
DOES TRADE DEVELOPMENT DEPEND ON ROAD NETWORK QUALITY?

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Abstract: Market globalization today presumes a free movement of people, goods, and capitals, which, in turn, is intended to stimulate growth of various economic sectors and trade in particular. To this end, the development of a high-quality road infrastructure with large territorial coverage is an essential condition for the successful operation of any commercial enterprise. This study contributes to understanding how road network development affects the commercial activities of individual countries within the European Union. The correlation between domestic sales and road network length was assessed using official statistical data. The findings support the opinion that the coverage and level of development of transportation infrastructure strongly correlate with the increase of trade volumes although this relationship is manifested differently across its subsectors.

Keywords: road network, trade, sales.

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Introduction

The concept of free movement of people, goods, and capitals was at the core of the European Union's establishment, which raises the question to what extent the EU member states have improved their trade operations benefiting from the existing road infrastructure to facilitate this movement. Could trade relations among member states be hindered or intensified due to objective factors related to the quantitative parameters of transportation arteries in each country?

This study aims to answer these questions by testing the hypothesis that there is a correlation between the development of the road network in the various EU member states and the volume of their offline and online trade. In other words, we will examine the extent to which a more extensive road network serves as a prerequisite for larger trade turnovers in these countries.

The aim of this study is to investigate, based on a theoretical synthesis of the significance and interdependence of trade and level of development of the road network across the EU-27 countries, the accessibility of the population to the road network and the correlation between its territorial density and the sales performance of economic activity in NACE section G in terms of divisions 45, 46, and 47, and specifically of class 47.91. The results from this analysis will outline the possibilities for future development of trade and increase of sales volumes.

To achieve the established scientific objective, it is essential to address key tasks, the most significant of which are:

1. To conduct a brief theoretical overview of the relationship between trade and transportation.
2. To analyse the condition of road networks and domestic trade in the EU member states at certain points of time and thus determine the interdependence between the development of transport infrastructure and its effect on trade in the EU.
3. To outline the prospects for development of trade in the context on the influence of transport infrastructure on trade volumes.

Methodology

The objective state of road infrastructure in the EU member states was determined using the two primary synthetic indicators of road network accessibility and road network density, which correlate the absolute parameters of a road network length with the territory of the respective country and its population. They give a valuable insight into the complexity of the transport

network, as they show the length of the road network per 1,000 square kilometres and per 10,000 inhabitants. (Бакалова & Николова, 2010, стр. 43).

A correlational analysis will be employed to confirm or reject the hypothesis for a correlation between road infrastructure and volume of sales. Further, the methods of content analysis, critical analysis, and comparative analysis will also be implemented.

The quantitative research is limited within the framework of the following general and specific assumptions:

1. Three specific time points were selected for the assessment of certain indicators, enabling a quantitative comparison for the years 2010, 2021, and 2022. This allows for an evaluation of the progress in the expansion of the road network within the EU and its impact on the development of domestic trade.

2. The scope of the study is confined exclusively to examining the accessibility of the road network and the degree of its territorial density, which is compared with the sales performance in NACE section G, including its divisions 45, 46, and 47 as well as class 47.91.

3. The analyses are conducted with data for selected EU member states from secondary sources aggregated within the official database of Eurostat.

4. The study was limited to assessing the impact of national road networks on the development of domestic trade, although the statement that "internal transportation infrastructure affects regional access to international markets" (Cosar & Demir, 2016, p. 232) is unequivocally supported.. Furthermore, there is quantitative evidence that transportation infrastructure enhances international trade to a greater extent than it does domestic trade. (Zheng & Hongtao, 2022).

