of the impact of the assessment of the implementation of the ESG strategy on the value of the company in a group of companies from many countries does not clearly say for which countries such a relationship is statistically significant. Egorova et al. (2022) and Friede et al. (2015) point out that so far no comparison has been made between different company groups or companies from different sectors that would show the relationship with the EGS strategy in these groups.

The main aim of this paper is to assess the level and dynamics of sustainable development of the logistics sector in the ten largest economies of the European Union from 2008 to 2020. We normalize diagnostic variables into synthetic indicators to verify the hypothesis. We created a synthetic sustainable development index and indicators describing its economic, social, and environmental pillars.

The study includes an introduction, literature review, research methodology, results, discussion, and conclusion. The review of scientific publications was based on the Scopus and Web of Science lists. The data for the analysis come from Eurostat databases.

Managing the sustainable development of enterprises takes place and requires analyzing the external situation, including macroeconomic conditions. The social development of the logistics sector is visible, and it is necessary to take further actions to improve working conditions and quality. The novelty in the paper is the creation of sustainable development indicators. The paper addresses many recipients interested in developing the logistics sector.

2. Sustainable development of enterprises

Sustainability in business refers to a company's strategy to reduce the negative environmental impact resulting from its operations in a particular market. An organisation's sustainability practices are typically analysed against environmental, social, and governance (ESG) metrics. Sustainable enterprise development is a multifaceted concept that involves integrating environmental, social, and economic considerations into business strategies to create long-term value while minimising negative impacts (Pererva et al., 2021; Ghauri, 2022; Diaz- Sarachaga, 2021). Here are key aspects and practices associated with the sustainable development of enterprises:

- Environmental sustainability - efficient use of resources, reduction of waste, and sustainable sourcing of materials; implementation of energy-saving practices and the adoption of renewable energy sources; strategies to minimize greenhouse gas emissions and contribute to climate change mitigation; Embracing circular economy principles, such as recycling, reuse, and reducing (Sribna et al., 2023; Hysa, 2020).
- Social Responsibility - ensuring fair wages, safe working conditions, and respecting workers' rights; promoting diversity within the workforce and fostering an inclusive workplace culture; Engaging with local communities, understanding their needs, and contributing positively to community development; Upholding human rights principles throughout the supply chain (Anh et al., 2022; Sribna et al., 2023).
- Economic viability - taking a long-term approach to business decisions rather than focussing solely on short-term profits; Embracing innovation to improve efficiency, create new products, and adapt to changing market conditions; Maintaining sound financial practices to ensure the company's resilience in the face of economic challenges (Mio et al., 2020; Teixeira et al., 2019).
- Transparency and Accountability - Provide transparent and comprehensive reporting on environmental, social, and governance (ESG) performance; Establishing mechanisms to ensure accountability for sustainable practices and continuous improvement (Hanaysha et al., 2022; Chege et al., 2020).
- Stakeholder Engagement - Working collaboratively with various stakeholders, including customers, suppliers, investors, and local communities; Actively seeking and considering the input of stakeholders in decision-making processes.
- Green Innovation and Technology - developing and promoting environmentally friendly products and services; Incorporating technologies that contribute to sustainability goals (Wojewnik-Filipkowska et al., 2019).
- Regulatory Compliance and Standards - ensuring compliance with environmental and social regulations in all areas of operation; Adhering to and, where possible, influencing industry standards that promote sustainability (Lu et al., 2019; Fotaki et al., 2020).

By incorporating these principles into their operations, companies can contribute to a more sustainable future, align with evolving social expectations, and build resilience in the face of global challenges. Sustainable development is not only a responsibility but also a source of innovation and competitive advantage in today's business landscape (Vuković et al., 2022; Jacyna et al., 2014; Przybylska et al., 2023).

Measurement of sustainable development poses several challenges due to the complex and multidimensional nature of the concept. There is no universally accepted definition or set of indicators for sustainable development (Brugmann, 2021). Different organisations, countries, and industries may use varying frameworks, making it challenging to compare and benchmark progress. Sustainable development encompasses economic, social, and environmental dimensions. Measuring progress in each of these areas and finding indicators that adequately capture their interactions is complex. Balancing and weighting these dimensions can be subjective. The benefits or negative impacts of sustainable practices may not be immediately evident. Long-term effects, especially in environmental sustainability, can take years or decades to manifest, making it difficult to assess the immediate success of sustainability initiatives (Miola et al., 2019; Hickel, 2020). Reliable and consistent data can be scarce on all dimensions of sustainable development. In some cases, the data may be incomplete, outdated, or difficult to obtain, hindering accurate assessments (Nilashi et al., 2023). The challenges and priorities vary significantly between regions and communities. Applying a uniform set of indicators may not capture the specific needs and nuances of different contexts. Stakeholders may have different views on what constitutes sustainable development. Perceptions of sustainability can vary between businesses, governments, NGOs, and the public, leading to subjective interpretations of progress (Attanasio et al., 2022; Gericke et al., 2019). Creating progress in one dimension of sustainability can have unintended consequences in another. For example, economic growth might lead to increased environmental impact. Balancing trade-offs and understanding complex interactions is challenging (van der Bom et al., 2020). Pressures for short-term results can conflict with the long-term nature of sustainable development. Companies may prioritise immediate economic gains over longer-term environmental or social benefits (Bandari et al., 2022). Inconsistent or evolving regulatory frameworks can impact measurement approaches. Changes in government policies or international agreements may influence the relevance and applicability of specific sustainability indicators (Glass et al., 2019; Breuer et al. 2019). Some organisations may engage in "greenwashing", where they present themselves as more sustainable than they actually are. This can mislead stakeholders and make it difficult to assess the true impact of sustainability efforts. Addressing these challenges requires ongoing collaboration among stakeholders, the development of standardised and universally accepted measurement frameworks, improved data collection and reporting mechanisms, and a commitment to transparency and accountability in sustainable development initiatives (Pizzetti et al., 2021; Kurpierz et al., 2020; Yang et al., 2020).

3. Sustainable development of enterprises in the countries TLS sector in the analysed

The logistics sector plays a crucial role in the movement of goods and services throughout the supply chain. It encompasses various activities involved in planning, implementation, and control of the efficient and effective flow of goods, services, and information from the point of origin to the point of consumption. The logistics sector is dynamic and continually evolving, influenced by technological advancements, globalisation, and changing consumer expectations. Effective logistics management is essential for businesses to enhance competitiveness, reduce costs, and meet customer demands in an ever-changing market (Camporek et al., 2022; Danilevičius et al., 2023; Martišius et al., 2022).

The relationship between regional development and the logistics sector is crucial to fostering economic growth, improving connectivity, and improving overall efficiency in a given geographical area. Here are key points that highlight the connection between regional development and the logistics sector:

1. The logistics sector is heavily dependent on well-developed infrastructure, including roads, railways, airports, and seaports. Investment in logistics infrastructure is essential for improving connectivity within a region, facilitating the movement of goods, and supporting economic activities. This is especially visible in highly developed countries such as Germany, France, and Sweden (Vanpetch et al., 2020; Rodrigue et al., 2010; Kennedy et al., 2005).
2. A robust logistics sector facilitates trade by providing efficient transport and distribution networks. Regions with a well-connected logistics infrastructure are more attractive to businesses engaged in import and export activities, contributing to regional economic development. Furthermore, Central European countries (Poland, Austria) invest in their transport infrastructure to support the sector's expansion, making it an attractive destination for logistics companies and a critical gateway for goods in Europe (Brdulak et al., 2021; Camporek et al., 2021).
3. The logistics sector creates employment opportunities in areas such as transportation, warehousing, and distribution. A thriving logistics industry can contribute to the creation and skill development in the region (Chhetri et al., 2014). The logistics sector also plays a significant role in terms of the number of employees: In developed economies it is approximately 5-10% of all employees. The report "Logistics - Global HR Trends" by Gi Group Holding shows that the number of employees in the logistics sector is 17.8 million in China and 4.8 million in Brazil. Germany is the leader in Europe, with 1.8 million people working in logistics, followed by Great Britain (1.6 million), Italy (1.4 million) and Poland (1.1 million).

