The Impact of Intermodal Connectivity of Transport Networks on Net Exports in the European Union Member States

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Abstract

In this paper we propose to evaluate the impact of intermodal connectivity of transport infrastructure on net exports in the European Union. In this context, we will test the hypothesis that the intermodal capacity development has the effect of increasing net exports. The impact assessment pursues two objectives: quantifying the extent to which intermodal connections help the balancing of net exports of European states and identifying the areas where infrastructural deficit has an impact on trade deficit in order to prioritize the infrastructure development interconnections. The volume of net exports is influenced by the degree of interconnection of transport infrastructure, which gives the intermodal nodes the role of cohesion agents at the community level. On the other hand, the integration into the global economy fosters improvements in net trade, fact revealed by the correlation between the KOF Index of globalization and the values of net exports.

Keywords: transport infrastructure; intermodal connectivity; net exports; European Union;

JEL Classification: F14; O18; R41;

1. Introduction

The net export (balance of trade) is an index that shows an economic relevance on both its sides, as trade surplus and a trade deficit. As a trade surplus, the net export represents one of the main economic growth "engines", seen as an essential contributor for the current account and Gross Domestic Product (GDP) creation, fact that explains the pro-export measures and strategies adopted by all governments. The trade surplus volume in the European Union has grown 3.7 times between 2007 and 2016, and this trade explosion has determined a significant pressure on the transportation network that sustains the goods and services stock. But the national net exports geography is highly unequal in the European space. Given the fact that the capital investments in many of the European states have a limited level (Bellak *et al.*, 2010, p.38), exports stimulation and the transition from a trade deficit to a surplus remains a desideratum to ensure the economic growth for more than half of the European governments.

Along with other international trade determinants, the endowment with reliable transportation infrastructures is a critical advantage for stimulating the commercial flows (Copenhagen Economics and Blomström, 2006, p. 18). The appropriate equipping with transportation infrastructures as a development and territorial cohesion vector represents, as a matter of fact, a major objective of the European Transportation Policy (European

Commission, 2013), but in the meanwhile it represents a variable depending on the investment capacity and the decisional will of national governments. The positive consequences of a good territorial equipping with transportation infrastructures on the net exports improvement are the elements broadly acknowledged in the real economy, but also in the scientific literature, which focuses its attention on the interrelations between the two measures.

According to the latest scientific studies' tendencies, the aim of this paper is to assess the impact of the transportation infrastructure intermodal connectivity on the national net exports in the European Union space. In this context we are not going to approach the transportation networks in their function as material infrastructures linked to production, as they are treated in the industrial economy studies (Gramlich, 1994, p. 1178), but from the perspective of their interconnection and accessibility agents, a quality which they offer to the commercial flow run.

The intermodal connectivity is given by the existence of network nodes where transportation lines belonging to different types of infrastructures (road, railway, airway, fluvial, maritime) meet. For every network type we will consider the following infrastructural elements: the highway network, the high speed railway network (that allow over 200 kph running speeds), national airports and maritime and fluvial harbours.

The approached paradigm postulates that the national policies in the transportation fields whose consequences are the development of intermodal connections will have effects in the net exports volume growth, which are also influenced by the degree of integration of national economies into the global economy.

The results of this undertaking highlight the relation between the inter-connective infrastructures and the net exports volume. In the European Union the accents put differently on the connection infrastructure development have a correspondent in the net exports value differences on the European Union's economic map, even though the commercial balance improvement is a declared aim of all the European governments. Also, the increased integration into the global economy catalyzes net exports, but at a more reduced pace and magnitude than the intermodal transport infrastructures.

The paper is structured as follows: first section introduces the scientific knowledge and the theoretical accumulation in the field of transportation infrastructure impact on trade; the second section depicts the various data categories used to quantify the net exports and the intermodal connection infrastructures and also the methodological tools used for the impact analysis; section three displays the research results and in the end one can find the conclusion.

2. Theoretical Background

Not only the transportation network interconnectivity but also the balance of trade are major interest elements for the regional and market development studies. They also represent an evaluation subject at the national and community decision-makers' level to underlie the normative regulations. Though, the relation between the two parameters was less approached in the literature, in comparison with the studying of the impact of other trade determinants (market factors, the exchange rate, the foreign exchange, foreign currency reserves, inflation, productivity etc). The fact is owed partly to the absence of

data and significant variables referring to the transportation networks intermodal connections.

The role of intermodal connections in the net exports dynamics is analyzed mostly in terms of impact on the investments generating exportable production according to the academic literature. The research attention is focused on the infrastructure equipment as a premise for the production investments (Bellak *et al.*, 2010, p. 40, *Apud* Richter *et al.*, 1996) and for export easing. Other references presume the fact that a transportation infrastructure development can determine a disinterest for the local firms to externalize their production (Egger and Falkinger, 2006, p. 2003), which may lead to increasing the internal production and hence increasing the exports volume. In their quality of determinant factors for the spatial economy (Rietveld and Bruinsma, 1998, p. 7), the transportation infrastructures matter as size, distribution, surface, but also as intermodal connections through which the transportation cost reduction and the trade volume growth are ensured (Macharis *et al.*, 2010, p. 557; Bensassi *et al.*, 2015). The actual spatial effects observed during the case studies show that the most elevated sensitivity of exports in relation to the transportation networks characteristics is registered for the border and coast regions, where the positive border effect is owed to the reduced distances and the intermodal nodes in the harbours (Bensassi *et al.*, 2015, p. 57).