A brief theoretical overview of the relationship between trade and transportation

Essentially, trade invariably aims "to direct all its energy and activities toward the optimal utilization of existing marketplaces and the discovery of new ones, to ensure more efficient transportation of goods, to consolidate stocks of products where demand exists, and thereby to establish better relationships between producers and consumers." (Белмеръ, 1928, стр. 12). Its primary function is related to "distribution of products from producers to consumers and their sale while ensuring the most effective utilization of resources and maintaining a high standard of service." (Данчев & Христова, 2017, стр. 20). Therefore, trade facilitates the circulation of goods by assisting by delivering products to buyers. By overcoming the arising imbalances in terms of assortment, quantity, spatial allocation, and timing, it serves as a vital link between production and consumption. In this context, "trade in both industrial

and consumer goods links them through active collaboration with transportation." (Сълова, 2010, стр. 26).

In their operations, exchange agents procure products from a variety of suppliers located in different regions of a country and organize their transportation to retail establishments in proximity to customers, thereby ensuring the necessary convenience and high-quality service. Without a suitably developed road network in terms of both length and structure, merchants cannot effectively transport the goods they want to offer at the points of sale and optimally meet consumers' needs. Thus, the condition and development of the transportation network are critical factors for the success of commerce.

Meeting consumer demand depends on the proper organization of supply within the retail distribution network, where adherence to several fundamental principles is essential: (Ранков, Вацов, Чаушев, & Георгиев, 1958, стр. 134-135): 1. the goods must be delivered in terms of quantity, quality, and variety in accordance with consumer demand; 2. consistency of deliveries; 3. deliveries should ensure maximum speed of stock turnover; 4. deliveries should be carried out with the most efficient use of transportation resources while minimizing delivery costs. Adherence to these principles guarantees swift stock turnover and rational utilization of the available corporate resources, which in turn facilitates the enhancement and expansion of commercial activities. Hence, "with a robust and well-supplied transportation system and high-capacity transport arteries, it is essential to maintain a lower level of stock, and vice versa." (Сълова, Александрова, & Стоянов, 1996, стр. 150). Thus, the overall adherence to the aforementioned principles unequivocally supports the opinion that any "enhancement of transportation and communication methods will boost trade." (Добрев, 1926, стр. 98).

A proof of the direct relation between transportation and trade is that "today it is hard to imagine any economic activity that is not strongly associated with means of transportation and communication; ... it can be asserted that the means of communication and transportation are an integral part of the overall economic process." (Добрев, 1926, стр. 128). This is the main reason why, in the context of increasing sales volumes in commerce, it is imperative to ensure "a comprehensive, rhythmic, swift, and cost-effective movement and sale of goods, which requires maintaining the best possible alignment between the offered and demanded goods in terms of quantity, assortment, quality, timing, and location of consumption, as well as rationalizing the methods and channels for movement of goods... considering the rapid development of transportation, which facilitates the flow of goods to consumers." (Георгиев & Георгиев, 1960, стр. 32).

Many economists have studied how changes in population size and composition as well as the state of industry, agriculture, trade, and

transportation influence the volume and structure of commodity turnover. (Тотев & Георгиев, 1957, стр. 28). Thus, road infrastructure “matches the needs, level of development, and activities of other sectors of the national economy, sustaining the overall rhythm and cadence of their systematic and proportional development for the collective enhancement of societal well-being.” (Чолаков, 1957, стр. 31) This is further corroborated by various quantitative studies that prove the correlation between road network density and quality and the regional economic development, measured by GDP per capita at the NUTS 3 level in Bulgaria. (Яззатов, 2024) This is also supported by a study conducted by A. Banerjee, which proves that access to internal transportation infrastructure has a positive causal effect on per capita GDP levels across various sectors in China. (Banerjee, Duflo, & Qian, 2020)

The above discussion supports the claim that road transport “plays a vital role in modern society by facilitating trade, economic growth, and social connections between communities” (Sennder, 2024).