4. Efficient logistics processes contribute to a smooth and reliable supply chain. This, in turn, enhances the competitiveness of businesses within the region, attracting investment and promoting economic growth (Shahbaz et al., 2019; Illahi et al., 2021). In 2019, transport services contributed around 5% of the gross value added of the EU and 5.4% of all jobs. In 2019, the transport of goods in the EU-27 amounted to 3392 billion tkm, of which 52% was carried out by road (Statistical pocketbook, 2021).
5. The rise of e-Commerce has heightened the importance of efficient logistics networks. Regions with advanced last-mile delivery systems and well-connected transportation networks are better positioned to support the growth of online retail and contribute to the development of the local economy (Zennaro et al., 2022; Kalkha et al., 2023). At the end of 2022, the European logistics services market working for online trade was worth more than EUR 81.6 billion, of which domestic services are valued at more than PLN 69.9 billion, which constitutes 85.6% of the sector's value. Cross-border services accounted for the rest, i.e. PLN 11.7 billion. In a more balanced proportion, approximately 43 billion to approximately EUR 38.6 billion euros (52.7% to 47.3%), last-mile transport services remain compared to warehouse services (fulfilment). However, the value of individual markets in Europe differs significantly. Great Britain has clearly outperformed the rest of the countries (23.9 billion); much further behind are Germany (16.5 billion), France (12.1 billion), Spain (4.3 billion), Italy (3.6 billion), the Netherlands (2.8 billion) and Switzerland (2.1 billion). The Polish market, worth EUR 2.139 billion, ranks eighth in Europe. Behind us are Sweden (2 billion), Turkey (1.9 billion) and in 11th place Austria with a logistics sector worth nearly EUR 1.3 billion (Statistical release: BIS international banking statistics and global liquidity indicators at end-December 2022).
6. Logistics considerations play a role in spatial planning and urban development. Well-planned logistics infrastructure can guide the growth of urban areas and industrial zones, contributing to sustainable development. The first to pay attention to this aspect were the Germans, Italians, Dutch, and Belgians. The investments were individual in nature, but their success was determined by the participation of the public sector, which was not only actively involved in individual projects but was also often their initiator. The active attitude of the public sector consisted in the economic activation of selected regions and then in the creation of consortiums that initiated the construction of logistics centres and participated in companies implementing investments (Pultrone, 2021; Margherita et al., 2023; Alpkokin, 2012).
7. Integration of technology in logistics, such as GPS tracking, warehouse automation, and data analytics, can improve efficiency and reduce costs. Regions that adopt innovative logistics solutions are likely to attract businesses seeking modern and streamlined supply chain processes (Mathauer et al., 2019; Vilas-Boas et al., 2023).

8. Sustainable logistics practices, including green transportation and eco-friendly packaging, contribute to environmental conservation. Regions that promote sustainable logistics align with global trends and can attract environmentally conscious businesses (Munuhwa, 2023; Karaman et al., 2020). The European Union is a leader in the fight against climate change and wants to achieve complete climate neutrality by 2050. Malta, Luxembourg, Lithuania, Romania, and Italy are the countries with the highest dynamics of green economy development in 2011-2019. Poland ranks in the second half of the ranking (18th out of 27 countries). The so-called countries were characterised by a higher rate of green economy development. the "new" EU than the countries of the "old" EU (8th Cohesion Report: Cohesion in Europe towards 2050).

In summary, the logistics sector plays an important role in regional development by facilitating trade, improving connectivity, creating employment opportunities, and improving overall economic efficiency. A strategic focus on the development and optimisation of the logistics infrastructure is essential to promote sustainable regional development (Twrdy et al., 2020; Surya et al., 2021; Hernita et al., 2021)

The Global Logistics Industry includes all activities of the supply chain such as transportation, customer service, inventory management, information flow, and order processing. Other activities of the supply chain include warehousing, material handling, purchasing, packaging, information dissemination, and maintenance, among others (Adeitan et al., 2020). The logistics market in terms of revenue was valued at US\$ 8185.46 billion in 2015 and is expected to reach US \$15 522.02 billion by 2023, growing at a CAGR of 7.5% from 2015 to 2024. The volume market was valued at 54.69 billion tons in 2015 and is expected to reach 92.10 billion tons by 2024 growing at a CAGR of 6% between 2016 to 2024 (Transparency Market Research, 2016).

4. Research methodology

The research aims to assess the level and dynamics of sustainable development of the logistics sector in the ten largest economies of the European Union from 2008 to 2020. We want to show what the situation of logistics companies was like from the financial crisis to the Covid-19 pandemic.

The research sample covers the ten biggest economies in the European Union, including the following countries: Germany, France, Italy, Spain, Netherlands, Poland, Sweden, Belgium, Ireland, and Austria (Table 1).

Table 1.

The GDP and main components in 2020 (output, expenditure and income)

Germany	France	Italy	Spain	Netherlands	Poland	Sweden	Belgium	Austria	Ireland
3403730	2317832	1661240	1119010	796530	526147,2	480556,4	460747,7	380888,5	375249,6

Source: own study on the basis of Eurostat <https://ec.europa.eu/eurostat/>, 19.11.2023.

Due to our research goal, we have proposed the following hypothesis: “The dynamics of sustainable development of the logistics sector is the highest in countries with the highest level of GDP from 2008 to 2020”. This approach results from the fact that the logistics sector is largely dependent on macroeconomic conditions.

Additionally, we formulated the following sub-hypotheses:

- “The three pillars of sustainable development of the logistics sector economic, social and environmental, have a positive trend”;
- “The dynamics of the economic development of the logistics sector is higher than the dynamics of the social and environmental development of this sector”;
- “Sustainable development of logistics in the largest EU economies has positive dynamics”.

To verify our research hypothesis we created the synthetic indicators of sustainable development (S) based on its three pillars:

- economic (E_D), including following stimulants: transport enterprises- number, turnover or gross premiums, production value, value added at factor cost, gross operating surplus, total purchases of goods and services, gross investment in tangible goods, investment rate;
- social (S_D): stimulants: wages and salaries, social security costs, employee- number, turnover per person employed, apparent labour productivity, gross value added per employee, growth rate of employment, investment per person employed and destimulants: personnel costs - million euro, share of personnel costs in production – percentage;
- environmental development (Env_D), based on destimulants: carbon dioxide, methane, nitrous oxide, sulphur oxides (SO₂ equivalent), ammonia (SO₂ equivalent);

Sustainable development indicators were determined by the variable standardization method based on the following formula:

- for the stimulants:

$$Z_{ij} = \frac{x_{ij}}{\max x_{ij}}, \quad Z_{ij} \in [0; 1] \quad (1)$$

- for the destimulants:

$$Z_{ij} = \frac{\min x_{ij}}{x_{ij}}, \quad Z_{ij} \in [0; 1] \quad (2)$$

where:

Z_{ij} - the normalized value of the j-th variable in the i-th year,

x_{ij} is the value of the j-th variable in the i-th year.

To calculate the indicator of sustainable development of the LOGISTICS sector (Sus_D) and its components economic (E_D), social (S_D), and environmental (Env_D) we use the formula:

$$Sus_D = \frac{\sum_{j=1}^n (E_{D\ ij} + S_{D\ ij} + Env_{D\ ij})}{n}, S_{D\ ij} \in [0; 1] \quad (3)$$