The results of some recent empirical research show that the interconnected development of the transportation networks determines in an indirect way the exports volume growth. According to the impact study realized by Tong *et al.* (2014), the accessibility given by the highway networks would cause weak effects on the economic growth (GDP), meanwhile economic growth determines effects, with a multiple years delay, on the transportation infrastructures development. At the same time the transportation and non-transportation infrastructures development has a cumulative impact on the exports growth, also with a certain delay. In fact, the authors consider that the broadening of transportation networks and intermodal connections has an indirect effect in the exports and economic growth, effect that is mediated by two intermediate measures: the transportation infrastructure generates at first the development of public non-transportation infrastructures and private capital accumulation (Tong *et al.*, 2014, p. 73), which, at their turn, determine in a second phase the GDP and exports growth. Consequently, the evaluation of economic benefits resulted from the intermodal connection of the networks (for example, between the highways and harbours), or from the highway building in regions with the highest probability to stimulate the private capital accumulation is recommended; the evaluation under scrutiny can fundament governmental decisions to prioritize the budgetary allocation to create intelligent transportation systems, in order to optimize traffic (Tong *et al.*, 2014, p. 76-77).

Starting from the assumption that the positive influence of transport networks on trade is given by infrastructure quality and transport costs, Limão and Venables (2001) quantifies the elasticity of commercial flows according to the cost of transport and demonstrates that the decline in transport infrastructure in the second the third quartile in terms of quality determines the increase in transport costs by 12% and reduces the volume of net exports by 28% (Limão and Venables, 2001, p. 451). At the same time, improving the quality of transport logistics from the 25^{th} to the 75^{th} quartile would be equivalent to the impact of a 5,000-mile decline in geographic distance and would generate an increase in bilateral trade between states by 25% (Clark *et al.*, 2004, p. 23); in the case of air transport, the same improvement rate would result in a 15% reduction in transport costs (Micco and Serebrisky, 2004). By a similar algorithm, Martinez-Zarzoso calculated that for Spain 1% improvement in contact infrastructure would lead to a 0.14% reduction in transport costs

and an increase of 1.65% in exports of ceramics products (Martinez-Zarzoso *et al.*, 2003, p. 187). The most obvious evidence of the influence of transport accessibility on trade results from the comparative assessment of the trade of coastal states and of those without sea opening. In the 1990s, coastal countries recorded an average net contribution of 28% in GDP formation, compared with 11% in the case of low-income economies; between 1965 and 1990, between the top 15 exporting countries in the world, 8 were island states, including the United Kingdom from the European Union and none without a sea opening (Limão and Venables, 2001, p. 451 *Apud* World Bank, 1998). At the same time, under the current conditions of global trade liberalization, transport costs constitute a more severe trade barrier than protectionist taxes and tariffs (Limão and Venables, 2001, p. 452).

Bensassi *et al.* (2015) quantified the role of expanding interconnected transport networks on the volume of exports through composite indices, namely land infrastructure index and logistics performance index. By applying the above mentioned indicators, the author estimated that, in the case of Spain, the increase in the space distribution of infrastructures from the 25th to the 75th quartile had the effect of increasing exports by 35% (Bensassi *et al.*, 2015, p. 54).

In order to improve the transportation infrastructure quality – essential to the net trade growth, especially for the less developed countries, Nordas and Piermartini (2004) proposed the solution of streamlining the harbour infrastructures as the key to increasing the participation in the global trade of the states under scrutiny. In the context of lack of financial possibilities for the governments of these countries to exhaustively develop their transportation networks, van Klink and van den Berg (1998) and Sanchez *et al.* (2003) state that the costs for improving the harbour infrastructures are more permissive and can serve as an engine for pulling out of underdevelopment the problematic economies and not only (van Klink and van den Berg, 1998, p. 2; Sanchez *et al.*, 2003, p. 205). Multiple case studies reveal that in the European Union the inter-connexive role of the harbours is undoubtedly to encourage the exports in the hinterlands they serve (Acciaro *et al.*, 2016), significant being the cases of the German Hanseatic harbours which will maintain the trading competition in the North Atlantic basin (Twrdy and Batista, 2016, p. 138; Paradigma Gmbh, 2014) and which succeed in competing the Italian ones in the South despite the geographic distance (Acciaro *et al.*, 2016, p. 343; SRM, 2015, p. 133; Ferrari *et al.*, 2011, p. 382). The harbours' developments as intermodal nodes would allow later, according to a gravitational model, the industrial areas emplacement next to them to facilitate exports (Nordas and Piermartini, 2004, p. 18). The gravitational model items calculation allowed Donaubauer *et al.* (2015, p. 9) to show that the positive relation of the transportation infrastructures on the trade exchange is governed by causality effects, non-linear reversible, quantifiable through an index which measures the trade relations between the member states in a free-change agreement. The significant innovative contribution of the Donaubauer index resides in the fact that it takes into consideration the role of the political elements in evaluating the transportation network impact on trade (Donaubauer *et al.*, 2015, p. 18). In the European Union's case, with more development speeds, the mentioned model could be applicable for the less developed member states of the "second speed European belt". Following some empirical studies made on the bilateral exchanges, Francois and Manchin (2013, p. 165) demonstrate that the interconnected transportation networks represent both a trade multiplier factor and a trade generator. Previously, the authors had shown that the political factor, through the quality of the institutional environment, plays a decisive role both in configuring some competitive transportation networks and a feasible normative frame for catalyzing exports (Francois and Manchin, 2006, p. 23).

The most pregnant input brought by the growth of interconnected infrastructure quality is registered in the less developed economies, where, as Wilson appreciates, the harbour and airport infrastructures' improvement, but also the business facilities, would increase the global trade volume with 377 billion USD (Wilson *et al.*, 2005, p. 841), and a decrease in the transportation of goods costs with 10% as a consequence of a good intermodal integration of the networks would cause a 4.4% increase in the global trade (Márquez-Ramos *et al.*, 2011, p. 569). Also, according to Coca-Castaño *et al.*, the improvement of the informatics assisting process of the interconnected infrastructures – intelligent transportation type, is responsible for a significant increase of the trade exchanges (Coca-Castaño *et al.*, 2005, p. 18).

