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Do spatial differences in the personal car market reflect a centre-periphery structure? The case of Poland

Bartłomiej Kołsut* and Tadeusz Stryjakiewicz

Abstract

Aim of the study: A centre-periphery structure reflects spatial inequalities in the level of economic development of countries and regions. Most often, it provides a simplified picture of spatial distribution of income or spatial accessibility. In this study the authors try to identify the relationship between the level of centrality/peripherality of an area and selected features of the personal car market, using the case of Poland.

Method: In order to identify the relationship between the level of centrality/peripherality of an area and selected features of the peresonal car market, the correlation and regression analysis has been used. As a dependent variable the index of centrality/peripherality consisting of population and enterprise income has been calculated for all Polish communes (*gminas*). The features of the car market (independent variables) are: 1) car ownership (number of cars per 1000 inhabitants), 2) sales of new cars, 3) the import of second-hand cars, and 4) the average age of personal cars.

Result: The research confirmed a positive correlation between the index of centrality/peripherality (and hence the central character of the commune) and the sales of new automobiles, and a negative correlation with the average age of cars. There is no correlation between the level of centrality/peripherality of an area and the indicators of car ownership and the import of second-hand vehicles.

Keywords: Centre-periphery structure, Peripheralisation, Car market, Car ownership, New cars, Second-hand cars, Poland

1 Introduction

The discussion on the centre-periphery (or core-periphery) structures has been taking place in the scientific literature for years.[1] This issue has been researched by representatives of various disciplines, including regional studies, geography, economics, sociology and political science, and the very notion of a 'centre-periphery structure' is understood in many ways. Most often, the central and peripheral location of areas as well as their typical features are connected with the process of economic growth polarisation and spatial socio-economic disparities [2, 5]. Periphery is also identified on the basis of distance from the centre, which is related primarily to the contribution of regional studies and geography to scientific debate [6]. Hence, different concepts of the centre-periphery structure and of the process of peripheralisation or marginalisation of areas have been adopted in academic discourse.

In this article we use the notion of a 'centre-periphery structure' primarily as a spatial metaphor which describes polarisation of socio-economic development, and we do not refer to any concrete centre-periphery model. On the other hand, we also try to join the discourse on measuring centrality or peripherality by finding their

[1] A review of the discussion on centre-periphery structures and their models can be found, among others, in Ferrao & Jensen-Butler [1], Copus [2], Raagmaa [3] and Pascariu & Frunza [4].

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new indicators and variables that explain their spatial patterns. According to Siliverstovs et al. [7], some characteristics of the personal car market may be very useful for this purpose. Our focus on the personal car market (excluding fleet cars) follows from the fact that fleet cars artificially inflate motorisation rate in large cities (as it is there that the leasing companies listed as vehicle owners in the registration papers are headquartered).

The aim of this article is to identify the relationship between the centrality/peripherality of a territorial unit (commune) and selected features of the personal car market, using Poland as an example. We assume that (1) some features of the car market can be a proxy of the level of local and regional development, and (2) they reflect spatial and socio-economic peripherality of regions. This is a step forward in searching for new measures of regional development and peripherality going beyond traditional indicators, such as GDP per capita.

The choice of Poland as a case study is justified by the fact that the country belongs to those emerging economies which experienced two important processes changing rapidly their regional patterns, such as: (1) transformation from a command to a market-oriented economic system, and (2) integration with the EU. Both of them had a significant impact on regional inequalities as well as on changes in the car market. Apart from the regionally diversified growth of motorisation rate, they also caused a decline in the sales of new cars (which turned out to be accessible primarily to the wealthiest car owners in the largest urban agglomerations) accompanied by an enormous increase in the import of second-hand cars. Hence, these features (or influential factors) may reflect the centre-periphery structure of the country.

The article begins with a short literature review as well as a presentation of methodology, research hypotheses and data sources, followed by a discussion on the internal centre-periphery structure of Poland. Next, the relations between the level of centrality/peripherality of an area and selected indicators of the Polish personal car market are analysed. The article concludes with a summary and discussion of the research outcomes.