Analysis of EU’s domestic trade and road network

In essence, the volume of sales is one of the main indicators of the business activity in NACE’s section "Trade; Repair of Motor Vehicles and Motorcycles". At the same time, it is the primary objective of every enterprise and a fundamental variable for calculating many economic metrics as it is the most crucial factor for enhancing profitability. Sales volume determine a company’s market share and potential for expanding its business as well as influence the level of consumption and the standard of living of the population. During the years covered by this study (2010, 2021, and 2022) there was a consistent increase in the sales volume (in million euros) across the entire economic sector of "Trade" in the EU-27, along with its subsectors; however, the most pronounced growth was reported in online retail, which recorded an astonishing growth rate of 389.7% in 2022 compared to 2010 (see Table 1).

The statistics presented in Table 1 reveal that trade within the 27 member states of the European Union shows a notable increase in both its turnover and significance as a sector that directly meets the needs of European consumers. It achieved an impressive volume of EUR 11,188,284 million in 2022, which is an increase of 13.8% compared to 2021 and an extraordinary 26.1% increase from the levels in 2010. The most substantial share of total sales over the three years is reported for NACE section G46 “Wholesale trade, except of motor vehicles and motorcycles (approximately 59% across the three years), attributable to the larger quantities of goods typically traded in this line of business.

The second position in terms of sales volume in this section is held by retail trade, except of motor vehicles and motorcycles (G47) as it is an

intermediary that directly engages with and meets the needs of end consumers. In 2022, the reported sales in this segment amounted to EUR 3,225,545 million, accounting for 28.8% of the total turnover of the EU-27 countries. Unsurprisingly, the third largest volume of sales, totalling EUR 1,364,135 million in the final year of the study, was reported for section G45, which encompasses the wholesale and retail trade of motor vehicles and motorcycles, along with their technical maintenance and repair.

Table 1

Volume and structure of sales in section G, its divisions G45, G46, G47 and class G47.91 in the EU -27 countries in 2010, 2021 and 2022

Year / Indicator	2010		2021		2022	
	Sales (EUR mln.)	Rel. share (%)	Sales (EUR mln.)	Rel. share (%)	Sales (EUR mln.)	Rel. share (%)
Econ. activity						
G Wholesale and retail trade; repair of motor vehicles and motorcycles	8 870 099	100.0	9 830 309	100.0	11 188 284	100.0
G45 Wholesale and retail trade and repair of motor vehicles and motorcycles	1 020 376	11.5	1 253 725	12.8	1 364 135	12.2
G46 Wholesale trade, except of motor vehicles and motorcycles	5 257 689	59.3	5 663 458	57.6	6 598 605	59.0
G47 Retail trade, except of motor vehicles and motorcycles	2 592 034	29.2	2 913 125	29.6	3 225 545	28.8
G47.91 Retail sale via mail order houses or via Internet	53 600	0.6	240 000	2.4	262 496	2.3

Source: (Eurostat, 2024a) (Eurostat, 2024b).

* The volume of sales in class G47.91 „Retail sale via mail order houses or via Internet” was calculated using the data published in Eurostat, where there is no information about the volume of sales in certain EU member states.

The share of sales made online is remarkably small, although their growth in 2022 compared to 2010 was significant due to advancements in technology, shifting consumer attitudes towards e-commerce, and the ongoing digitalization. Nonetheless, online shopping cannot supplant traditional sales, as the European population remains reluctant to use online channels for everyday purchases. Since its emergence as an independent economic activity, the existence of the retail sector has been contingent upon road network availability and coverage as it serves as essential infrastructure for product distribution and customer interaction.

The road freight transport sector plays a crucial role in the European transportation system. According to Eurostat data for 2022, its relative share of transport activities among EU member states stands at the impressive 73.2%, significantly surpassing maritime transport, which accounts for only 18.9%. Rail freight transport follows at a modest 7.8%, while inland waterway transport contributes a mere 2.6% of European cargo shipments, and air transport unsurprisingly holds an insignificant 0.07% share of the total freight activity. Thus, road freight transport is essential for ensuring that the commercial sector is supplied with a wide range of products, effectively catering to customer demand.