Considering the last four decades of international trade continuous growth context, Blonigen and Wilson (2013) appreciate that there is also a reverse determination relation, respectively the trade growth bears pressure on the transportation network development, especially of the maritime and harbour infrastructures. These are the most appropriate to be used as intermodal connection nodes to ensure the commercial flows' run (Blonigen and Wilson, 2013, p. 630), responsible for maintaining the big harbours in the Western Europe as the main "hubs" of export-import of the European Union.

3. Empirical Approach

3.1. Data and measurement of net exports and intermodal connectivity

In order to measure the balance of trade (net exports), we will take into account the aggregate net exports of goods and services for each European Union member state at 2016 values. This paper uses data on net exports of world states obtained from the OECD Data (OECD, 2016). The use of cumulative data for the net export of goods and services offers the advantage of unitary quantification of the relationship between transport networks' interconnections and total trade balance. However, this approach also has limits in terms of the absence of a separate assessment of the impact of infrastructure on net exports of goods and net exports of services. In spite of this, the assessment allows us an integrated perspective on the impact of intermodal infrastructures in the configuration of national current accounts.

The intermodal connectivity, expressed by the number of intermodal nodes, was determined by the authors by interpolation of the categories of transport networks (motorways, high-speed railways), starting from international airports and ports, as reference interconnection nodes. We will analyze the impact of intermodal capacities on net exports through three parameters that we have designed to evaluate the impact on networks integration levels:

- Intermodal nodes of the first order (main nodes) interconnect the infrastructure elements of all four categories of network (highways, high-speed, airports, ports). The 54 main nodes identified in European Union are major international ports and airports located exclusively within the trans-European network TEN-T and are the main export-import hubs in European Union (Heijman *et al.*, 2017, p. 352); they play a major role as developers for the regions they polarize, but contribute to the creation of large economic divergences in the community space (Rotter, 2004, p. 362) because the other non-equipped spaces with such connections lag behind them.
- Intermodal nodes of the second order (412 intermediate nodes) interconnect elements of three out of the four categories of networks.

▪ Third order intermodal nodes (870 primary nodes) interconnect the infrastructure elements of two out of the four categories of networks and provide basic synapses of transport networks across the continent. Their relevance in the network derives from the fact that, although they do not have the polarizing valences of the first and second order nodes, they are the most widespread in the territory and thus contribute to the interconnection of the less developed regions and to the reduction of the interregional cleavages.

The table of the intermodal connectivity supply of the transport infrastructure compared to the net exports of the European Union member states (Table 1) highlights both direct and indirect correlations, analyzed in the next section of this paper.

Table 1. Intermodal connectivity of transport networks and net exports of European Union countries

Intermodal connections \ Trade balance		Excess trade balance	Deficit trade balance
Total number of intermodal connections	≥50	Germany, Spain, Italy, Belgium, Netherland, Austria, Sweden	France, United Kingdom, Finland
	20-49	Denmark, Poland, Portugal	Greece
	<20	Bulgaria, Czech Rep., Estonia, Ireland, Croatia, Latvia, Lithuania, Luxembourg, Hungary, Slovenia, Slovakia, Malta	Cyprus, Romania
Number of first order intermodal connections	≥3	Germany, Spain, Italy, Netherland, Sweden	France, United Kingdom, Greece
	1-2	Belgium, Denmark, Austria, Poland, Portugal	Finland
	0	Bulgaria, Czech Rep., Estonia, Ireland, Croatia, Latvia, Lithuania, Luxembourg, Hungary, Malta, Slovenia, Slovakia	Cyprus, Romania
Number of second order intermodal connections	≥10	Germany, Spain, Italy, Netherland, Sweden, Belgium, Denmark, Austria	France, United Kingdom, Finland, Greece
	5-9	Ireland, Poland, Portugal	–
	<5	Bulgaria, Czech Rep., Estonia, Croatia, Latvia, Lithuania, Luxembourg, Hungary, Slovenia, Slovakia, Malta	Cyprus, Romania
Number of third order intermodal connections	≥30	Germany, Spain, Italy, Netherland, Belgium, Sweden, Austria	France, United Kingdom, Finland
	10-29	Portugal, Denmark, Ireland, Poland	Greece
	<10	Bulgaria, Czech Rep., Estonia, Croatia, Latvia, Lithuania, Luxembourg, Hungary, Malta, Slovenia, Slovakia	Cyprus, Romania

Source: Authors' own representation using data from OECD (2016)

