Network core-periphery model in the EU automotive manufacturing: properties and specifics

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Abstract. The article dwells on the study of network 'core-periphery' production structure as a firm pattern of EU automotive manufacturing. The Visegrad countries integration into the sector of EU economy is dissected with multiscalar approach. The first section of the paper deals with the complex analysis of geographical, structural, and topological foundations of the network 'core-periphery' model. In the second section the quantitative assessments are elaborated to demonstrate the relevant properties of the EU automotive core-periphery pattern. As a result, two of four empirical hypotheses have been proved. It has also been suggested that EU automotive core-periphery dynamics follows the introduced 'factor price equalization cycle'. The results obtained allow for the further forecasting of the European network core-periphery model evolution. The insufficiency of regional-level data is a limitation of the study conducted.

Keywords: Visegrad countries, automotive manufacturing, firm-level integration, New Economic Geography, Global Production Networks, trade in intermediates, node centrality, factor prices.

JEL codes: C18; F15; F17; F23

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Introduction

The 'core-periphery' interactions pattern encompassing geographical regions of different socio-economic level is on the limelight in the literature owing to its practical applicability. The well-known Krugman's (1991) concept of spatial interconnections between regions within the country or transborder region is one of the most frequently referred to. According to him, there are three variables responsible for regional spatial differentiation, namely transportation costs, economies of scale, and manufacturing share in the regional output. In Krugman's assumption, international trade cannot solely ensure factor price equalization as an optimum condition in Heckscher-Ohlin model. It has to be backed by capital mobility and unconstrained value flows.

In the literature, there are several modifications of this model. The core-periphery model with trade in intermediates (Brakman & van Marrewijk, 2016) deserves particular attention. It suggests that manufacturing is largely stimulated by international trade through the access to necessary parts and equipment. In its turn, the core-periphery production convergence is accelerated.

The model analyzed is a subject to centrifugal and centripetal forces which lead to its economic structure polarization with the core diversifying its output increasing the market volume on the one hand and the periphery taking root in primitive production on the other (Kolomak, 2013). Eventually, peripheral economies close the gap with core ones which spurs factor price equalization and spatio-temporal fix (Jessop, 2005).

In essence, the studies bridging international production and economic geography are required to explicitly portray the modern core-periphery phenomena.

Literature review

In order to holistically perceive modern production cooperation systems of regions the relevant theoretical and methodological elaborations have to be taken into consideration. Conceptually, the literature suggests three critical attributes of core-periphery model: flexibility, mutability, and multi-vector dynamics. Practically speaking, the model represents its characteristics on divergent regional levels (be that macroregion or transborder region), thus unveiling its multiscalar essence.

For instance, Great Lakes cluster situated on the US-Canada border symbolizes the cooperation between transborder region as a periphery with a pool of large productive centers in the USA as a core (Rutherford & Holmes, 2014). Core-periphery pattern can be discerned in a more aggregate level while analyzing offshoring and production relocation to Southeast Asia. With a factor price equalization (namely, wages in China became comparable with those in the USA) the opposite reshoring trend came into being. Hence, now one can contemplate two separate centers of global economic system.

In regard to the EU, it is worth referring to the Visegrad group entry into the Union in 2004. Historically, its members specialize in transport production and manufacturing in general.

On the one hand, automotive manufacturing is currently notable for its dynamism and technological transformation (specifically, in commodity supplies and original equipment manufacturing) (Kondrat'ev et al., 2020). On the other, integratory prerequisites for EU core-periphery structural shifts deserve particular attention. With respect to the abovementioned point on goods and production factors high mobility significance, the Single Market Act (2011) can be addressed. The Act promotes the entrepreneurial and investing potential calibration between EU founders and the newcomers.

In "Geography and Trade" (MacPherson & Krugman, 1992) P. Krugman highlights two reasons for the international trade and localization theories dialogue. First, the interregional trade is as important for large economies as the international one. Second, the diffusion of interregional and international trade occurs due to integration activity as in the EU. R. Baldwin and P. Martin developing Krugman's ideas draw on interlinkages between agglomeration and regional growth (Baldwin & Martin, 2003). As J. Gaspar points out, economic geography should incorporate spatial topologies analysis in its subject to conceivably depict the geographical space (Gaspar, 2020).

The network paradigm of relational analysis is punctuated in economic, social, and other studies. E. Wallerstein and his successors (Wuthnow, 1979) in the World-System theory emphasized that decentralization and multicentricity properties established the foundation of the unique European capitalistic model which stands it apart from the foregone empire formations. Within the interstitial position between the core and the periphery economies favor the options to both downgrade to peripheral status (as it has been with Spain in the XVII-XVIII centuries) or acquire the core attributes (as with Japan in the XX century) (Chirot & Hall, 1982). De Lombaerde et al. (2019) point out that international trade has gone beyond trade in goods involving trade in services and "trade in tasks" under globalization. Consequently, world trade network is a highly modular structure which implies greater interlinkages accordance within the continents, not between them. Thus, geographical patterns still play a critical role in determining modern trade networks, despite the gains from globalization (i.e., transportation costs reduction).