2 Literature review

The existing literature has identified several possible relationships between the centrality of an area and some characteristics of the local or regional personal car market. Firstly, the impact of income on car ownership (or the motorisation rate) is very often highlighted, especially in international studies [8]. In the global perspective, the number of cars per 1000 inhabitants or per one household becomes one of the variables which indirectly show economic well-being and prosperity[2] [9, 10]. This is further confirmed by research into societies (especially developing ones) where the car is a symbol of higher social status [11–13]. However, the role of income in the development of motorisation of a given country or region decreases with increasing wealth. In the light of previous research, the relationship between car ownership and personal income is described by the S-shaped Gompertz function [8], in which after reaching a certain level of saturation, the number of goods purchased despite further income increases remains unchanged (wealthier people tend to buy more expensive cars rather than more cars). In such a case, the car ownership index ceases to be a measure of the central or peripheral character of an area and other structural features of the car market come into play.

The spatial distribution of centres and peripheries is also connected with the preferred type of car purchased. In peripheral countries and regions, second-hand cars, often imported from developed countries, are much more common [14–16]. For different reasons (e.g. due to higher environmental fees), they become too expensive or less comfortable for residents of such developed countries. Grubel [16] has proved, e.g. that car depreciation in developing countries is much slower due to lower costs of used vehicles repairs (a mature market for this type of services is emerging) and there is a lower demand for luxurious car features. This, of course, has more far-reaching consequences for the peripherality of an area in the form of a greater negative impact on the environment of older cars and lowering the level of road safety [17]. Areas receiving old second-hand cars also take responsibility for their scrapping, which in the light of research is particularly complex and has a negative impact on the environment.

The development of the second-hand car market reduces the primary market, i.e. displaces the sale of new cars [15]. This, too, may be a source of enhanced peripheralisation, since the sharp dominance of the second-hand goods market severely limits domestic demand for new products of the same type, which in turn results in the shrinkage of the production sector in a given country. However, even a very strong position of importers of second-hand cars will not result in the disappearance of sales of new cars, purchased mainly by the richest part of the developing country's population, living mainly in large agglomerations [18]. This in turn means that in some areas the growing wealth of the population may trigger the growth of the primary market, and its size becomes a measure of the centrality of the area.

The interrelations presented above have so far been identified and described mainly with regard to Western European countries, the USA and some Asian countries.

[2]It should be noted that in well-developed countries this indicator can also be considered as a measure of ecological backwardness.

There are no similar studies on post-socialist countries of Central and Eastern Europe, where both the automotive market and the polarisation of social and economic spaces are especially dynamic at the beginning of the twenty-first century. It is worth noting that the economic transformation and social changes observed in post-socialist countries provide an excellent ground for innovative research. They enrich the existing achievements of regional studies, geography, economics, and sociology with new knowledge on the course and causes of the processes which in the case of these countries occur in a different institutional context.

3 Methodology, research hypotheses and data sources

In order to identify the relationship between the level of centrality/peripherality of an area and selected features of the personal car market, the correlation and regression analysis has been used. The analysis is based on several 'non-standard' indicators. For determining the centre-periphery structure of Poland we decided to implement the authors' own indicator, called 'index of centrality/peripherality' which is used as a dependent variable. The reason was twofold. Firstly, earlier research had not focused on the local level of communes in the identification of centres and peripheries. They were characterised by a higher level of data aggregation (sub-regions or regions), which may entail a loss of detailed information. Secondly, this was due to gaining access to reliable and adequate measures of centrality/peripherality at the local level, made available by the Ministry of Finance. The index of centrality/peripherality is a sum of the revenues of communes from personal income tax (PIT) and corporate income tax (CIT) per capita. It is an aggregate measure of the total income of both inhabitants and enterprises in a given territorial unit.