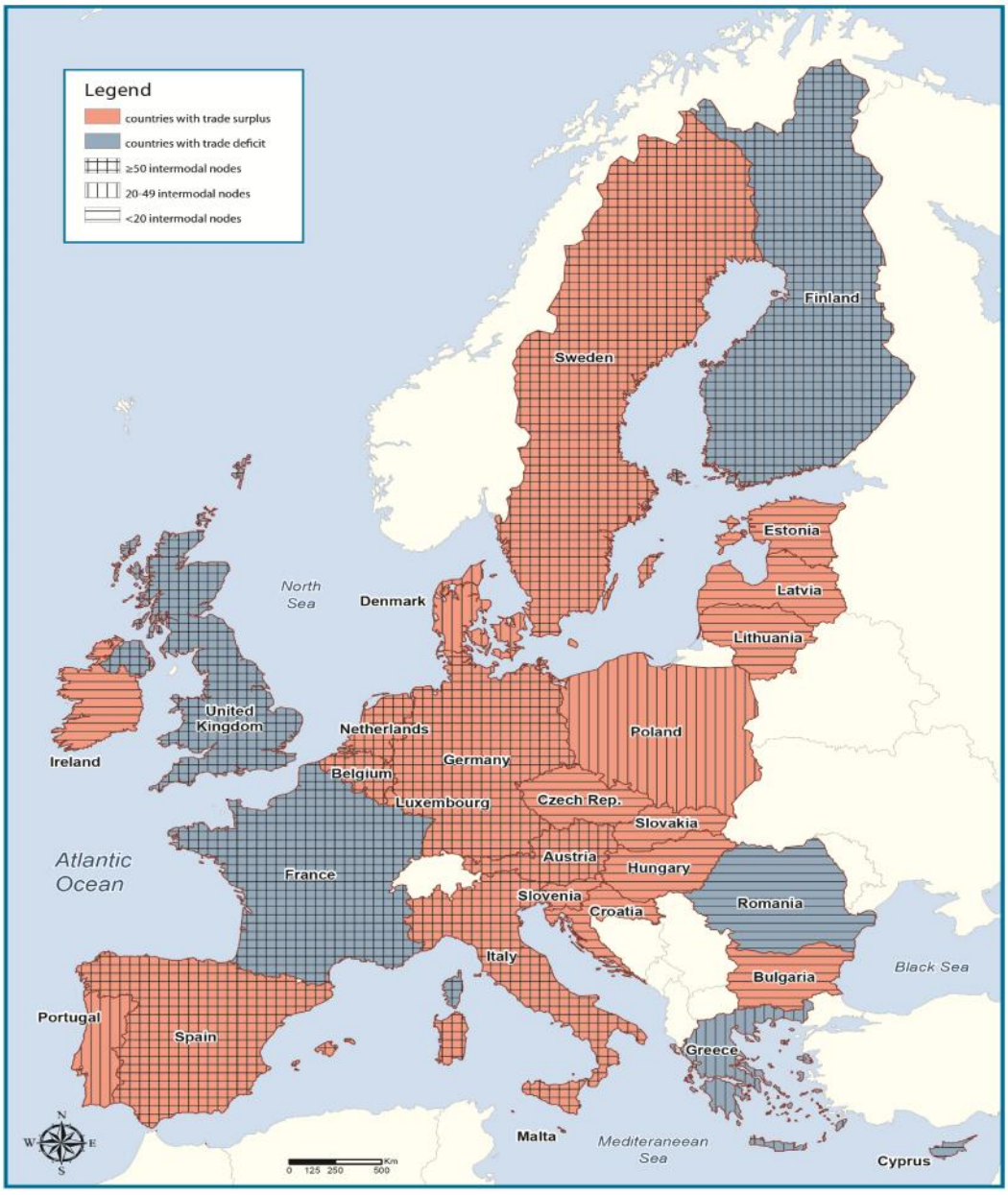
Territorial equipment with intermodal nodes projects a European Union with more interconnection "speeds" (Figure 1), according to the following model:

- well-interconnected transport infrastructure (with more than 50 intermodal nodes, of which at least 3 of them are of the first order) generally have a surplus trade balance (Germany, Spain, Italy, the Netherlands, Belgium, Austria, Sweden); exceptions to the rule, such as France, the United Kingdom or Finland, whose trade balance is severely deficient, are due to other specific economic factors.
- most of the medium-interconnected spaces of transport networks (20-50 intermodal nodes of which at least one of the first order) also have an over-trade balance (Denmark, Poland, Portugal) and for the exception of Greece the deficient net export is due to internal economic factors.

- countries with poor intermodal connections (less than 20 intermodal nodes and no first level connections) comprise 12 states integrated after 2004 (except Poland) plus Ireland and Luxembourg; they register a trade surplus balance, with the exception of Cyprus and Romania.

In order to estimate the degree of integration into the global economy, we will take into account the values of KOF Index of globalization for each European Union member state, obtained from the KOF Swiss Economic Institute database (Gygli *et al.*, 2018).

Figure 1. Distribution of intermodal connections and national net exports in EU



Source: Authors' own representation using data from OECD (2016)

3.2. Methodological aspects

Our research hypothesis states that government decisions for the development of intermodal transport capacities, along with the degree of global economic integration, have the effect of increasing net exports.

In this context, the main objective of our approach is to show to what extent the intermodal connections of transport networks contribute to balancing the trade balance. A second objective is to identify the areas where the infrastructure deficit places its mark on the trade deficit, in order to prioritize the development of interconnected infrastructure at decision-makers level.

In order to estimate the impact, we will use an econometric gravitational model consisting of two sets of linear regressions similar to those used by Nordas and Piermartini (2004), but different by the linear and not logarithmic character of the equations. In the first regression, the number of intermodal nodes represents the independent variable, and the net exports of European Union member states is the dependent variable. In the second multiple regression, we will quantify the influence of the intermodal connections and global economic integration on the net trade growth; in this equation the values of the national net exports are the dependent variable and the number of intermodal nodes and the values of the KOF Index of globalization are the independent variable.

In this section we present the gravitational model with its equations, and in the next section ("Results and Discussion") we evaluate and interpret the regression results. The equations of the two sets of linear regressions will be the following:

$$y = ax + b + \varepsilon_e \quad (1)$$

where: y - net exports (dependent variable);
x - number of intermodal nodes (independent variable);
a, b - regression coefficients;
ε_e - regression residuals.

$$y = ax + bz + c + \varepsilon_i \quad (2)$$

where: y - net exports (dependent variable);
x - number of intermodal nodes (independent variable);
z - KOF Index of Globalization (independent variable);
a, b, c - regression coefficients;
ε_i - regression residuals.