Visegrad countries share several properties with another integrated periphery economies in Europe (Klier et al., 2018). These are relatively cheap labor force, geographical proximity to large markets, membership in regional trade agreements, and some investment stimulus for international agents. Besides, European integrated periphery is characterized by a low share of assembly employment in the total workforce in automobile industry (for example, Central and Eastern Europe countries has a share of 18%, while Germany – 58,5% respectively) (Klier & Rubenstein, 2017). Core-periphery relations in European automotive manufacturing in recent decades demonstrate the dependence of local producers from the lead firms and original equipment manufacturers commercial strategies. FDI flows to the integrated periphery have not contributed greatly to their industrial upgrading (Simonazzi et al., 2020).

With regard to transport manufacturing, one can state that regional specialization is inextricably bound with product and technological fragmentation. As a production process gets more technologically complex, export specialization becomes narrower which is a precondition for empirical analysis of a highly

disaggregated product basket. The fragmentation itself is motivated by the fact that consequential production unbundling based on comparative advantages exploitation can flatten the curve of production and commercial costs while adding to the constant costs related to distributed system coordination (Jones et al., 2005).

Concerning the upgrading of integrated periphery production complex, it is reasonable to study the proportions of technological subsectors in employment, value-added, and labor productivity (i.e., such an analysis is elaborated in I.V. Izvorski et al. (2008)). Additionally, product specialization of separate regions should be dissected. This way, specialization-diversification dilemma can be analyzed both within the sector and between the sectors in integrated peripheries.

Apart from theoretical assumptions, methodological foundations for these studies have also gained popularity.

'World trade network' term resonates with 'international production network' of I. Cingolani et al. (2018). that is conceived as analytical structure with nodes as separate countries and linkages as revealed trade preference indices. Relational aspect displaces the geographical dimension in the analysis of such networks. Hence, we shall particularly rely on that model in our paper.

Whilst studying global production networks, P. Dicken (2004) distinguishes three analytical dimensions: macrostructures of capitalistic system (institutes, conventions), relational networks mediated by global production and social networks, and uneven distribution of benefits among individual localities and regions. The fundamental mechanism of GPN functioning is transformation of inputs to outputs in a functional and material circulation (Coe et al., 2008). In its turn, GPN 2.0 paradigm is aimed at better explanation of interconnections between global production networks and uneven territorial development (Coe et al., 2019).

At the same time, a survey is widely used as an alternative to customs statistics to determine both relations of economic entities and production integration effects on industrial upgrading (Pavlínek, 2018).

The research into specialization shifts of Central and Eastern Europe countries resulting from their integration to regional production systems has earlier been carried out with gravity modelling separately for extensive (specialization on new products) and intensive (existing specialization reinforcement) trade margins (Martínez-Zanzoso et al., 2011). The study suggests that over 1999-2009 trade costs reduced notably which allowed for a better local advantages exploitation, as well as export profile diversification.

A separate branch in the European regional systems studies is research into technological specialization and local industrial and academic systems relations with the calculation of revealed technological advantage index as an extension of RCA (Caviggioli et al., 2022). Undoubtedly, technological specialization can act as an anticipatory or supportive indicator in the estimation of the sectoral development.

In an attempt to solve the specialization-diversification dilemma O. Farhauer and A. Kröll (2012) introduce the concept of "diversified specialization" implying specialization of individual localities on a limited number of sectors. According to the authors, that type of specialization is favorable for regions to gain from both Marshall-Arrow-Romer clusterization externalities (due to the presence of specific labor force and infrastructure) and Jacobs' externalities of diversification (knowledge flows and cross-fertilization between sectors).

Under new patterns of international production cooperation core-periphery model exceeds dualistic collaboration of regions with pronounced structural disproportions. Taking account of the global production networks prominence, it is more correct to articulate the network core-periphery model as a concept containing both structural and geographical prerequisites, as well as topological patterns of regional embeddedness into global production systems.

Overall, our study is devoted to formulization of the attributes of network core-periphery model and to empirical verification of hypo

Concept

Topological structures of the independent regional entities' collaboration are network models whereby they trade in intermediates upscaling the final good value. The linkages pattern unveils peculiar aspects of the network structure formation, as well as good and value flows efficiency and resilience under external

shocks.

It is worth mentioning that economic globalization covering Europe and other regions has been tightly bound with production factors, intangible assets, and technology flows liberalization which encouraged the network structures formation based on the principle of the contribution of every single node to the whole network creation. In that sense, the conjoint account of geographical and topological foundations of the network core-periphery model is required.

The statement concerning the 'pendulum' nature of core-periphery interactions and convergence is critically important for our study. As it was pointed out, economic integration with trade and factor flows liberalization stimulates factor prices equalization. However, it is differences in factor prices that spurs on the fragmentation of production (Deardorff, 1998). In its turn, this encourages the peripheral economies' specialization on high-tech products empowering them with a higher competitiveness and allowing for closer integration with the core. Hence, the process of factor price equalization and non-equalization in the core and in the periphery is endogenously cyclical (Figure 1), which determines fragmentation and production cointegration, in essence.

At bottom, this analytical layout suggests the intersection between New Economic Geography (in core-periphery model and factor price equalization), Global Production Networks (in terms of local producers' integration into macroregional production structures), and Fragmentation Theory (detailed specialization in the production of knowledge-intensive goods).