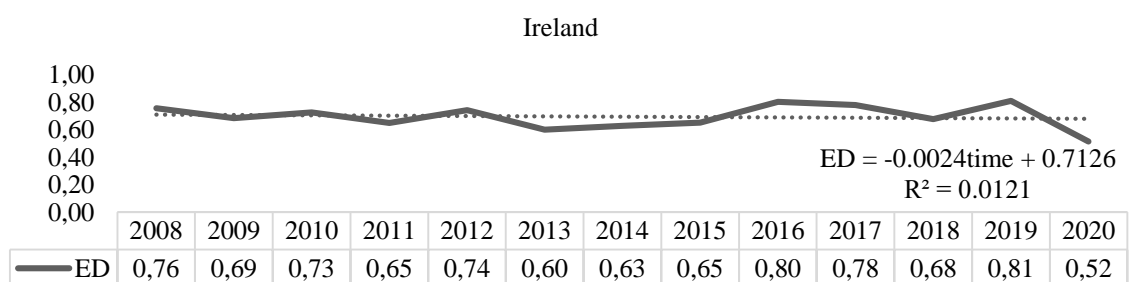
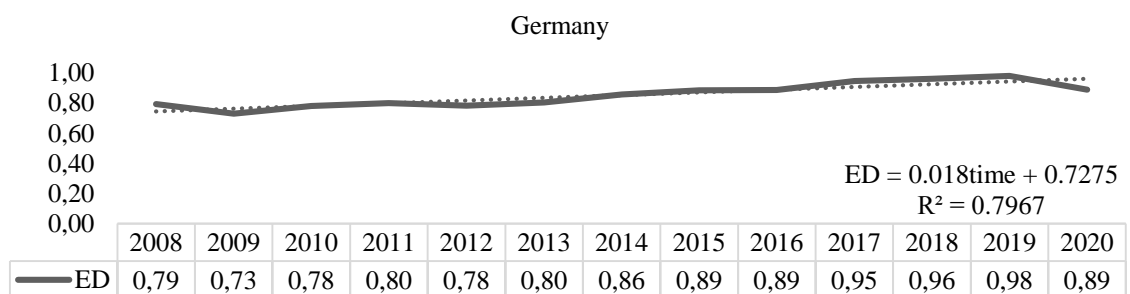
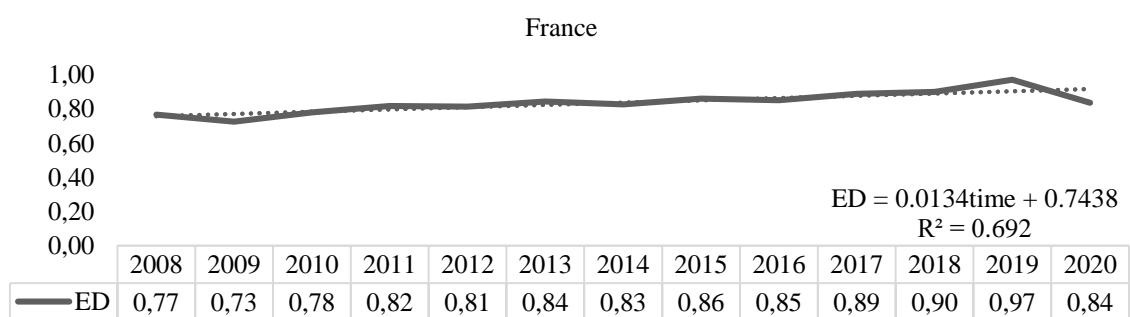
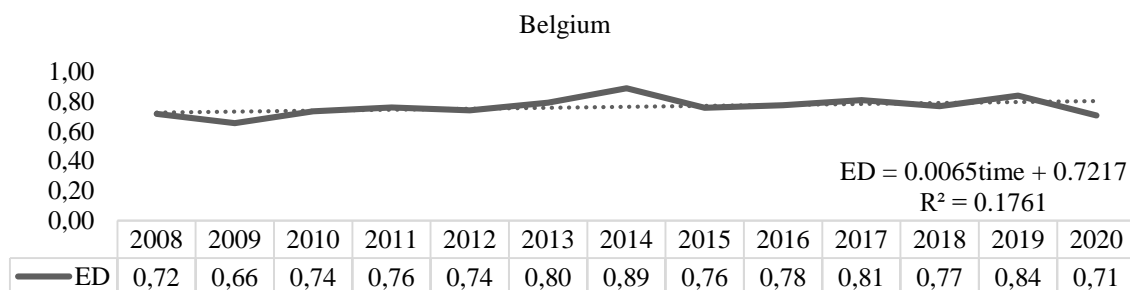
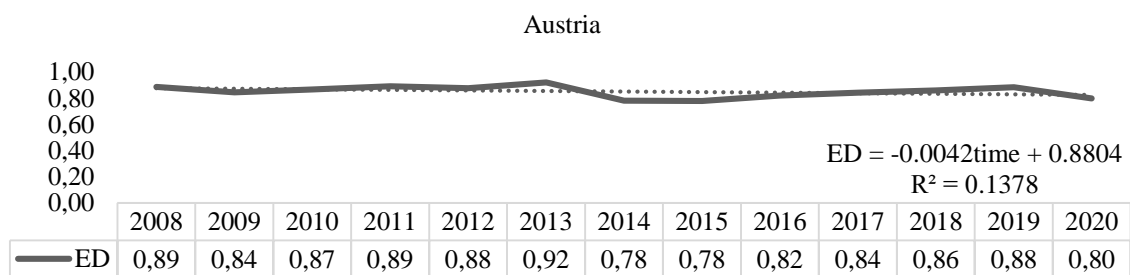
We created a linear equation, which we estimated using the classic least squares method, based on formula:

$$\begin{aligned} E_{D\ ij} &= \alpha_0 + \alpha_1 t + \varepsilon_i \\ S_{D\ ij} &= \alpha_0 + \alpha_1 t + \varepsilon_i; \\ Env_{D\ ij} &= \alpha_0 + \alpha_1 t + \varepsilon_i; \\ Sus_{D\ ij} &= \alpha_0 + \alpha_1 t + \varepsilon_i \end{aligned} \quad (4)$$

$$s(\hat{\alpha}_0, \dots, \hat{\alpha}_5) = \sum_{i=1}^n e_i^2 = \sum_{i=1}^n (Sus_{D\ i} - \hat{Sus}_{D\ i})^2 \rightarrow \min \quad \text{where } t\text{-time} \quad (5)$$

5. Research results

Figure 1 presents the synthetic indicator of the economic development of the logistics sector in the largest EU economies in the period from 2008 to 2020. The value of indicators in the analyzed period and countries is highly diversified. The indicator shows a positive trend in Belgium, France, Germany, the Netherlands, Poland, Spain and Sweden, which should be assessed as favourable. The enterprises from the logistics sector are highly involved in activities for economic development in these countries. The highest positive dynamics is in Poland ($E_D = 0.0357 \text{ time} + 0.4776$, $R^2 = 0.8596$). The lowest positive dynamics is in Belgium ($E_D = 0.0065 \text{ time} + 0.7217$, $R^2 = 0.1761$). In Austria, Ireland and Italy the indicator shows a negative trend. In these countries, logistics sector enterprises should pay special attention to their economic development. The highest negative dynamics is in Austria ($E_D = -0.0042 \text{ time} + 0.8804$, $R^2 = 0.1378$). The lowest negative dynamics is in Italy ($E_D = -0.0023 \text{ time} + 0.850$, $R^2 = 0.0409$).