Specifically, we will use the value of regression coefficients and residuals to customize for each European Union member state the contribution of interconnected infrastructures and global integration to net exports. The adjusted correlation coefficient (adjusted R^2) gives the average share of the influence of intermodal capacities and global integration on net exports at community level. The regression coefficients provide information on the added value of each intermodal node to the net export volume. The value of the regression residuals gives the measure of the "weight" of the intermodal infrastructures and the level of integration into the global economy in the net export configuration compared to other determinants. Mapping of residual values provides significant indications of spaces for which the improvement of interconnection links and deeper global integration would lead to an improvement in the trade balance.

4. Results and Discussion

As shown in the previous section, we apply the gravitational analysis model in the two specific situations: the impact of intermodal transport network connections on net exports and the cumulative impact of intermodal connections and degree of global economic integration on net export volumes.

4.1. The impact of intermodal connections on net exports

The gravitational econometric assessment reveals a significant link between the development of interconnected infrastructures and national trade balances for each member state (Table 2).

Table 2. Table of net exports regression of European Union countries depending on intermodal connections of transport networks

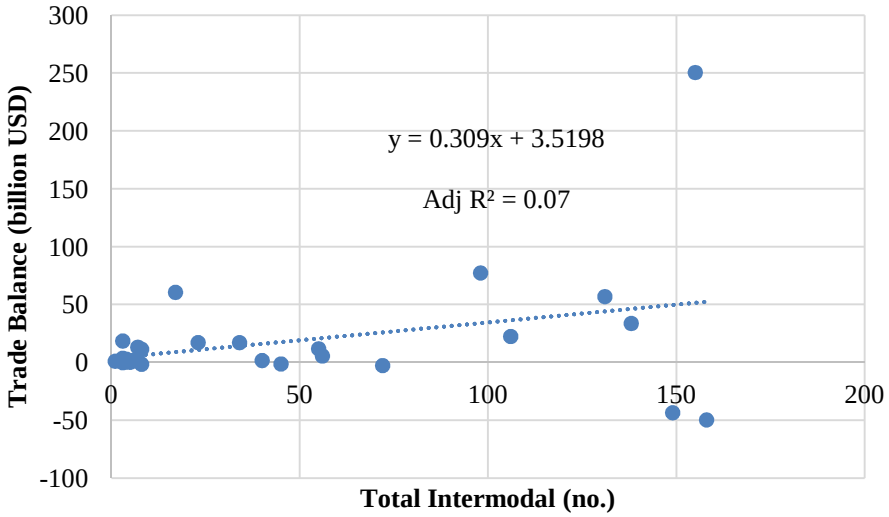
Regression Statistics	
Multiple R	0.324634355
R Square	0.105387465
Adjusted R Square	0.07097929
Standard Error	50.38470044
Observations	28

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	7775.434844	7775.434844	3.06286126	0.091895114
Residual	26	66004.06901	2538.618039		
Total	27	73779.50385			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	3.520	12.731	0.276	0.048
Total Intermodal (no.)	0.309	0.177	1.750	0.032

Figure 2. The relationship between the net exports of European Union countries and the intermodal connections of transport networks



Source: Authors' own representation using data from OECD (2016)

The relationship between the two parameters is valid (Significance F=0.09189) and the equation of the linear regression is (Figure 2):

$$y = 0.309x + 3.52 + \varepsilon_e \quad (3)$$

where: y - net exports;
x – no. of intermodal nodes;
ε_e - residual of net exports' regression.

According to the positive value of the coefficient a=0.309, the correlation between the volume of national net exports and the number of intermodal nodes is direct and positive at the European Union level, and each existing or configured intermodal node accounts for USD 309 million in the trade balance. Theoretically, if there were any state in the European Union (non-existent situation), its trade balance would be only USD 3.52 million (according to the coefficient b=3.52), plus the value of the residual for the concerned state (ε_e).

Residuals of regression (ε_e) represent the most interesting parameter of evaluation and interpretation, as they measure the influence of other factors which contribute together, as we have seen, 93% of the trade balance. The calculated residual values vary over a wide range, from a maximum of 19.9 for Germany to a minimum of -10.1 for the United Kingdom. Such eccentric values reflect, as we have seen, a particular dynamics of the economic situation resulting from a much more substantial contribution of market and productivity factors than infrastructure. For this reason, it is more interesting to evaluate the spatial distribution of residuals by removing the three states (Germany, United Kingdom, France) from the analysis that we will continue to perform.

The value of the adjusted R^2 coefficient (0.07) highlights that intermodal transport network links account for 7% of national net exports. It is a relatively small share, which highlights the major role of other determinants (market factors, exchange rate, foreign exchange reserves, inflation, labour productivity), which contributes 93% to the trade balance. At the same time, the graph of the equation renders an exaggerated dispersion of the corresponding values for states with high commercial surplus (Germany) or with major trade deficit (United Kingdom, France); this phenomenon distorts the results of the assessment, namely it diminishes the impact of intermodal connections on net exports.

In this context, we made a new regression by excluding the three mentioned states, resulting in a more homogeneous regression model (Table 3).