A critical condition for the operational effectiveness of road transport in freight logistics is the development of the road network across the European continent, as its extent and characteristics fundamentally determine both market accessibility and transportation efficiency.

Table 2 presents a systematic compilation of data used to calculate road network density both across the entire EU and for each member state, expressed in kilometres per 100 square kilometres of territory. Additionally, it includes indicators for road network accessibility level, again for the entire EU, measured in kilometres per 10,000 inhabitants and further differentiated by member state.

Considering the information in Figure 1, we can objectively assert that many of the countries with larger populations report lower road network accessibility levels compared to those with smaller populations. A remarkable disparity is observed between the lowest value of 10.8 km per 10,000 inhabitants for Portugal and 669.4 km per 10,000 inhabitants for Estonia, which is a significant deviation from the EU average, which, as of 2022, stands at 90.4 km per 10,000 inhabitants.

Table 2

Indicators of road network density and accessibility in the 27 Eu member states in 2010, 2021 and 2022

Member state	Road network density (km/100 sq. km. of territory)			Road network accessibility (km/10 000 people)		
	2010	2021	2022	2010	2021	2022
EU-27	76.1	87.5	87.5	79.6	90.4	90.4
Belgium	500.4	506.1	506.1	141.6	134.3	133.6
Bulgaria	17.1	17.2	17.2	25.6	29.3	29.5
Czech Republic	164.7	164.1	164.1	124.2	123.3	123.1
Denmark	n.a.	171.3	171.4	n.a.	125.9	125.3
Germany	n.a.	64.3	64.3	n.a.	27.6	27.6
Estonia	128.6	196.7	196.7	437.2	670.4	669.4
Ireland	136.0	146.1	146.1	209.0	201.7	198.3
Greece	n.a.	89.5	89.5	n.a.	110.4	112.7
Spain	29.9	29.7	29.7	32.6	31.7	31.6
France	162.7	171.3	170.7	160.6	161.4	160.4
Croatia	49.6	44.3	44.4	65.3	64.5	65.1
Italy	82.1	75.8	76.5	41.6	38.6	39.2
Cyprus	134.7	140.2	140.8	152.1	144.7	144.0
Latvia	91.2	89.0	89.8	277.9	303.5	309.1
Lithuania	125.3	129.4	128.4	260.4	300.6	298.7
Hungary	213.0	230.8	232.7	197.8	222.4	225.2
Malta	747.3	903.5	899.1	57.0	55.3	54.6
Netherlands	344.2	370.4	371.9	77.6	79.2	79.0
Austria	134.6	148.6	150.5	135.1	139.5	140.6
Poland	130.2	137.8	137.1	106.8	115.9	115.9
Portugal	11.3	12.2	12.2	9.8	10.8	10.8
Romania	34.4	35.8	35.8	40.4	44.4	44.8
Slovenia	188.0	188.4	188.1	186.2	181.1	180.9
Slovakia	87.5	92.0	92.0	79.6	82.6	83.0
Finland	31.0	23.0	23.0	196.3	140.8	140.4
Sweden	47.5	44.2	44.2	227.4	190.6	189.4
Norway	24.3	24.7	24.7	192.5	176.4	175.3

Source: Authors' calculations based on Eurostat data (Eurostat, 2024a); (Eurostat, 2024b); (Eurostat, 2024c); (Eurostat, 2024d); (Eurostat, 2024e).

Bulgaria ranks 25th within the Union; however, a closer examination of the evolution of this indicator over the years reveals that the increases in its values for the country are not primarily due to the expansion of the national road network, but rather the result of a population decline of over one million in the past thirteen years. It is evident that the positive trend in the indicator of road network accessibility in Bulgaria is largely influenced by the significant reduction of its population, which offsets the rate of road construction in the country. This is corroborated by the official data published by the National Statistical Institute, which indicates that from 2010 to 2022, a total of 488 km of roads were constructed in Bulgaria, of which 388 km are highways and 200 km are tertiary roads, while 91 km of first-class roads and 9 km of second-class roads have been decommissioned. (НСИ, 2024).