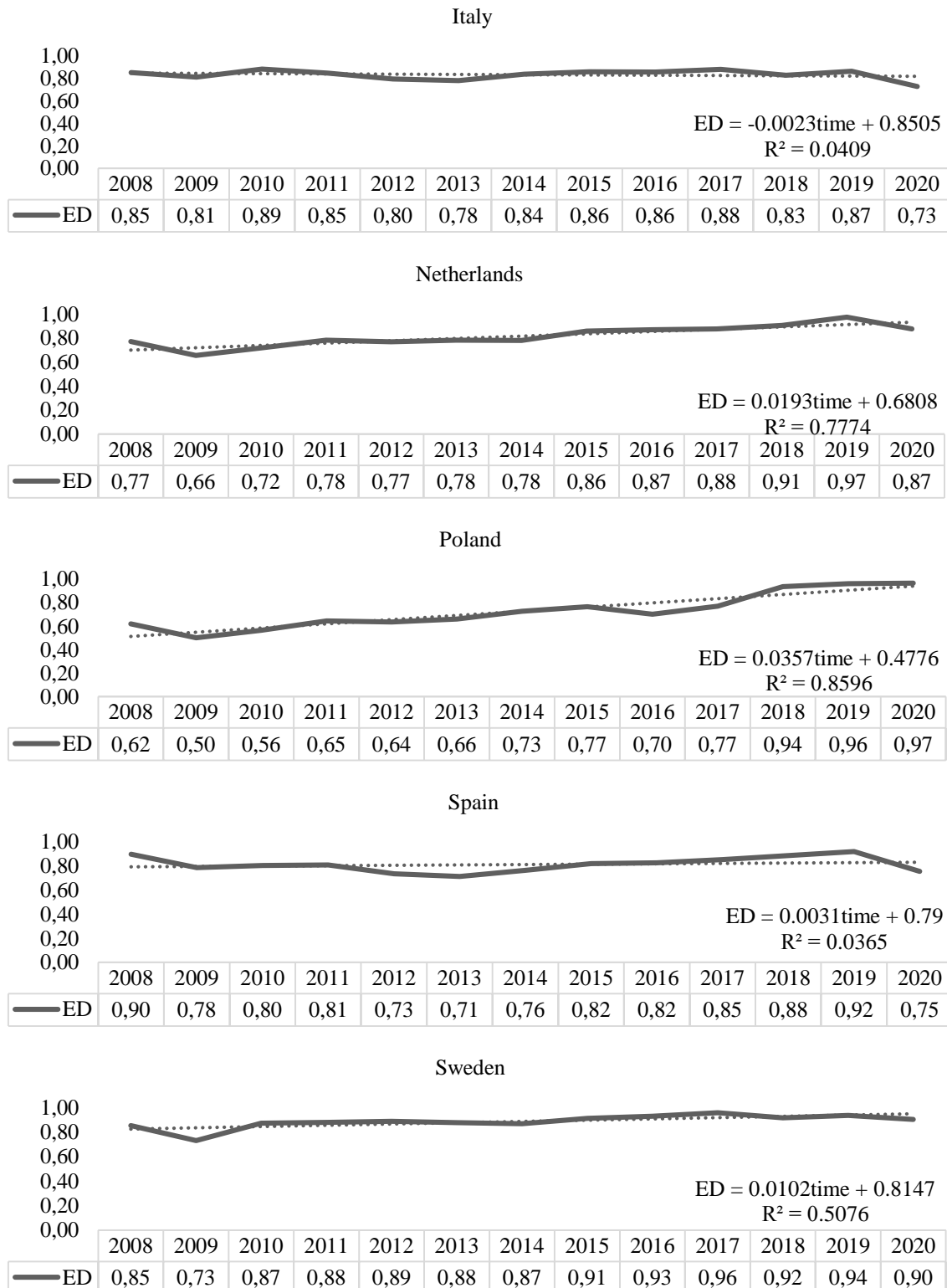


Figure 1. The synthetic indicator of the economic development in the largest EU economies (2008-2020, the logistics sector).

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Table 1 shows the descriptive statistics of the synthetic indicator of the economic development of the logistics sector in the largest EU economies in the period from 2008 to 2020. In the analyzed countries, the values of descriptive statistics of the indicator vary. The highest average level is in Sweden, 0.89 (SD = 0.05, median = 0.89). The lowest average level is in Ireland, 0.70 (SD = 0.08, median = 0.69). The maximum level is in Germany (0.98; 2019), and the minimum is in Poland (0.50; 2009).

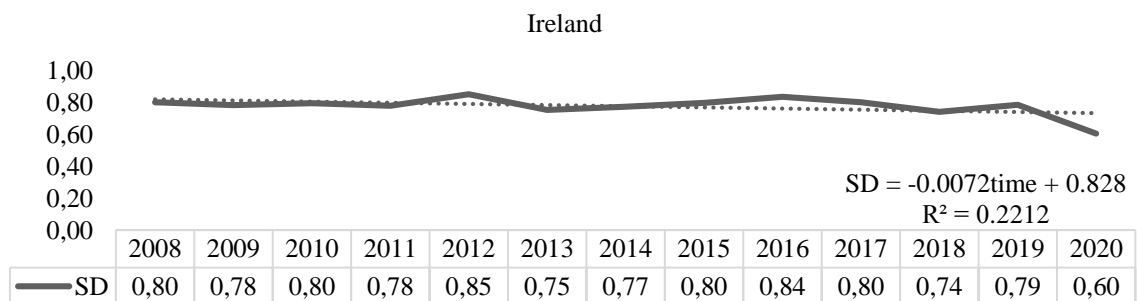
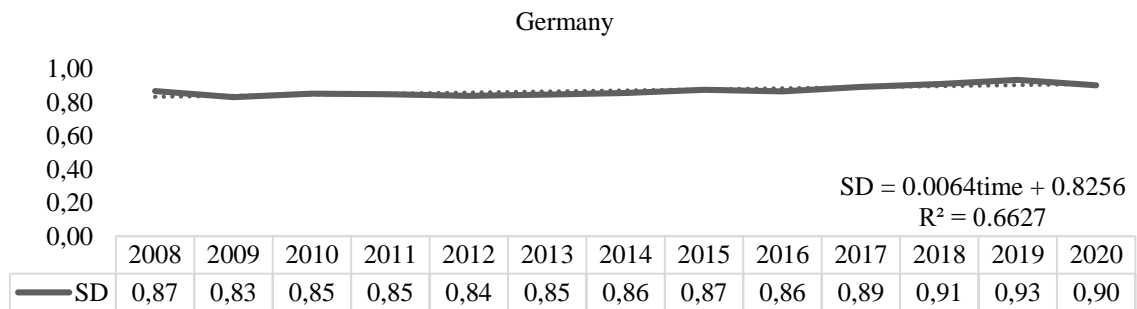
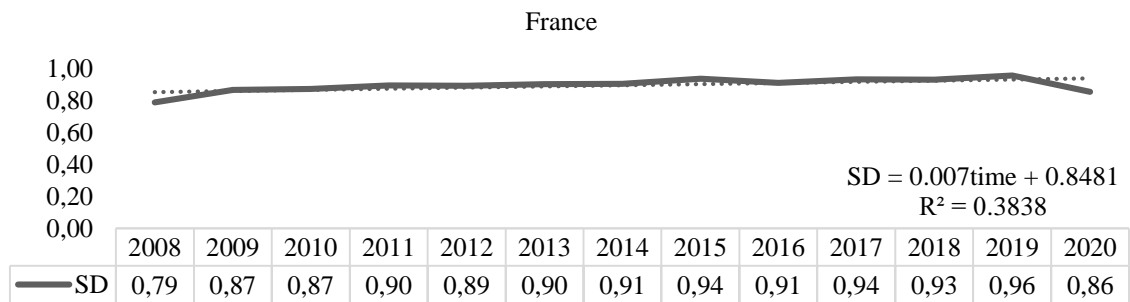
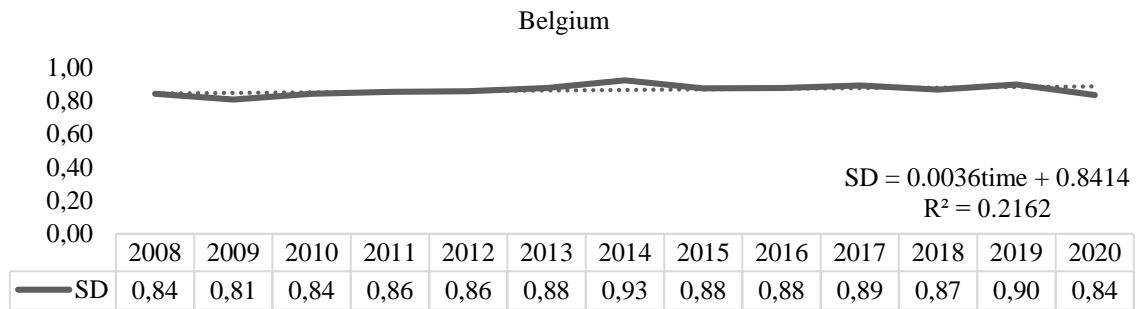
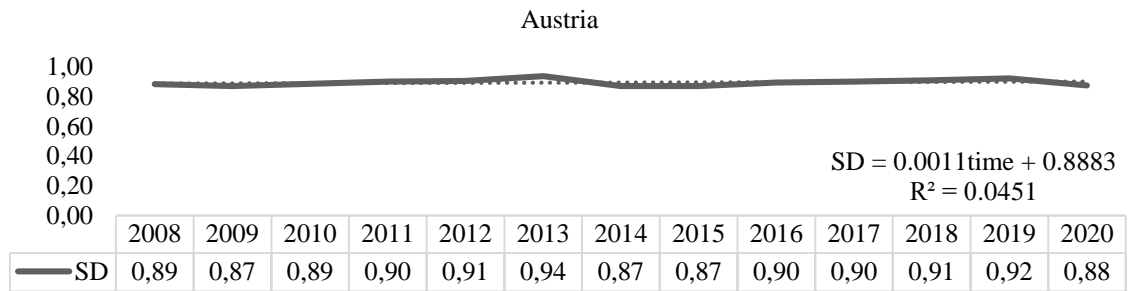
Table 1.