Table 3. Table of net exports regression of EU countries' intermodal connections of transport networks, excluding Germany, France and the UK

Regression Statistics	
Multiple R	0.580933187
R Square	0.337483368
Adjusted R Square	0.308678297
Standard Error	17.7711206
Observations	25

ANOVA

	Df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3700.09652	3700.09652	11.716109	0.002325831
Residual	23	7263.69273	315.8127274		
Total	24	10963.7892			

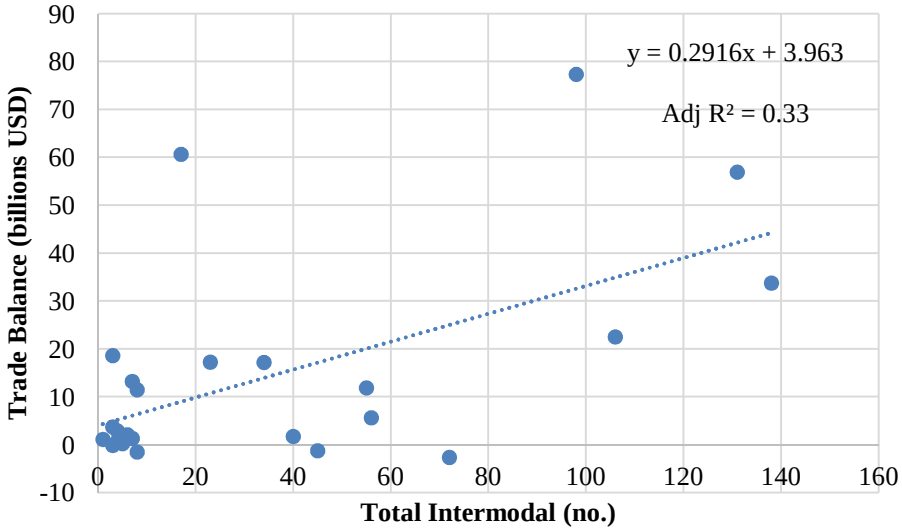
	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	3.963	4.646	0.853	0.040
Total Intermodal (no.)	0.292	0.085	3.423	0.002

In this case, the equation of linear regression is (Figure 3):

$$y = 0.291x + 3.963 + \varepsilon_e \quad (4)$$

where: y - net exports;
x – no. of intermodal nodes;
ε_e - residual of net exports regression.

Figure 3. The relationship between the net exports of European Union countries (excluding Germany, France and the UK) and the intermodal connections of transport networks



Source: Authors' own representation using data from OECD (2016)

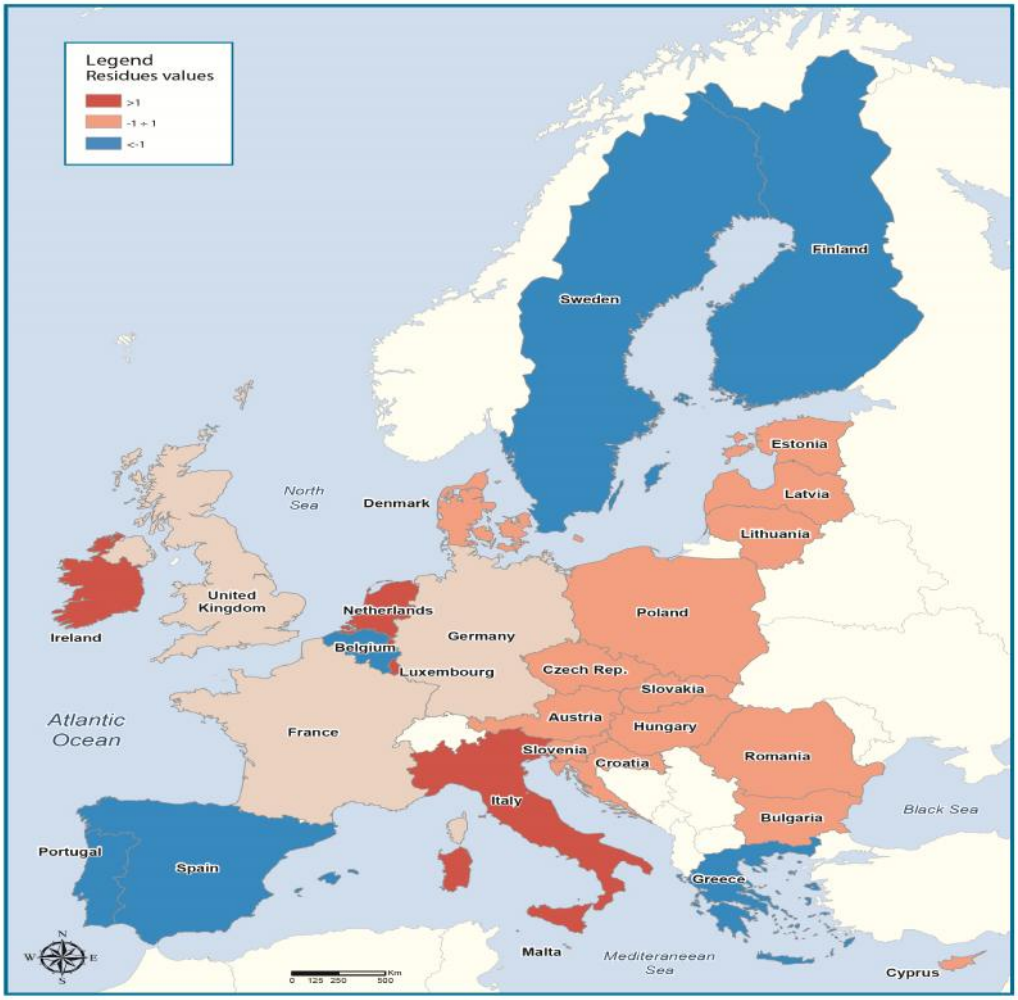
In this new version of the regression, each existing or configured intermodal node brings, according to the value of the coefficient a = 0.2961, a balance of trade contribution of USD 296.1 million. The value of the adjusted R^2 coefficient (0.308) points out that the interconnection nodes of the transport networks account for 30.8% of the national net exports. It is a relatively large proportion, which shows that, in the absence of the three major European economic powers (Germany, United Kingdom and France), the other determinants contribute only 69.2% to the trade balance. Of these, the customs tariffs acting as external trade barriers (Anderson and van Wincoop, 2003) represent, in the case of the European Union, a serious protectionist factor in relations with extra-community partners. Our findings are in line with the ones of Bougheas *et al.* (1999), Clark *et al.* (2004), or Blonigen and Wilson (2008), who all found that increases in either infrastructure or port efficiency lowers transport costs and leads to increases in international trade.