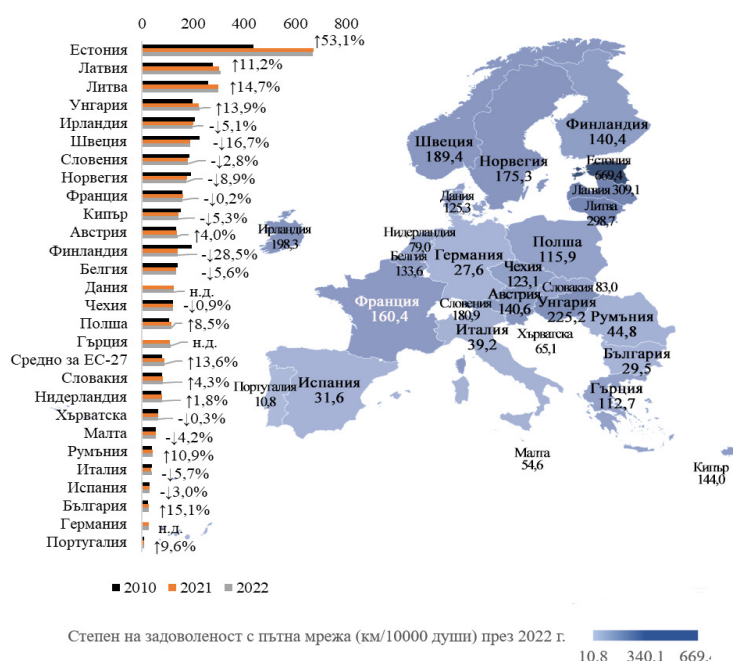


Figure 1. Road network accessibility by EU member state. Compiled by the authors using information from Eurostat (Eurostat, 2024c); (Eurostat, 2024d)

Consequently, this indicator may be used to assess road networks capacity to accommodate freight traffic of consumer goods and provides a sound foundation for analysing the relationship between freight flows and the quantitative measures of the existing transport infrastructure as it is directly

related to the empirical measures of the population, i.e. the consumers of commercially exchanged goods.

Another significant measure of road network development is the density indicator, i.e. the ratio of the length of roads and the territory of a country, which reveals the level of infrastructure development achieved. It is a well-established fact that there is a considerable disparity among the EU member states. For instance, Malta boasts the highest density, with 899.1 km of roads per 100 square kilometers of territory, while Portugal reports the mere 12.2 km. per 100 sq. km. (see Figure 2).