The descriptive statistics of the synthetic indicator of the economic development in the largest EU economies (2008-2020, the logistics sector)

Country	Sector	Variable	Mean	SD	Median	Max	Min
Austria	Logistics	E_D	0.85	0.04	0.86	0.92	0.78
Belgium			0.77	0.06	0.76	0.89	0.66
France			0.84	0.06	0.84	0.97	0.73
Germany			0.85	0.08	0.86	0.98	0.73
Ireland			0.70	0.08	0.69	0.81	0.52
Italy			0.83	0.04	0.85	0.89	0.73
Netherlands			0.82	0.08	0.78	0.97	0.66
Poland			0.73	0.14	0.70	0.97	0.50
Spain			0.81	0.06	0.81	0.92	0.71
Sweden			0.89	0.05	0.89	0.96	0.73

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Figure 2 presents the synthetic indicator of the social development of the logistics sector in the largest EU economies in the period from 2008 to 2020. The value of the indicator varies in the analyzed countries. The indicator shows a positive trend in all countries (except Ireland). It can be concluded that logistics enterprises in the surveyed countries pay special attention to social development, ensuring fair wages, safe working conditions, and respecting workers' rights. The highest positive dynamics is in Poland ($S_D = 0.0199 \text{ time} + 0.6607$, $R^2 = 0.8572$). The lowest positive dynamics is in Austria ($S_D = 0.0011 \text{ time} + 0.8883$, $R^2 = 0.0451$).



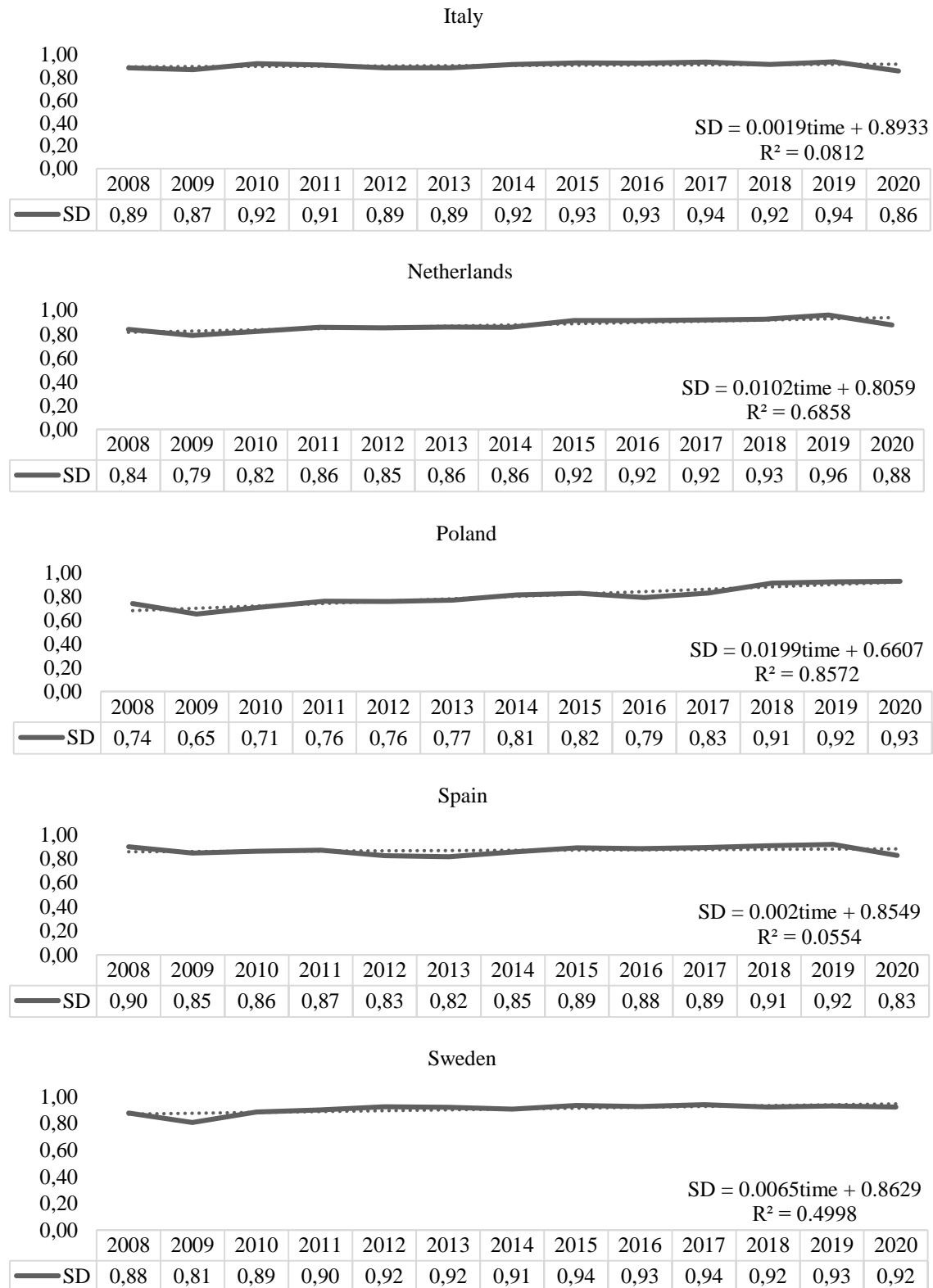


Figure 2. The synthetic indicator of the social development in the largest EU economies (2008-2020, the logistics sector).

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Table 2 shows the descriptive statistics of the synthetic indicator of the social development of the logistics sector in the largest EU economies in the period from 2008 to 2020. In the analyzed countries, the values of descriptive statistics of the indicator vary. The highest average level is in Italy and Sweden, 0.91 (SD = 0.03, median = 0.92). The lowest average level is in Ireland, 0.78 (SD = 0.06, median = 0.79). The maximum level is in France and the Netherlands (0.96; 2019), and the minimum is in Ireland (0.60; 2020).