Within the framework of the exclusion of the three major European economies, the residual values ε_e describe a more interesting distributional geography of the influence of the other determinants (Figure 4). Thus, for the most of the European Union space (15 states) the balanced residual values (between -1 and +1) predominate, which points that in a predominantly well-developed area such as the one of the European Union, there is a balance between the contributions of the various factors that stimulate trade. For 6 states

(Belgium, Greece, Spain, Portugal, Finland, Sweden) intermodal connections stand out as the main stimulating factor of trade, as evidenced by negative eccentric residual values (ε_e<-1). In contrast, for only 4 states (Ireland, Netherlands, Luxembourg, Italy), the intermodal nodes, though well-represented and interconnected, are eclipsed in supporting trade by the multitude of other high-quality stimulating factors, confirmed by positive eccentric residues (ε_e> 1), given by a robust trade surplus.

As for the case of Central and Eastern Europe, only Poland represents a more evolved space from this point of view (Šakalys and Palšaitis, 2006, p. 151), managing to configure 23 intermodal nodes of which 1 node of first order, a real premiere for the spaces of the new accession wave after 2004 and with a beneficial impact on net exports (the largest trade surplus in ex-communist countries).

Figure 4. Distribution of the residual regression of net exports by number of intermodal nodes in EU



Source: Authors' own representation

In terms of comparing the residual values with the net export values, the differentiated relevance of the contribution of intermodal connections of different orders to balance of trade is highlighted (see the Appendix). It is noted that all states with negative eccentric residual values and significant trade surpluses are well equipped with first-order intermodal nodes (Belgium, Greece, Spain, Portugal, Finland and Sweden). These first-order infrastructure elements are thus the main nucleus of economic and space polarization. Also, by interpolating the residual values of the regression with the net

exports values, we formed a map of the European Union of the needs of covering the European space with intermodal nodes in order to offer greater trade dynamics (Figure 5).

Figure 5. Estimating spatial connection intermodal priorities in relation to potential trade growth

Source: Authors' own representation

As a function of the degree of vulnerability given by the rarity of intermodal connections, we propose a hierarchy of spaces that require priority intermodal interlinking (third order), highlighting two priority spatial categories:

- the most vulnerable are the countries with negative residual values of regression and without intermodal connections of the first order respectively Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Estonia, Malta, Romania, Slovenia, and Slovakia;
- the second priority spatial category is represented by the areas with positive subunit residual values of regression and without intermodal connections of first order, respectively Hungary and the Czech Republic.

4.2. The cumulative impact of intermodal connections and global integration on net exports

The gravitational econometric analysis reveals a more significant relationship between net trade dynamics on the one hand and the development of intermodal connections which adds the degree of global economic integration on the other hand (Table 4).

Table 4. Table of net exports regression of European Union countries depending on both intermodal connections of transport networks and global economic integration

Regression Statistics	
Multiple R	0.326856484
R Square	0.106835161
Adjusted R Square	0.035381974
Standard Error	51.34092273
Observations	28

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	7882.24517	3941.122585	1.49517699	0.243582018
Residual	25	65897.25868	2635.890347		
Total	27	73779.50385			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-29.916	166.604	-0.180	0.859
Total Intermodal (no.)	0.292	0.200	1.461	0.157
KOF Index of Globalization	0.410	2.035	0.201	0.842

Sources: Authors' own representation using data from OECD (2016) and Gygli *et al.* (2018).

The value of the significance coefficient (Significance F=0.243582) highlights the irrelevance of the complex relationship among the variables taken into account. Both intermodal transport network links and degree of global economic integration explain only a 3.5% share of the national net exports. This is a very small share due to the fact that the main three major European economies (Germany, United Kingdom and France) have exaggerated trade surplus (Germany) or trade deficit (United Kingdom, France), despite they are also highly integrated into the global economy according to KOF Index values.

This phenomenon distorts the results of our assessment. Therefore, we made a version of the regression with the exclusion of the three specified states, resulting in a more homogeneous regression model (Table 5).

Table 5. Table of net exports regression of European Union countries depending on both intermodal connections of transport networks and global economic integration, excluding Germany, France and the United Kingdom

Regression Statistics	
Multiple R	0.661330321
R Square	0.437357793
Adjusted R Square	0.386208502
Standard Error	16.74500004
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	4795.09867	2397.54934	8.55061292	0.001788774
Residual	22	6168.69058	280.395026		
Total	24	10963.7893			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-104.975	55.300	-1.898	0.041
Total Intermodal (no.)	0.214	0.089	2.399	0.025
KOF Index of Globalization	1.340	0.678	1.976	0.032

Source: Authors' own representation using data from OECD (2016) and Gygli *et al.*(2018).

In this case, the equation of multiple linear regression is as follows:

$$y = 0.214x + 1.34z - 104.975 + \varepsilon_i \quad (5)$$

where: x - no. of intermodal nodes;
z - KOF Index of Globalization;
ε_i - residual of net exports' regression.

Within this version of the regression, the correlation between the values of national net exports, the number of intermodal links and the degree of global economic integration makes sense only if there is a positive balance of trade (trade surplus). In this situation, the correlation is even stronger: each intermodal node brings, according to the value of the coefficient a=0.214, a balance of trade contribution of USD 214 million, and the degree of integration into the global economy added about 1.34 billion USD, according to the value of the coefficient b=1.34.