On the other hand, four features characterizing the car market have been selected

1) car ownership (or the motorisation rate),
2) sales of new cars,
3) the import of second-hand cars, and
4) the average age of cars.

These features together with their indicators (served as independent variables) are listed in Table 1. They have been related to the synthetic index of centrality/peripherality using a model of correlation and regression analysis. Four hypotheses were formulated that are consistent with the results of the empirical studies conducted in other countries to date. They are also presented in Table 1, whereas basic statistical characteristics of variables can be found in Table 2.

For each pair of hypothetical relationships, Pearson's correlation coefficients and regression equations were calculated using the IBM SPSS Statistics programme. It should be noted at this point that various function types were estimated, both linear and non-linear (exponential, logarithmic, power), calculating the coefficient of determination r^2 for each of them and eventually selecting that form of function which approximated best the real distribution of variables (i.e. for which the coefficient of determination was the highest). We considered that the hypotheses were positively verified in those cases where the value of the coefficient of determination r^2 was higher than 0.450 at the significance level of $\alpha = 0.001$ (and only those forms of function are presented in the figures of Section 5). The coefficients of determination for different types of functions are presented in Table 3.

Our research is based on record data on all personal cars in Poland [this type of data was used, among others, by Jansson [22], Siliverstovs et al. [7] and Lansley [21]]. They are xcollected and made available by the Ministry of Digitisation and help to analyse the personal car market for all administrative units. In our case data for 2478 communes (*gminas*) were used.

4 Centres and peripheries in Poland

The debate over the centre-periphery structure in Poland is ongoing and has produced an extensive body of texts [23–28]. Most of the aforementioned works focus on the identification of centres and peripheries

Table 1 Features of the personal car market, their indicators and hypotheses assuming their correlation with the centrality of a given area

Feature	Indicator (independent variable)	Hypothesis (relationship)	Literature
Car ownership (motorisation rate)	Number of personal cars per 1000 inhabitants	H1: higher centrality ➔ higher motorisation rate (+)	[8, 14, 19]
Sales of new cars	Number of new cars sold per 1000 inhabitants	H2: higher centrality ➔ higher sales of new cars (+)	[14, 18, 20]
Import of second-hand cars	Number of imported second-hand cars per 1000 inhabitants	H3: higher centrality ➔ lower import of second-hand cars (–)	[14–16]
Average age of cars	Average age of cars	H4: higher centrality ➔ lower average age of cars (–)	[21]

Source: own elaboration

Table 2 Basic statistical characteristics of variables

Variable	Arithmetic mean ($\bar{x}$)	Minimum	Maximum	Standard deviation (σ_x)	Coefficient of variation[a]
Index of centrality/peripherality	617.4	174.3	3403.5	325.9	0.528
Number of personal cars per 1000 inhabitants	412.9	206.1	1252.8	57.7	0.140
Number of new cars sold per 1000 inhabitants	2.8	0.0	21.0	1.7	0.597
Number of imported second-hand cars per 1000 inhabitants	26.8	8.9	77.0	6.4	0.238
Average age of cars	15.7	12.1	19.0	1.1	0.073

[a]This is a synthetic measure of spatial differences of a given variable and is calculated by the formula: $\sigma_x/\bar{x}$
Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

based on different criteria. Czyż [24] used for this purpose the model of a quotient of income potentials and a population for 38 subregions (NUTS 3), showing as a result a very high centrality of the Warsaw subregion and a slightly smaller ones of the Poznań and Silesian subregions. The general conclusion of this study was a high centrality of urbanised subregions and the large scale of peripheral areas of Eastern Poland and Central Pomerania. Similar results were obtained in his earlier studies by Rykiel [27], who eventually distinguished on the one hand: (1) cores, (2) sub-cores (growth poles) and (3) development axes, and on the other hand areas showing different levels of peripherality: (a) semi peripheries, (b) frontier regions, (c) depressed regions, and (d) underdeveloped regions. In turn, Rosik et al. [26] identified changes in peripheralisation seen in terms of public transport accessibility at international, domestic and intra-regional (provincial) levels. Although the authors of all of the above studies analysed the centrality/peripherality of areas from slightly different perspectives, the final results concerning the centre/periphery structure of Poland were quite similar. Central areas are mainly large urban agglomerations (especially Warsaw, Poznań, Upper Silesian cities, Tricity, Wrocław) and their suburbs, while peripheral areas are those of Eastern Poland, Central Pomerania and border zones in the internal territorial system of Poland consisting of 16 regions.