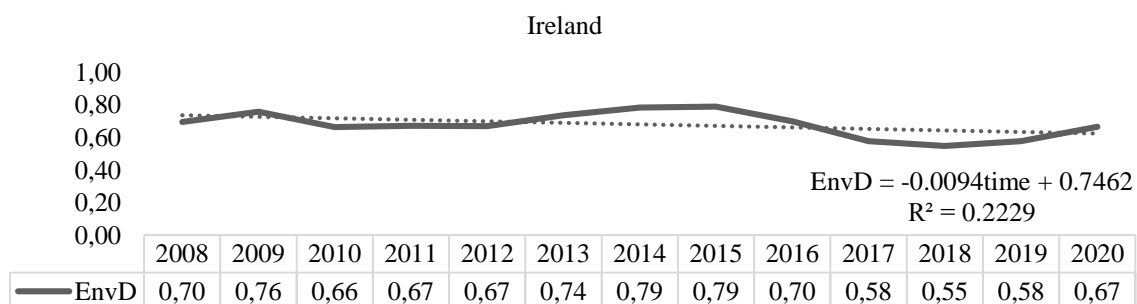
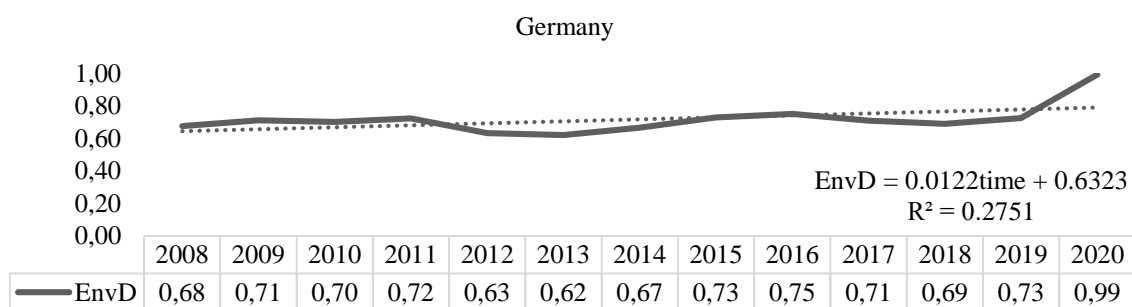
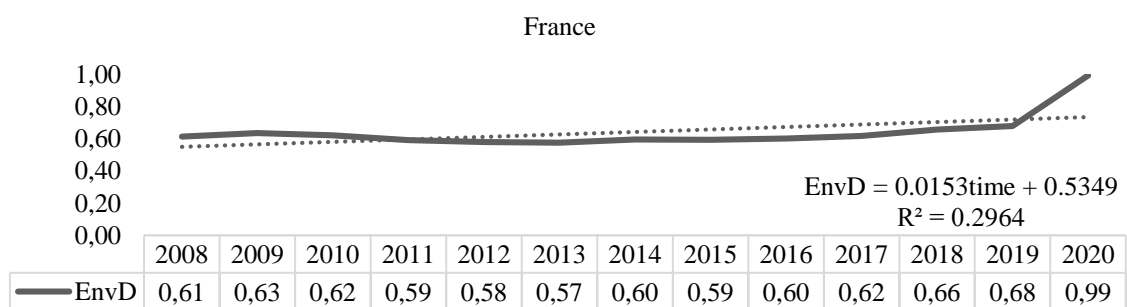
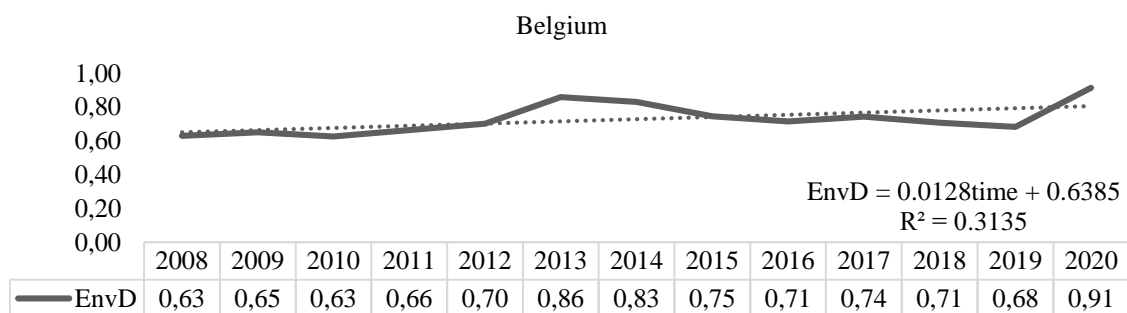
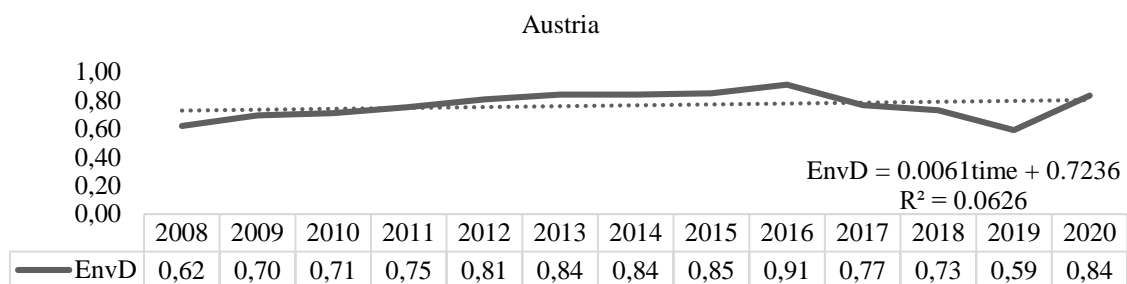
Table 2.

The descriptive statistics of the synthetic indicator of the social development in the largest EU economies (2008-2020, the logistics sector)

Country	Sector	Variable	Mean	SD	Median	Max	Min
Austria	Logistics	S _D	0.90	0.02	0.90	0.94	0.87
Belgium			0.87	0.03	0.87	0.93	0.81
France			0.90	0.04	0.90	0.96	0.79
Germany			0.87	0.03	0.86	0.93	0.83
Ireland			0.78	0.06	0.79	0.85	0.60
Italy			0.91	0.03	0.92	0.94	0.86
Netherlands			0.88	0.05	0.86	0.96	0.79
Poland			0.80	0.08	0.79	0.93	0.65
Spain			0.87	0.03	0.87	0.92	0.82
Sweden			0.91	0.03	0.92	0.94	0.81

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Figure 3 presents the synthetic indicator of the environmental development of the logistics sector in the largest EU economies in the period from 2008 to 2020. The value of indicators in the analyzed period and countries is highly diversified. The indicator shows a positive trend in Austria, Belgium, France, Germany, Italy, Poland, and Sweden, which should be assessed as very good. The enterprises from the logistics sector are highly involved in activities for environmental development in these countries and pay attention to the implementation of strategies to minimize greenhouse gas emissions, which contributes to climate change mitigation. The highest positive dynamics is in France ($Env_D = 0.0153 \text{ time} + 0.5349$, $R^2 = 0.2964$). The lowest positive dynamics is in Italy ($Env_D = 0.0024 \text{ time} + 0.8119$, $R^2 = 0.0124$). In Ireland, the Netherlands and Spain, the indicator shows a negative trend. In these countries, logistics sector enterprises should pay special attention to activities aimed at protecting the natural environment. The highest negative dynamics is in the Netherlands ($Env_D = -0.0004 \text{ time} + 0.7451$, $R^2 = 0.002$). The lowest negative dynamics is in Spain ($Env_D = -0.0127 \text{ time} + 0.868$, $R^2 = 0.1879$).