The value of the adjusted R^2 coefficient (0.386) points out that the interconnection nodes of the transport networks and the degree of global economic integration account for 38.6% of the national net exports. It is a relatively large proportion, which shows that, in the absence of the three major European economic powers (Germany, United Kingdom, France), the other determinants contribute only 61.4% to the trade balance.
The difference between the two regression adjusted R^2 coefficient values (0.386 for the multiple regression of net exports according the intermodal connections and the degree of integration into the global economy and 0.308 for the simple regression of net exports according the intermodal connections only) shows the influence (7.8%) exerted by global economic integration in national trade balances configuration.

5. Conclusion

In this paper, we evaluated the role of the intermodal transport network connections and the integration into the global economy, in order to calibrate the net exports of the European Union Member States.

The results obtained allow for a better understanding of the inter-relational mechanism between the interconnection capacities of the transport infrastructure, the degree of global economic integration and the export-import trade flows of the European Union countries. Our empirical analysis shows that intermodal transport nodes appear to be one of the active factors that influence the volume of national net exports, playing the role of agents of economic and territorial cohesion in the European area. The spatial accessibility of intermodal connectivity is one of the essential premises for the development of commercial flows, a perspective from which the interconnection facilities are a mandatory reference for the substantiation of transport policies in all European Union countries.

The relationship between intermodal infrastructures, global integration and the volume of net exports follows a gravitational model analyzed by us using two sets of linear regressions that quantify the impact on net exports. Consequently, the research quantifies the extent to which the infrastructure interconnectivity deficit is found in the trade deficit. Infrastructure deficiency draws a map of European Union with more interconnection speeds (well interconnected spaces, medium interconnected spaces and poorly interconnected spaces). Based on this reasoning, we highlighted the differentiated relevance of the contribution of intermodal connections of different size orders to the configuration of net exports. Thus, we have found that all states with significant trade surpluses are well equipped with higher-order intermodal nodes that are the nucleus of economic and territorial polarization and are the main active trading engine. Also, by interpolating the residual values of the regression with the net exports values, we have compiled a map of European Union with intermodal nodes that offer greater trade dynamism.

Our analysis may be useful to decision-makers as a working tool to support governmental decisions, because, depending on the degree of vulnerability given by the rarity of intermodal connections and trade deficits, we have proposed a hierarchy of spaces that require the extension of intermodal connections as a matter of priority. The proposed map reveals two priority spatial categories covering the states which adhered to the European Union after 2004, with the exception of Poland - the only country of the “new Europe” with more advanced infrastructure equipment, having a positive impact on the trade surplus. In terms of policy recommendations and judging by the degree of vulnerability given by the rarity of intermodal connections, we underline that for the following countries is a matter of urgency to build first order intermodal connections: Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Estonia, Malta, Romania, Slovenia, Slovakia; the second priority concerns Hungary and the Czech Republic.

Our analysis also highlights the additional impact of the integration into the global economy, which explains a share of 7.8% of national net exports, in addition to the 30.8% share of incumbent intermodal transport network connections. As a concluding remark, it is necessary to show that the two categories analyzed (intermodal connections and integration into the global economy) act as a functional binomial on the net exports.

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Appendix

Intermodal connections, KOF Index, net exports and the residuals regressions by European Union member states

ε_e - simple regression residuals of net exports according to the intermodal connections
ε_i - multiple regression residuals of net exports according to the intermodal connections and KOF Index of Globalization

Country	First order Intermodal Nodes (No.)	Second order Intermodal Nodes (No.)	Third order Intermodal Nodes(No.)	Total Intermodal Nodes(No.)	KOF Index	Net Exports (billion $)	ε_e	ε_i
Belgium	2	17	37	56	91.75	5.625	-1.4	-2.4
Bulgaria	0	3	3	6	76.89	2.076	-0.3	0.2
Czech Rep.	0	2	5	7	84.88	13.213	0.7	0.3
Denmark	2	12	20	34	88.37	17.188	0.3	-0.3
Germany	5	52	98	155	84.57	250.619	–	–
Estonia	0	0	4	4	79.27	0.814	-0.4	-0.1
Ireland	0	6	11	17	92.15	60.644	5.1	3.8
Greece	4	16	25	45	80.60	-1.259	-1.8	-1.4
Spain	6	44	88	138	84.56	33.748	-1.0	-0.4
France	7	46	94	149	87.19	-43.415	–	–
Croatia	0	3	4	7	81.39	1.308	-0.4	-0.4
Italy	6	40	85	131	82.19	56.925	1.4	2.3
Cyprus	0	0	3	3	85.00	-0.142	-0.4	-0.9
Latvia	0	2	3	5	71.45	0.223	-0.5	0.8
Lithuania	0	1	3	4	77.47	0.5	-0.4	0.0
Luxembourg	0	1	2	3	84.21	18.607	1.3	1.0
Hungary	0	1	7	8	86.55	11.466	0.5	-0.1
Malta	0	0	1	1	75.86	1.114	-0.3	0.4
Netherlands	3	31	64	98	92.84	77.348	4.4	3.7
Austria	2	20	32	54	90.05	11.859	-0.8	-1.5
Poland	1	5	17	23	81.32	17.241	0.6	0.8
Portugal	2	9	28	39	85.04	1.727	-1.3	-1.5
Romania	0	2	6	8	76.51	-1.528	-0.7	0.0
Slovenia	0	1	2	3	76.91	3.701	-0.1	0.5
Slovakia	0	1	3	4	84.36	2.842	-0.2	-0.6
Finland	2	15	55	72	86.30	-2.649	-2.7	-2.8
Sweden	4	34	68	106	87.96	22.51	-1.2	-1.3
UK	8	48	102	158	87.26	-49.637	–	–
EU	54	412	870	1,338		512.668		

Source: Authors' own representation using data from OECD (2016) and Gygli *et al.* (2018)