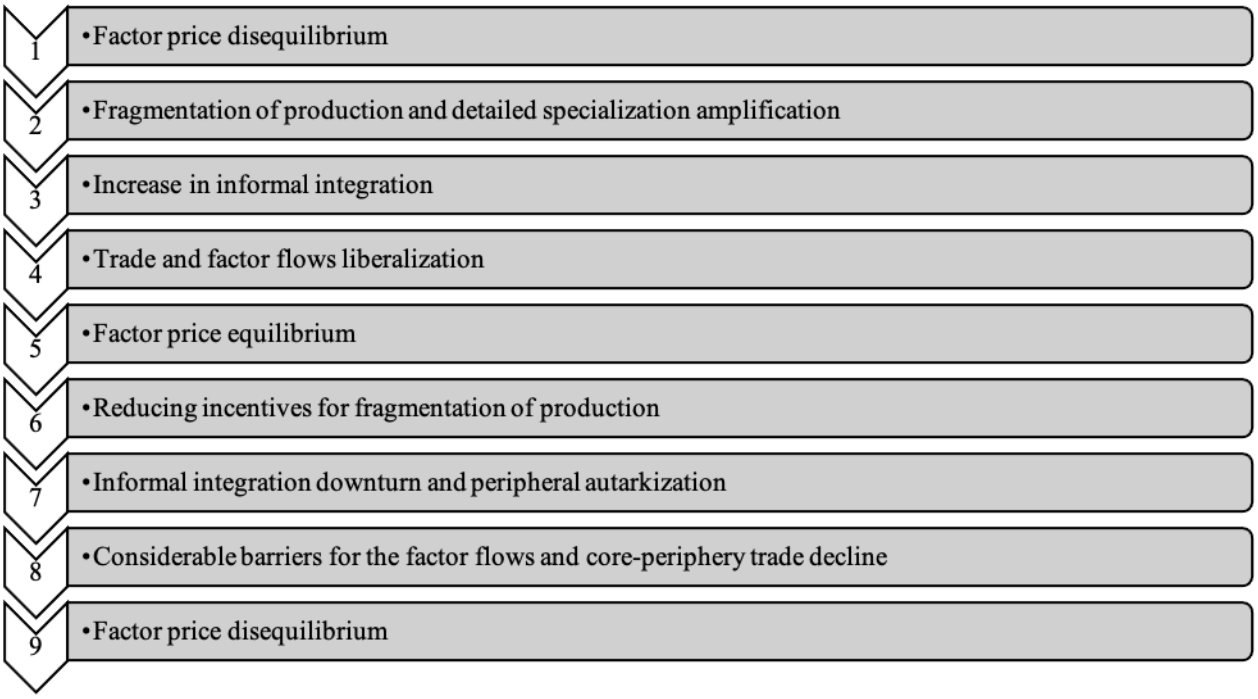

Figure 1. Dynamic cycle of the network core-periphery model
Source: composed by author

One can see that the aforementioned cyclical stages subsequently characterize the system from the point of the three analytical dimensions (Figure 2): geographical (evenness of production distribution in core and periphery, as well as between them), structural (namely, dominance of a given sector for the economy), and topological (here, local producers embeddedness in macroregional production systems).

Geographical and structural degrees of analysis portray the traditional core-periphery model attributes. Topological degree is of particular significance for this study as it paths the way for geographical and spatio-network approaches to core-periphery analysis bridging.

The 'dominance' degree is analyzed in terms of specialization and diversification categories. Specialization is perceived dually in the study, namely as an absolute specialization (the industry's dominance in the economy) and as a relative specialization (i.e., international specialization). Diversification, respectively,

is understood as a situation when the economic structure is balanced, and the country does not demonstrate a pronounced specialization in some particular exports.