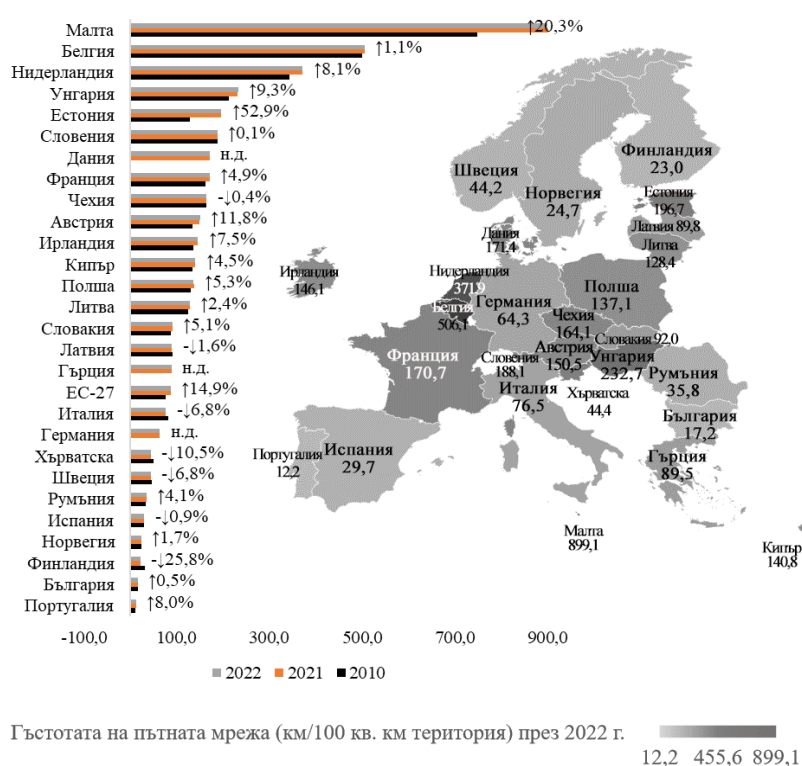


Figure 2. Road network density by EU member state. Compiled by the authors using information from Eurostat (Eurostat, 2024c); (Eurostat, 2024e)

Obviously, this indicator is affected by the absolute size of the country, given that Portugal's territory is 92,212 sq. km. while the territory of Malta is only 316 sq. km. However, despite the substantial disparities, it is noteworthy that Portugal considerably diverges from the EU average European Union, which is 87.5 km. per 100 sq. km.

Similar conclusions can be drawn for Bulgaria, which ranks 10th in the EU by territory, effectively making our country one of the relatively larger states in Europe in terms of land area. Nevertheless, with regards to the density of its road network, however, Bulgaria occupies the penultimate 26th position in this ranking.

Undoubtedly, we have to take into account the influence of rationality in the strategic development of road networks, which should cover and connect various transportation hubs and destinations, with a priority on economic viability and demand of transportation links.

The analysis of the data should take into account the fact that road network characteristics are affected not only by economic and social factors, but also by natural and geographical factors, such as the topography of the territory. However, it is also imperative to acknowledge the inadequate degree of awareness regarding the significance of investments in road infrastructure for Bulgaria's national and regional social and economic development.

A brief overview of the road network density indicators of the EU member states reveals their significance within the context of examining the relationship between transportation infrastructure and trade dynamics because road network density level defines the diversity of transport decision-making and the rates of goods exchange as well as guarantees the physical access of traders to remote markets.

Assessment of the correlation between road network development and volume of trade in the EU member states

The analysis of the correlations between road network length (LRN) and highways length (LH) in kilometers on the one hand and domestic sales volumes (in mln. EUR) in sector G and its divisions 45, 46, and 47, specifically class 47.91 in the EU member states, reveals that their statistical significance is increasing (see Table 3).

Comparatively, the length of highways is assumed to be a significant factor for the overall growth of sales in trade sector G and its main divisions sectors (G45, G46, and G47). However, its effect is not as pronounced with regard to e-commerce. Such a finding can be explained with the role of other means of transportation (primarily air and maritime transport) in facilitating more expedient or cost-effective delivery of goods ordered online. Conversely, the reason for this situation may be the proliferation of local deliveries of goods purchased online, which is the backbone of rapid commerce (Q-commerce), where highways do not present a viable solution for the delivery of goods shipped via the local road networks and delivered up to 60 minutes after the order is placed. Another distinctive characteristic is that in the short-term period of 2021–2022, the correlations did not change significantly and remained at high and very high levels, whereas there is a notable increase in their values compared to 2010.