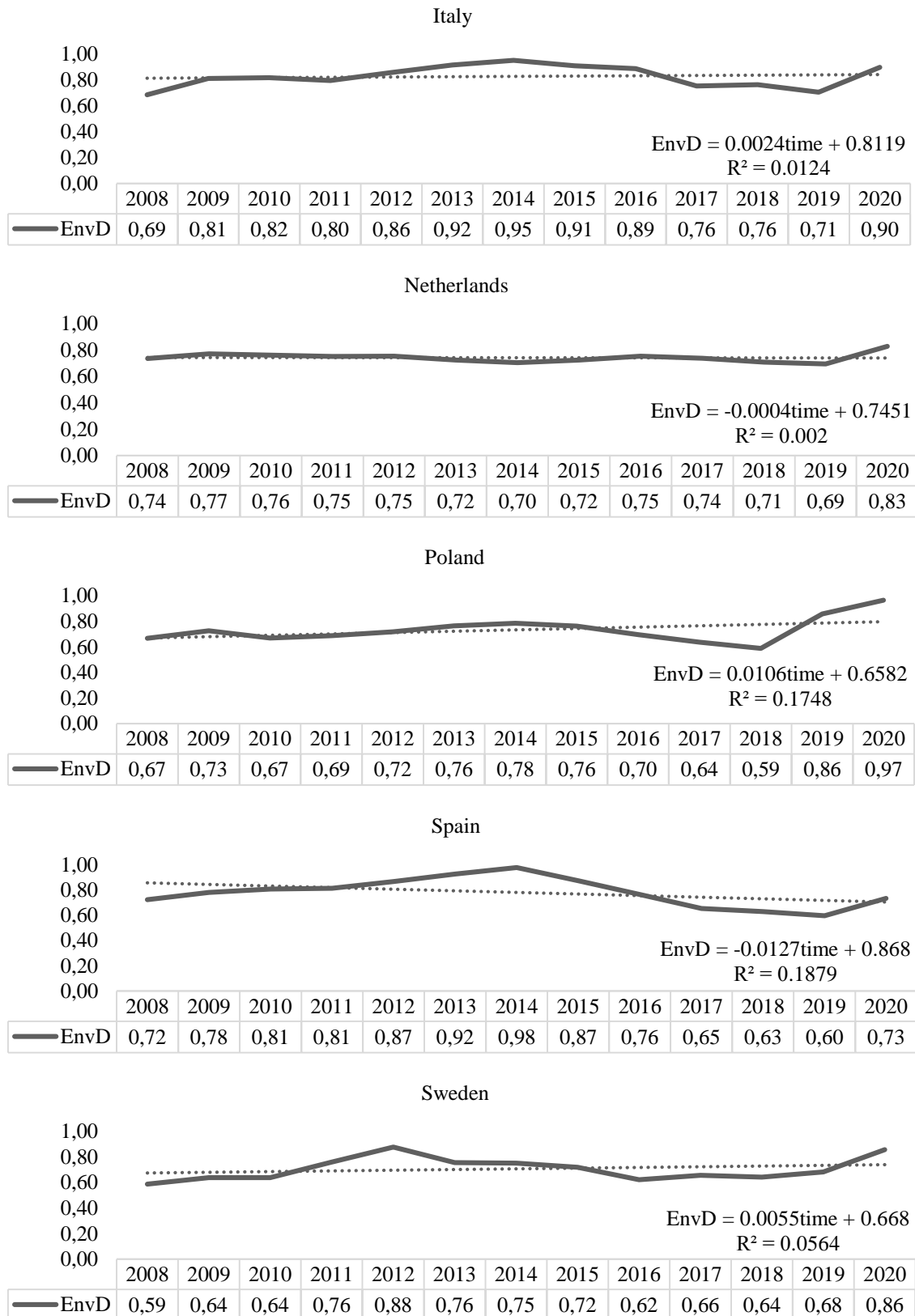


Figure 3. The synthetic indicator of the environmental development in the largest EU economies (2008-2020, the logistics sector).

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Table 3 shows the descriptive statistics of the synthetic indicator of the environmental development of the logistics sector in the largest EU economies in the period from 2008 to 2020. In the analyzed countries, the values of descriptive statistics of the indicator vary. The highest average level is in Italy, 0.83 (SD = 0.08, median = 0.82). The lowest average level is in France, 0.64 (SD = 0.11, median = 0.61). The maximum level is in France and Germany (0.99; 2020), and the minimum is in Ireland (0.55; 2018).

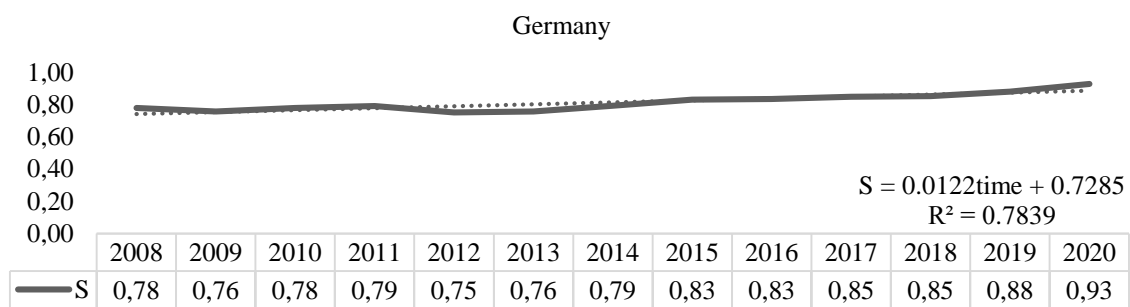
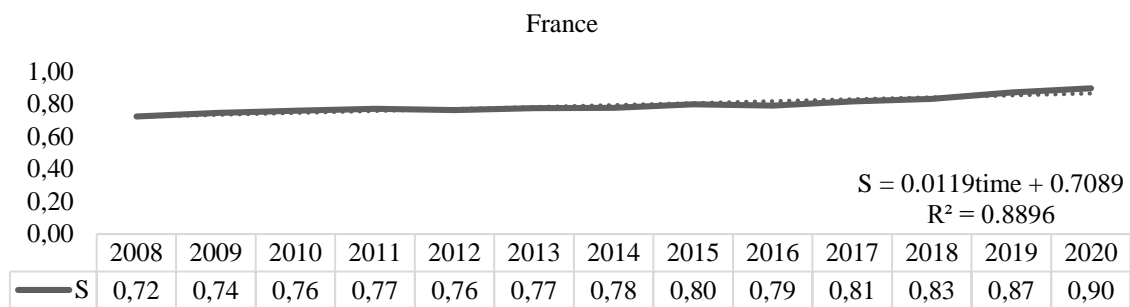
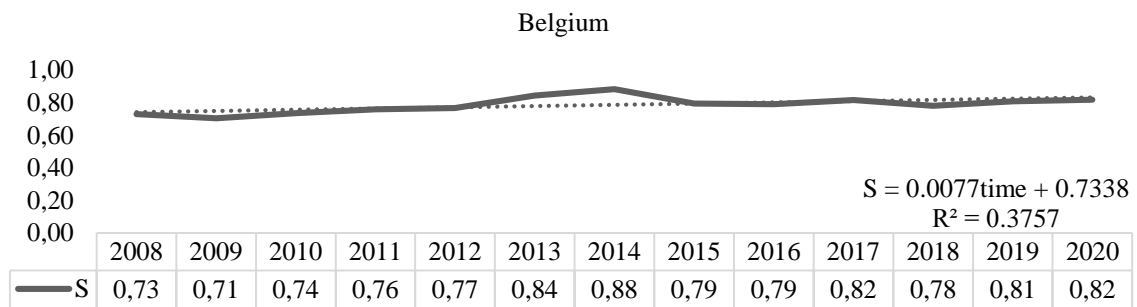
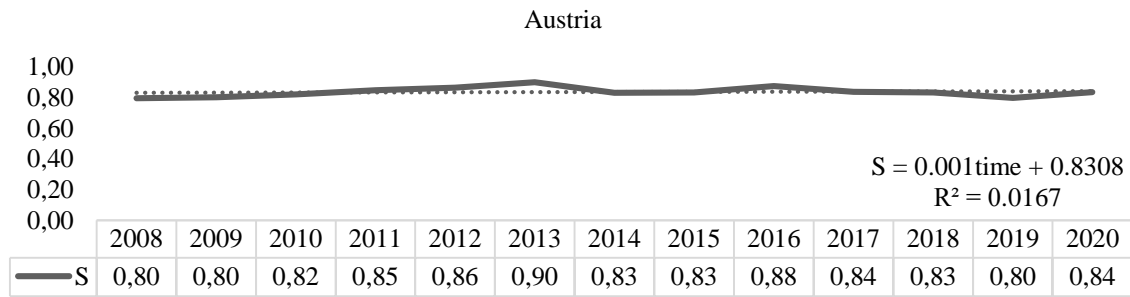
Table 3.

The descriptive statistics of the synthetic indicator of the environmental development in the largest EU economies (2008-2020, the logistics sector)

Country	Sector	Variable	Mean	SD	Median	Max	Min
Austria	Logistics	Env _D	0.77	0.09	0.77	0.91	0.59
Belgium			0.73	0.09	0.71	0.91	0.63
France			0.64	0.11	0.61	0.99	0.57
Germany			0.72	0.09	0.71	0.99	0.62
Ireland			0.68	0.07	0.67	0.79	0.55
Italy			0.83	0.08	0.82	0.95	0.69
Netherlands			0.74	0.03	0.74	0.83	0.69
Poland			0.73	0.09	0.72	0.97	0.59
Spain			0.78	0.11	0.78	0.98	0.60
Sweden			0.71	0.09	0.68	0.88	0.59

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Figure 4 presents the synthetic indicator of the sustainable development of the logistics sector in the largest EU economies in the period from 2008 to 2020. The value of the indicator varies in the analyzed countries. The indicator shows a positive trend in Austria, Belgium, France, Germany, Italy, the Netherlands, Poland, and Sweden, which should be assessed well. Logistics sector enterprises in these countries are concentrating on sustainable development from 2008 to 2020. The highest positive dynamics is in Poland ($S = 0.0221 \text{ time} + 0.5988$, $R^2 = 0.7968$). The lowest positive dynamics is in Italy ($S = 0.0007 \text{ time} + 0.8519$, $R^2 = 0.0082$). In Ireland and Spain, the indicator shows a negative trend, which is disturbing. In these countries, logistics sector enterprises should implement actions to improve sustainable development. The highest negative dynamics is in Ireland ($S = -0.0063 \text{ time} + 0.7623$, $R^2 = 0.2657$). The lowest negative dynamics is in Spain ($S = -0.0025 \text{ time} + 0.8376$, $R^2 = 0.1514$).