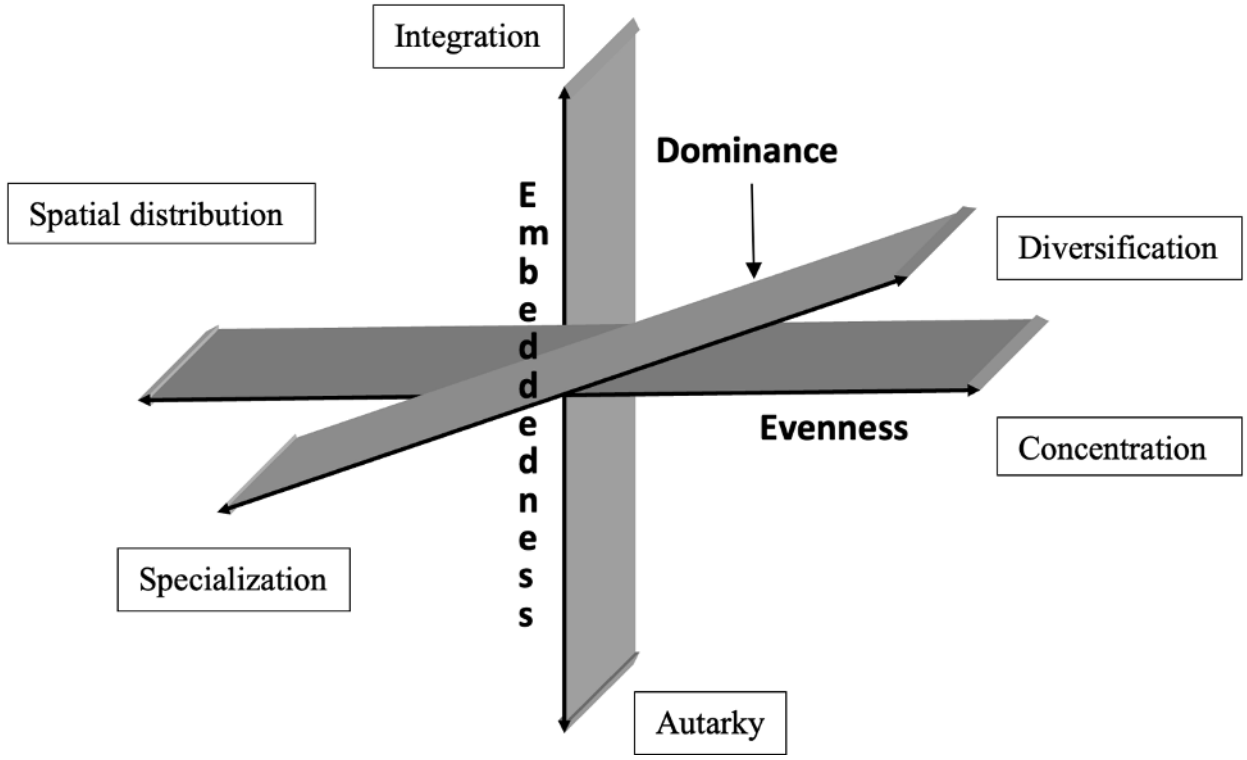

Figure 2. Analytical framework for the network core-periphery model specification
Source: composed by author

In turn, the 'evenness' degree is responsible for the spatial distribution of manufacturing production among core (or periphery) regions. Two extremal states here are spatial distribution (even distribution of production capacities) and concentration (conglomeration of production in a few, or the only, regions). With respect to the periphery as an object of our research, these two analytical degrees depict the properties of transport manufacturing development within the periphery itself.

The 'embeddedness' degree represents the peripheral integration into European automotive manufacturing networks. Thus, peripheral position is derived analytically between integration (dependence on and mediatory importance in production networks) and autarky (namely, production self-sufficiency and external cooperation denial) extreme states.

Methods

The relative periphery position in that three-dimensional structure is determined whereby multiscalarity principle, i.e., matching and interconnection of empirical assessments implemented on regional level, as well as on country level for the core and the periphery at large.

'Evenness' degree analysis is elaborated on NUTS 2 data and for the core-periphery in general. 'Dominance' degree related to specialization metrics is studied on both regional and country levels. 'Embeddedness' degree is characterized on the country-level statistics.

In the final empirical section regression analysis of factors impacted on labor productivity in periphery transport manufacturing is carried out. Taking the analyzed object specifics into consideration, the regression is based on fixed-effects panel data model.

A Dominance degree analysis

In order to specify the significance of transport manufacturing in EU periphery economies Herfindahl and revealed comparative advantage indices are calculated. The first one is assumed to reflect industrial diversification in peripheral economies (the higher the index, the more diverse is an economy) (Kolomak, 2013). RCA is designed to shed light on relative specialization degree of peripheral economies on transport

manufacturing in comparison with the world (the value higher the unity suggests the country's relative specialization on a given production).

Herfindahl index is calculated according to the Formula 1,

$$HH_{it} = \sum_{s=1}^{S} SEMP_{sri}^2 \quad (1)$$

Where SEMP is the the share of sector s employment (s=1, …, S) in an overall employment in i economy in period t.

Revealed comparative advantage index is calculated in the study according to B. Balassa (Formula 2),

$$RCA = \frac{X_{i,j} \Big/ X_{i,w}}{X_j \Big/ X_w} \quad (2)$$

Where $X_{i,j}$ is the country j exports of i good for a specified period of time, $X_{i,w}$ is the world exports of i good for the same period, X_j is an overall country j exports for the period, X_w is an overall world exports for the period specified.

For the purpose of a proper characterization of comparative advantage shifts, RCAs of HS 6-digit level are also calculated. Therefore, detailed specialization is studied, which allows for the sectoral and firm-level analysis cohesion. The estimations obtained are compared with product complexity indices (Higaldo, 2021) revealing technological sophistication and profitability of a given good. In essence, 'product complexity' term stands for a specific degree of the knowledge acquired in a society that is embodied in products manufactured there (Higaldo & Hausmann, 2009).

Juxtaposing RCA dynamics with product complexity one can conclude qualitatively on the changes occurring in a country's specialization profile.

BEvenness degree analysis

The specific properties of transport manufacturing spatial distribution among the EU periphery regions are portrayed whereby Theil index calculation (Formula 3),

$$T = \sum_{r=1}^{R} \left(\frac{GVA_r}{GVA} ln \frac{GVA_r}{GVA/R}\right) \quad (3)$$

Where GVA_r is gross value-added in a region r (r = 1, …, R), GVA is aggregated gross value-added, R is a number of regions.