The spatial distribution of the centrality/peripherality index created by the authors for the purpose of this article and described in Section 3, is presented in deciles in Fig. 1. It shows a pattern similar to the earlier results of identification of centres and peripheries in Poland. First of all, the developmental potential is accumulated mainly in large urban agglomerations (including Warsaw in Mazovia region, Poznań in Wielkopolska, Katowice in Silesia, Wrocław in Lower Silesia, and Łódź). Second, a marked concentration of peripheral areas in Eastern Poland (except for large cities, i.e. Białystok, Lublin and Rzeszów) is evident. Third, many peripheral *gminas* are located on the borders of regions without large urban centres (e.g. the border of Mazovia and Kujavia-Pomerania, Łódź and Wielkopolska, or Świętokrzyska Land and Łódź); these are so-called internal peripheries.

Table 3 The coefficients of determination r^2 for different types of functions

Relationship	Function			
	linear	exponential	logarithmic	power
H1	0.017	0.015	0.015	0.016
H2	**0.468**	0.352	0.452	0.404
H3	0.010	0.016	0.016	0.003
H4	0.519	**0.557**	0.536	0.552

The highest values of r^2 are shown in bold print.
Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

5 Centre-periphery structure vs car market characteristics

5.1 Car ownership

Car ownership seems to be the most frequently analysed research question of the car market. In quantitative studies based on econometric modelling [29], it is operationalised by the application of aggregate models of car ownership (using the number of cars per 1000 inhabitants as the basic indicator) or disaggregate models (using the average number of cars per household). The figures of both indicators vary in size, depending on the country, region and commune but they are generally related to the level of development and income of a territorial unit. However, the analysis carried out in this article for Poland does not confirm such a relationship (Fig. 2). The coefficient of determination for the linear function (see Table 3) assumes a very low value, which means that the relationship between the index of centrality/peripherality of an area and the motorisation rate in Polish *gminas* is very weak. This is all the more interesting as research for other Central and Eastern European countries [14, 30, 31] implies that the countries of this region have still not reached the market saturation, which largely affects the income elasticity of demand for personal cars. On the other hand, there are also studies by Polish authors [32, 33] indicating that already at that stage of development, i.e. in 2003, income ceased to