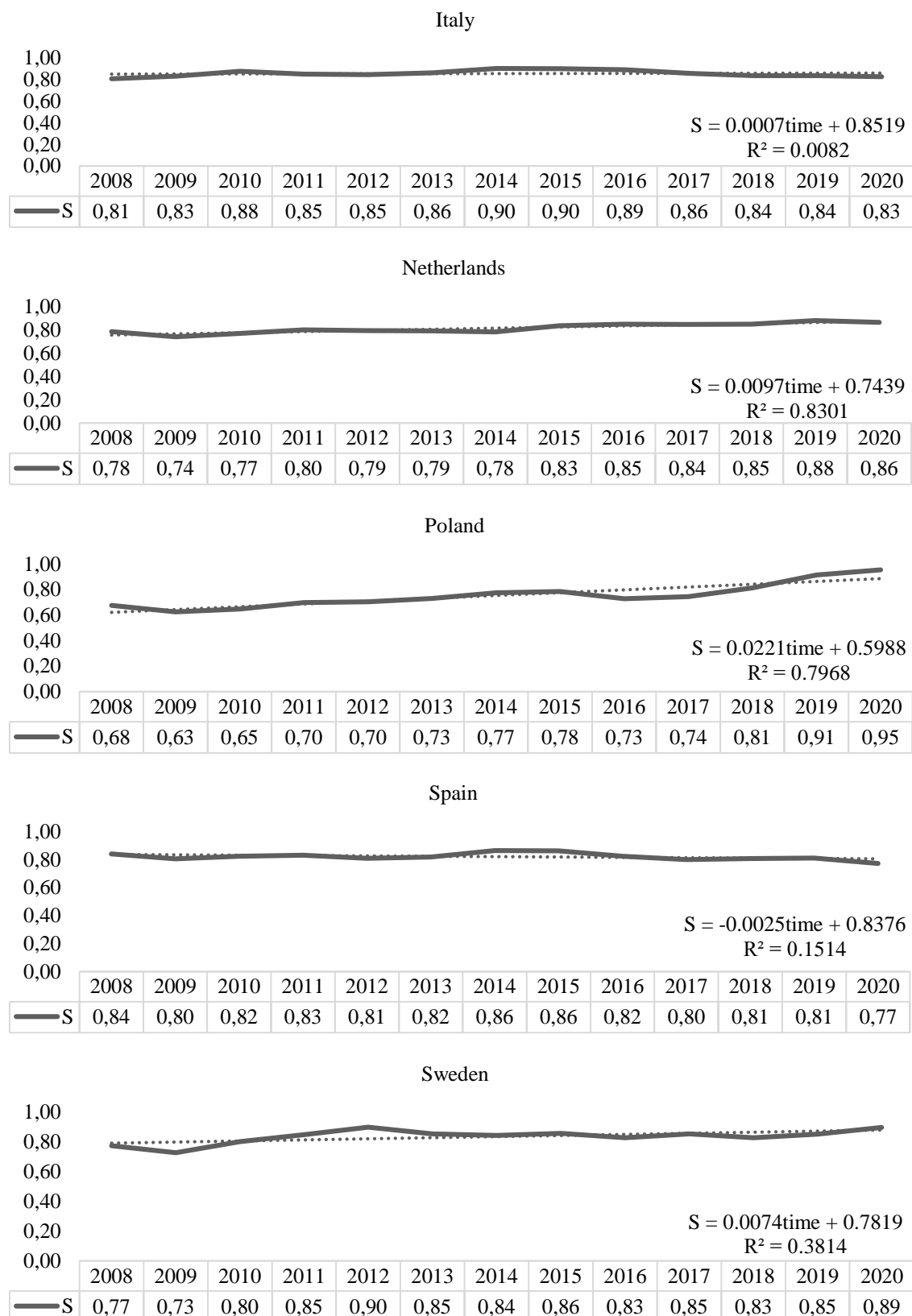


Figure 4. The synthetic indicator of the sustainable development in the largest EU economies (2008-2020, the logistics sector).

Source: own study on the basis of Eurostat <https://ec.europa.eu/Eurostat>, 21.11.2023.

Table 4 shows the descriptive statistics of the synthetic indicator of the sustainable development of the logistics sector in the largest EU economies in the period from 2008 to 2020.

Table 4.

The descriptive statistics of the synthetic indicator of the sustainable development in the largest EU economies (2008-2020, the logistics sector)

Country	Sector	Variable	Mean	SD	Median	Max	Min
Austria	Logistics	S	0.84	0.03	0.83	0.90	0.80
Belgium			0.79	0.05	0.79	0.88	0.71
France			0.79	0.05	0.78	0.90	0.72
Germany			0.81	0.05	0.79	0.93	0.75
Ireland			0.72	0.05	0.73	0.78	0.60
Italy			0.86	0.03	0.85	0.90	0.81
Netherlands			0.81	0.04	0.80	0.88	0.74
Poland			0.75	0.09	0.73	0.95	0.63
Spain			0.82	0.02	0.82	0.86	0.77
Sweden			0.83	0.04	0.85	0.90	0.73

Source: own study on the basis of Eurostat <https://ec.europa.eu/eurostat>, 21.11.2023.

In the analyzed countries, the values of descriptive statistics of the indicator vary. The highest average level is in Italy, 0.86 (SD = 0.03, median = 0.85). The lowest average level is in Ireland, 0.72 (SD = 0.05, median = 0.73). The maximum level is in Germany (0.93; 2020), and the minimum is in Ireland (0.60; 2020).

6. Discussion

The sustainable development of the logistics sector takes place in three pillars: economic, social and environmental (Breuer et al., 2021). Economic development means expanding the economic base, increasing the asset base, and improving the financial and property situation. Social development means improving working conditions and quality. Environmental development means improving eco-innovation and reducing the emission intensity of the sector (Comporek et al., 2022).

The sustainable development of the logistics sector in the ten largest economies in the European Union is diverse, although the vast majority of it has a positive trend, which is a positive phenomenon. It can be seen that in 2020, the level of economic development of the logistics sector decreased slightly, which was caused by the pandemic, but the level of social and environmental development increased. Therefore, it should be noted and agreed with researchers who point out that the pandemic has positively impacted the state of environmental protection (Brdulak, Brdulak, 2021; Comporek et al., 2021; Vilas-Boas et al., 2023; Danilevičius et al., 2023).

The main hypothesis is true because, in the most developed countries, the dynamics of sustainable development are also higher in most of the examined cases. This positive phenomenon proves that the sector is implementing good social changes and cares more about the natural environment.

The first research sub-hypothesis can be accepted because, in most economies, economic development has a positive trend (except Ireland), social development (except Ireland and the Netherlands), and environmental development (the exception is Ireland).

The second research sub-hypothesis should be rejected because only in a few cases is the level of economic development higher than social and environmental development; this could have been determined by the beginning of the COVID-19 pandemic.

The dynamics of sustainable development of the logistics sector are positive in all surveyed countries, which means that the directions of changes in the EU environmental protection policy and the fight for social development are going in the right direction.

The study has several limitations related to selecting analytical variables for the model, the research period and the availability of statistical data.

7. Conclusion

Logistics sustainability has a significant impact on social development and the state of environmental protection in all EU countries. The sustainable development of the logistics sector shows a positive trend from 2008 to 2020. In the case of the pillars of this development, the situation is also similar, although it should be noted that the economic development index in most economies decreased in 2020. Sustainable development of the sector in the most developed economies is more noticeable, and its dynamics are higher.

In our further research, we will focus on a broader assessment of the impact of external and internal conditions on the sustainable development of the logistics sector in all economies of the European Union. We want to conduct a comparative analysis of highly developed and developing economies in the European Union.

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