Separability of Theil index (Formula 4) allows one to estimate sigma-convergence both within the periphery and between the core and the periphery of production system.

$$T = T_{inter} + T_{intra} \quad (4)$$

$$T_{inter} = \sum_{m=1}^{M} \frac{GVA_m}{GVA} ln \frac{GVA_m/R_m}{GVA/R}$$

$$T_{intra} = \sum_{m=1}^{M} \frac{GVA_m}{GVA} T_m$$

Where GVA_m is gross value-added of a macroregion (be that core or periphery), R_m is a number of regions within the macroregion. T_m is the Theil index calculated for the macroregion m according to Formula 5.

$$T_m = \sum_{}^{R_m} \frac{GVA_r}{GVA_m} ln \frac{GVA_r}{GVA_m/R_m} \quad (5)$$

C Embeddedness degree analysis

According to several studies (Vičková, 2018), EU peripheral economies reinforced their positions after the entry into the European Union. However, for us the comparative integration is of an interest. Hence, integration in our study is perceived as core-periphery inequality reduction, whereas autarkization, accordingly, is understood as an increase of the disproportions in favor of the core.

The patterns described are supposed to be indicated whereby the calculation of the variance coefficient (Formula 6),

$$K_{var}\frac{\sigma_B}{\overline{B}} \tag{6}$$

where σ_B is a standard deviation of betweenness centrality indicator among the countries analyzed, B is an average betweenness centrality for the given countries. Supposedly, as a result of an increase in embeddedness of peripheral economies into the European automotive manufacturing network the absolute difference in betweenness centralities for the core and the periphery becomes lower. Thus, variance coefficient dynamics shall be downgrading.

Betweenness centrality index which is a relative significance of the node as an intermediary indicator is calculated in a following way (Formula 7):

$$B_i = \sum_{s \neq v \neq t} \frac{\sigma_{st}(i)}{\sigma_{st}} \tag{7}$$

Here σ_{st} is a number of shortest paths from s node to t node, while σ_{st} (i) is an overall number of paths which pass through i node when i is not a final destination.

The 'embeddedness' degree analysis is elaborated on OECD input-output tables where intermediate flows between the sectors of different economies are presented. For every analyzed country betweenness centrality metrics in the EU-27 transport manufacturing (ISIC 29-30) are calculated.

The final stage of the empirical elaboration is econometric modelling of the factors determining the relative position of peripheral economies in each of the three degrees impact on the labor productivity in automotive manufacturing. The fixed-effects panel data model is specified where gross capital formation and export quota have been chosen for as controls. Since the base function is Cobb-Douglas production function, two obligatory variables are labor and capital.

Results

The general empirical hypothesis is that informal integration on the firm-level impedes core-periphery industrial profile convergence under trade liberalization (Fedyunina, 2016) and overall centripetal and centrifugal forces dynamism .

To prove the general hypothesis four specific hypotheses have been tested.

H1: the modern profile of EU automotive industry periphery is peculiar for a high level of specialization of these economies in automotive production, as well as for a trend towards an increase in spatial distribution of productive capacities within peripheral economies and for a deepening integration into the European automotive manufacturing.

H2: the deepening of peripheral economies integration into European transport manufacturing proceeds simultaneously with an increase in product complexity of goods which these countries specialize on.

H3: disproportions in gross value-added between the core and the periphery decrease.

H4: labor productivity in transport manufacturing of peripheral countries is determined largely by the embeddedness of these economies in the European production.

A Dominance degree analysis

he index (Figure 3) possible variation is in the region of 0.05-1. The figures in the interval of 0.08-0.14 testify about a considerable degree of industrial diversification of these economies. However, peripheral economies demonstrate a sustained trend for manufacturing dominance over other sectors.

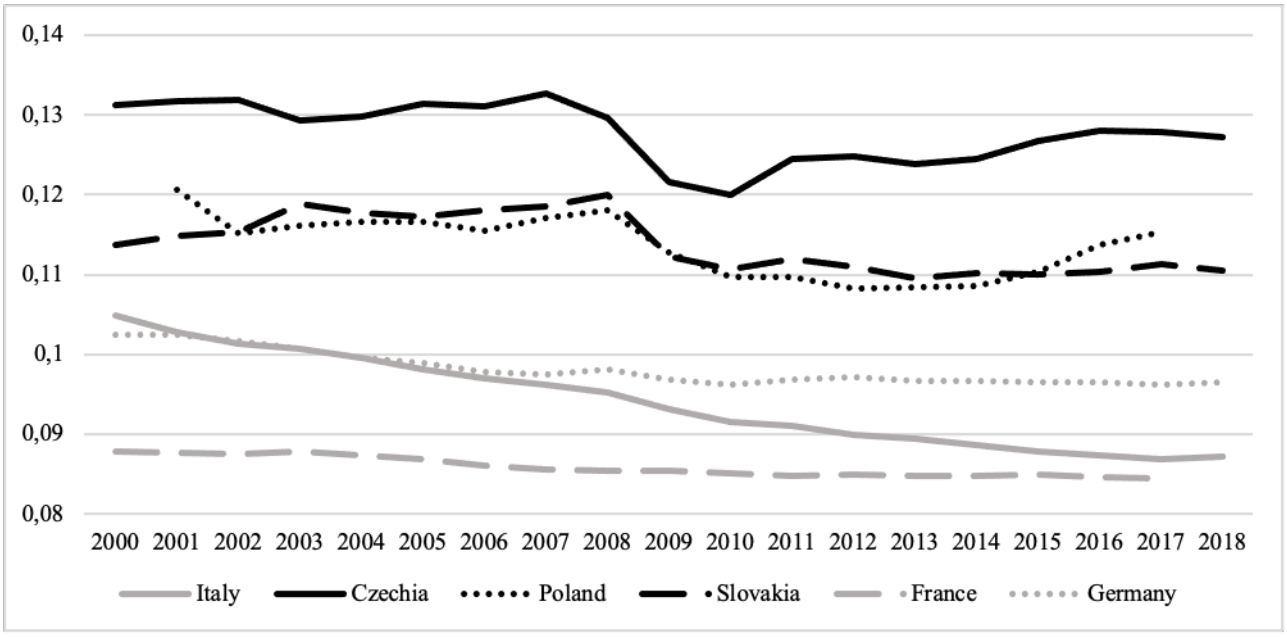

Figure 3. Herfindahl index of industrial diversification

Source: composed by author

Patterns of the relative international specialization of the core and the periphery on manufacturing exports have been dissected (Figure 4).