Table 3

Correlations between sales volumes in Sector G and its divisions and the length of road networks and highways in 2010, 2021 and 2022

Year/Indicator Econ. activity	2010		2021		2022	
	RNL (km)	HL (km)	RNL (km)	HL (km)	RNL (km)	HL (km)
G Wholesale and retail trade; repair of motor vehicles and motorcycles	0.406*	0.503	0.795**	0.838**	0.809**	0.839**
G45 Wholesale and retail trade and repair of motor vehicles and motorcycles	0.396*	0.512	0.802**	0.829**	0.814**	0.813**
G46 Wholesale trade, except of motor vehicles and motorcycles	0.406*	0.509	0.818**	0.833**	0.804**	0.819**
G47 Retail trade, except of motor vehicles and motorcycles	0.395*	0.528	0.791**	0.849**	0.791**	0.864**
G47.91 Retail sale via mail order houses or via Internet	0.424*	-0.053	0.833**	0.716**	0.750**	0.673**

Source: Authors' calculations using Eurostat data (Eurostat, 2024a); (Eurostat, 2024b); (Eurostat, 2024c); (Eurostat, 2024f).

Note: * the correlation coefficient is statistically significant at level 0.05. ** the correlation coefficient is statistically significant at level 0.01.

The highest correlation coefficient for 2022 was calculated for the relationship between the length of highways (in kilometres) and retail sales (G47), which reached the remarkable value of 0.864. This positive correlation supports the assumption that countries with superior highway infrastructure report higher primary effects stemming from the economic activities of commercial enterprises in the retail sector. The interpretation of the other correlations is similar and definitely highlights the significance of road length in kilometres for the volumes of sales (in millions of euros) in this sector of trade and its subsectors.

Therefore, the countries with poorer road network accessibility will have poorer trade performance in the commercial sector. It follows naturally that lower values of primary effects in trade cannot be explained solely by the influence of transportation infrastructure; logically, they should be attributed to a broader complex of factors inhibiting sales (e.g. unfavourable developments in price levels, income instability, level of implementation of appropriate trade networks, etc.)

Discussion and prospects for further development

The corroborated correlation between the growth of trade volumes and the level of infrastructure connectivity undoubtedly defines the primary imperative that investments in transportation infrastructure development should be the top priority in national development. The underlying logic is that transportation infrastructure has a profound stimulatory effect on the entire economic and social system not only within individual countries but also in the broader context of their interconnectivity. One of the key development prospects that has the potential to impact trade is the emergence and proliferation of autonomous transportation vehicles and unmanned cargo delivery. Beyond the public debate regarding the risks associated with automation in transportation technologies, they provide opportunities for significant reduction of operating costs (mostly those related to the human factor), route optimization, improvement of real-time control and monitoring of deliveries, timely execution, adherence to delivery conditions, etc. Autonomous delivery technologies should be considered in both the context of large transportation vehicles and smaller delivery solutions for short distances. They will boost the online trade volumes and order delivery times by means of autonomous drone deliveries on short distances. Their growing popularity can be directly attributed to “advancements in technology and legislation, exacerbated conventional delivery challenges, and pandemic-mediated need for contactless deliveries.” (Srinivas, Ramachandiran, & Rajendran, 2022, p. 102834).

Conclusion

The main conclusions of this paper are based on the following major findings:

1. The development of road infrastructure measured in terms of road network density (the ratio of road length to country's territory) and road network accessibility (the ratio of road length to population size) is a significant factor

for trade performance. Its level of development is considered a crucial factor for increasing trader's economic efficiency.

2. Road infrastructure accessibility is a vital factor in enhancing the domestic trade volume, which increased significantly over this period, primarily due to the proliferation of e-commerce.

3. Economic integration and barrier-free international connectivity among EU member states and third countries serve as a catalyst for further accelerating trade performance, not least due to the fact that citizens of individual countries can, through the right to free movement, take advantage of more favourable trading conditions in neighbouring member states.

These conclusions are valid under *ceteris paribus* conditions, i.e. when the quality of the road network, the competition, and the level of development of alternative transportation networks (railways, air transport, waterways, etc.) as well as the impact of various other economic factors (such as product pricing, consumer income, trade margins, traders' operating costs, market competition, market strategies, etc.) on trade performance are not taken into account.

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