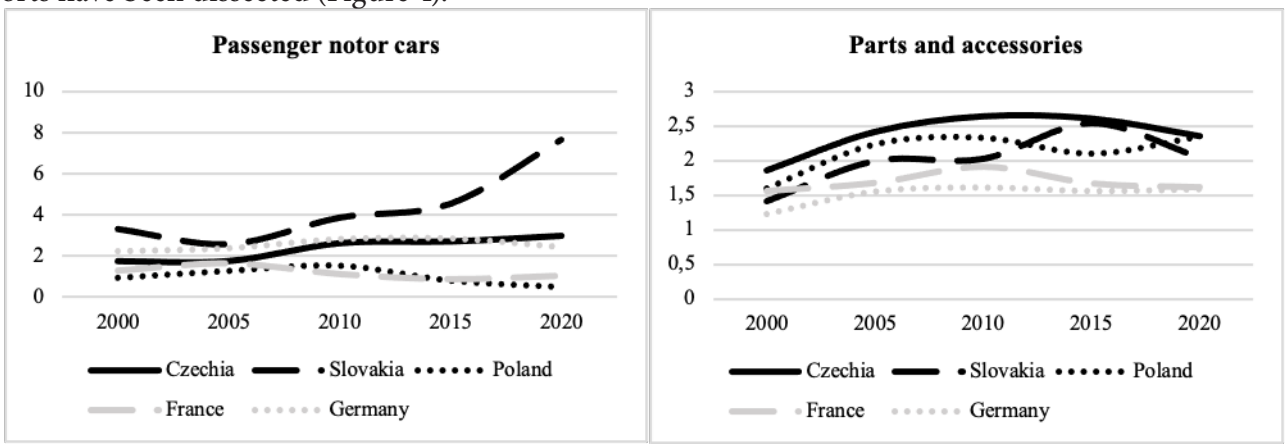

Figure 4. RCA indices for passenger motor cars and automobile parts and accessories, 2000-2020

Source: composed by author

According to the data, Visegrad countries are specialized on parts and accessories production higher than core economies. At the same time, Slovakia (and to a smaller extent Czechia) sustain the trend towards higher specialization in exports of passenger motor cars which symbolizes a new chapter in peripheral economies participation in global production networks.

It is beneficial to study the patterns of peripheral economies specialization on intermediate exports on a disaggregated level (Table 1).

Table 1 – Revealed comparative advantage and product complexity indices for Slovakia (HS 6-digit nomenclature)

Product	Product complexity index (2020)	RCA 2001	RCA 2010	RCA 2020
870600 (motor vehicle classis)	0.67	0.069	0.134	1.549
870790 (bodies for tractors, buses, trucks)	0.92	0.239	0.171	1.057

Product	Product complexity index (2020)	RCA 2001	RCA 2010	RCA 2020
870870 (wheels including parts/accessories)	0.47	0.420	1.165	1.318
870880 (shock absorbers)	1.27	0.132	2.533	4.886
870891 (radiators)	0.42	0.053	3.041	9.621
870710 (bodies for passenger vehicles)	0.63	3.343	89.571	0.080
870821 (safety seat belts)	1.04	1.926	0.567	0.080
871496 (bicycle peals/crank gear)	0.86	12.641	0.969	0.171

Source: composed by author

The table contains the positions for which there have been the most notable specialization shifts in Slovakia. This way, as a result of structural convergence with the core of transport manufacturing Slovak firms gained a relative specialization on the production of high-end goods, such as bodies and shock absorbers. At the same time, it has lost the specialization on the exports of several products (safety seat belts and peals) which are also technologically complex. Overall, the effect of production integration is ambiguous. However, up to a point, the second hypothesis is still confirmed.

B Evenness degree analysis

After the analysis of data (Figure 5), one can conclude that the third empirical hypothesis received confirmation. The differences in manufacturing gross value-added (black color) decreased over the period. While it should be noted that intraperipheral interregional disproportions in manufacturing GVA, at least, have not shrunk remaining high enough. This suggests that conglomeration trends in manufacturing are persistent in the EU periphery.

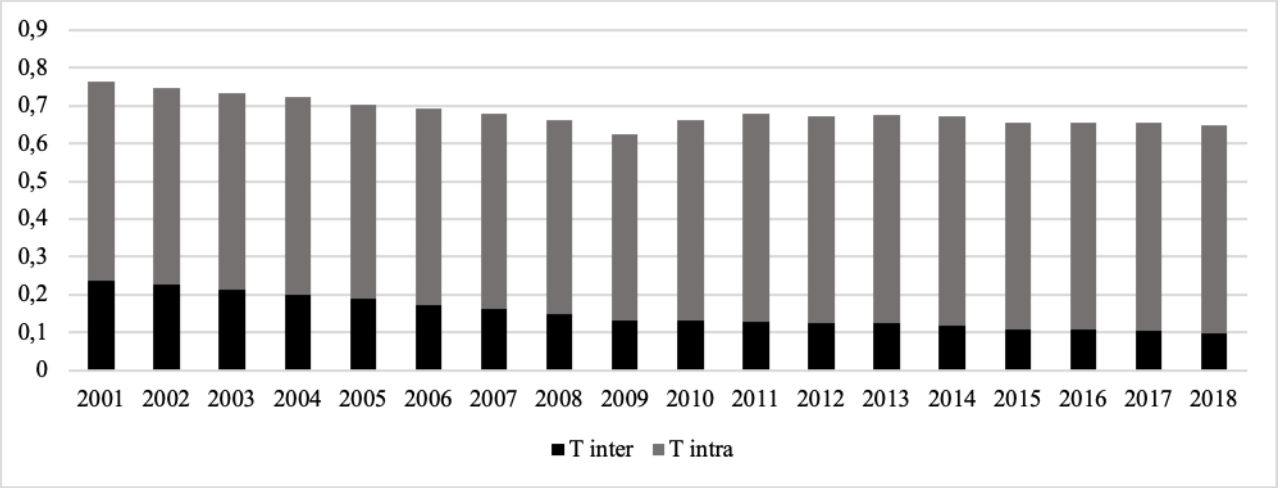

Figure 5. The Theil index calculated on manufacturing gross value-added generated in the EU core and periphery

Source: composed by author

C Embeddedness degree analysis

As one can see (Figure 6), over the whole period of the study the variance coefficient downgraded both for vehicle production (ISIC 29) and for other automotive production (ISIC 30). Thus, this can be a justification for a deepening of peripheral economies integration into macroregional production structures and for their convergence with the core countries.

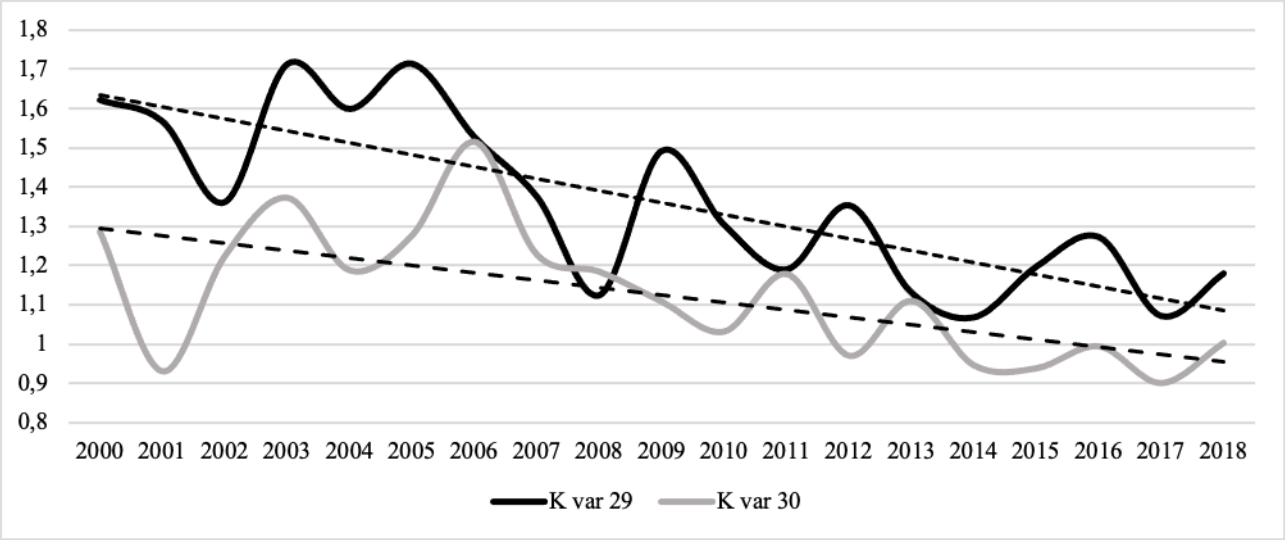

Figure 6. Variance coefficient calculated on betweenness centralities of Visegrad countries and the core European economies
Source: composed by author

D Synthesis

Conceptualizing, there has been a 'triple convergence' in the transport manufacturing between the EU core and periphery: structural convergence (higher extent of core-periphery industrial structure similarity), geographical convergence (reduction in production capacities distribution disparities), and topological convergence (the increase in likeness of the mode of integration into the European production structures).

Sectoral labor productivity upgrading, as well as the rationalization of transport manufacturing as a source of regional and national economic growth has long been a subject of research. According to the latest McKinsey report (Cornet et al., 2019), automotive sector demonstrates one of the highest employment levels in the EU totaling 13,3 million working places. Besides, this sector grants around 7% of total taxation in the Union. At the same time, European automobile semiconductors sells tripled over the last 20 years, whilst automobile software contributes largely to the sector's economic sophistication and supports the entry to the more beneficial GVC stages. Automotive manufacturing cooperation implies heavy intermediates imports on every production phase. In this regard, according to studies (Veeramani, 2009), the positive role of intermediate supplies for the overall economic development is grasped.

With respect to the EU regional convergence policy, it is assumed that the growth of European regions is 'cascading' in line with the Growth Poles Theory (Rauhut & Humer, 2020). Polycentrism, as it is seen under convergence activity in Europe, is an underlying principle for closing the gap between economically developed and peripheral regions in the EU.

Table 2 – FE-model factors estimations (value equivalent of annual output per worker as a dependent variable)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Consumption of fixed capital	0.06 (0.05)	0.04 (0.05)	-0.00 (0.07)	0.03 (0.05)	0.09* (0.04)	0.07 (0.05)	0.06 (0.08)
Labor costs (compensation of employees)	0.80*** (0.08)	0.82*** (0.09)	0.77*** (0.08)	0.78*** (0.08)	0.70*** (0.07)	0.73*** (0.10)	0.72*** (0.07)
Gross capital formation	0.28* (0.13)	0.25 (0.13)	0.38** (0.13)	0.30* (0.12)	0.44*** (0.11)	0.43*** (0.13)	0.39** (0.12)
Export quota	0.54*** (0.14)	0.56*** (0.15)	0.60*** (0.14)	0.53*** (0.14)	0.48*** (0.12)	0.47*** (0.13)	0.49** (0.15)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Betweenness centrality	-	-0.02 (0.02)	-	-	-	-	-0.02 (0.02)
Herfindahl index	-	-	-0.36 (0.52)	-	-	-	0.38 (0.54)
RCA (BEC 51)	-	-	-	0.08 (0.04)	-	-	0.07 (0.04)
RCA (BEC 53)	-	-	-	-	0.57*** (0.11)	0.59*** (0.11)	0.58*** (0.11)
Theil index (intra)	-	-	-	-	-	-0.01 (0.12)	0.19 (0.42)
R2	0.94	0.94	0.94	0.94	0.96	0.96	0.96
Adj. R2	0.93	0.93	0.94	0.94	0.95	0.95	0.95
Num. obs.	76	76	74	76	76	72	71

Source: composed by author

An important takeaway of the empirical study conducted (Table 2) is that labor productivity growth in the EU periphery automotive manufacturing is dependent on average compensation of employees and the relative international specialization on the exports of automotive parts and equipment.

All in all, in spite of 'triple convergence', structural convergence and higher participation in transport manufacturing cooperation are of the significance for peripheral economies in Europe. Hence, the fourth hypothesis has not been proved.

Discussion

To recap, through the empirical analysis the second and the third hypotheses have been confirmed. EU transport manufacturing periphery has reinforced its specialization on high-end intermediate exports. At the same time, a notable reduction in gross value-added distribution between the core and the periphery disproportions was registered. Partially, the first hypothesis has also been confirmed (despite an increase in specialization, there was no positive shifts towards production spatial distribution). Anyway, there is no proof for the fourth hypothesis (the degree of peripheral economies integration into macroregional production pays no contribution to labor productivity in transport manufacturing of the EU periphery).

In sum, the results obtained follow the core-periphery factor price equalization cycle. Visegrad countries have already proceeded through the four stages of the cycle if one begins it with the entry of automotive MNEs into these economies.

The research method applied is considered to be relevant for the majority of questions. Network indicators characterizing spatial topologies depict relational integration aspects concerning peripheral economies in the European systems in an effective way. Although several indicators (in particular, Herfindahl index of industrial concentration) have been calculated on the more aggregated (industry-level) data. Possibly, the raw data amelioration would allow one to get clearer and more precise findings.

Followingly, our results can be verified with the two propositions. At first, network metrics should be calculated on firm-level survey data of international production agents. At second, an estimation of geographical concentration of production capacities can be implemented with a greater precision (for instance, whereby Moran I-statistics calculation).

Conclusions

In this article an approach for the analysis of network core-periphery model development has been formulated and empirically challenged. This model shows a resilient EU automotive manufacturing organizational structure capturing the relevant trends in the sector's evolution.

The theoretical review has allowed for the punctuation of the attributes of the conventional core-

periphery model. First, it is crucial to take trade in intermediates as a factor price equalization driver into consideration. Second, the dual core-periphery model perception should be substituted with a multidimensional conceptualization of topological patterns of interregional cooperation. Third, concerning core-periphery analysis, the debates arise around the question of how to correctly apply multiscalarity principle for both the micro- and macro-level indicators assessment.

Based on theoretical assumptions, the conceptual framework for the network core-periphery model analysis has been suggested. Its foundation is the synthesis of economic-geographical and spatio-network concepts. In the new framework three analytical degrees are studied, namely structural (industry dominance), geographical (spatial distribution of production), and topological (core and periphery embeddedness into macroregional production). Network core-periphery model evolution has been framed in the introduced factor price equalization cycle.

Empirical testing has been elaborated on the automotive manufacturing. Revealed comparative advantage, Theil index, as well as betweenness centrality have been analyzed. Eventually, there was the evidence in favor of the core-periphery convergence in the all three analytical degrees. Apart from that, it has been unveiled that the increase in the sectoral labor productivity was mainly determined by the peripheral economies' specialization on intermediate products exports. This notion positively resembles with the theoretical assumptions.

In our opinion, the empirical results follow factor price equalization cycle. Hence, there is an opportunity to furtherly forecast the trends in European automotive production with the application of the introduced model.

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