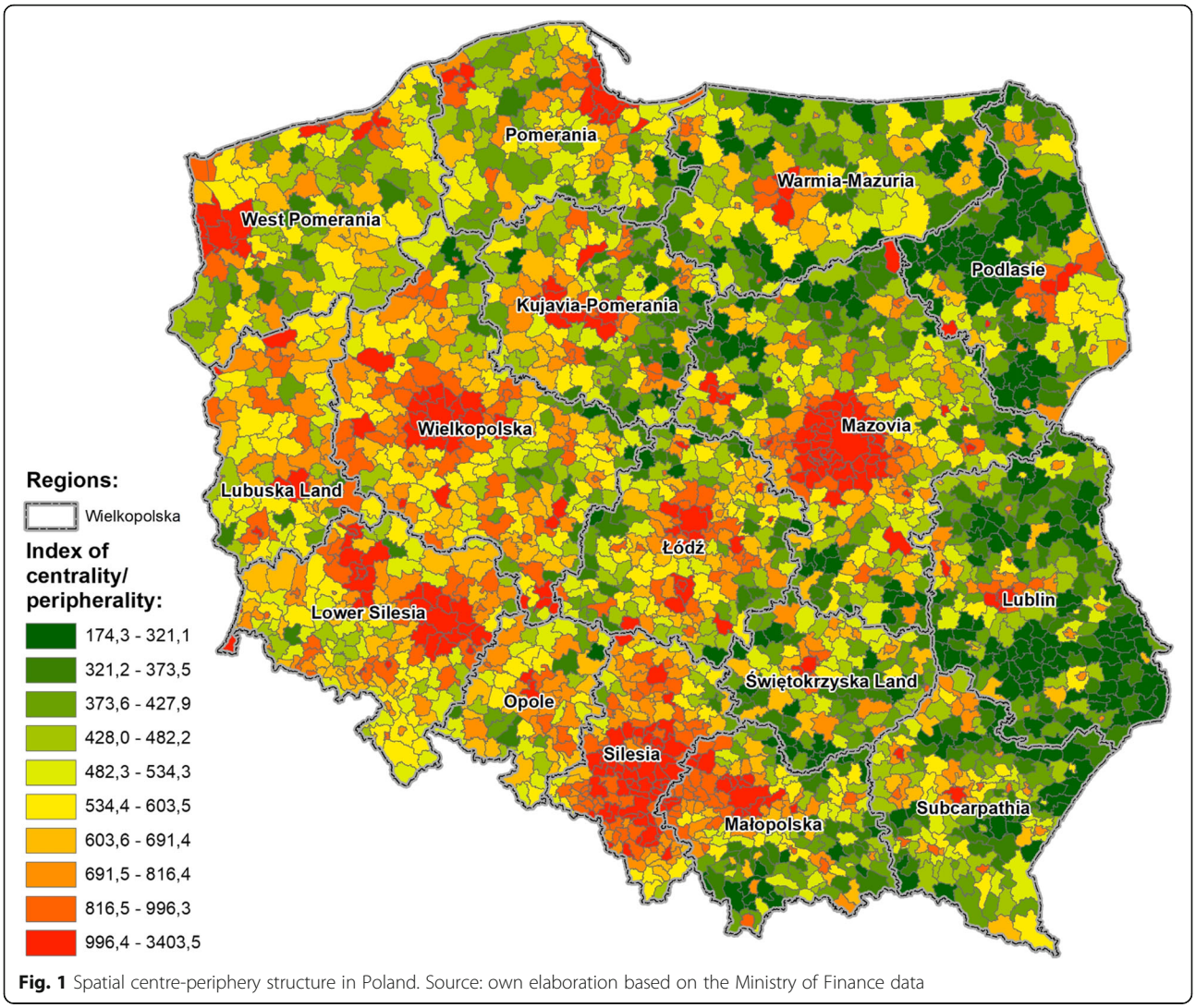

Fig. 1 Spatial centre-periphery structure in Poland. Source: own elaboration based on the Ministry of Finance data

determine the level of car ownership in Poland and began to significantly affect the structure and type of the cars chosen.

Figure 3 presents the spatial distribution of the indicator of car ownership (motorisation rate) in Poland. In order to ensure comparability with the centre-periphery structure map (Fig. 1), the same method of creating classes, i.e. deciles, was used. The distribution of car ownership differs significantly from the centre-periphery structure and indicates several other spatial regularities. Firstly, large cities have a low motorisation rate. This is due to the exclusion from the analysis of fleet cars and the important role of urban public transport [34, 35]. Secondly, high values of the motorisation rate are observed mainly in central Poland, especially in Wielkopolska, and to a lesser extent also in Łódź and Mazovia. These are regions which have for many years demonstrated a high motorisation rate (Wielkopolska) or where the availability of public transport is limited and the population flows (e.g. commuting) are relatively significant (areas north and west of Warsaw and south of Łódź). Explanations of these spatial regularities call for further, in-depth studies.

5.2 Sales of new cars

The market of personal cars in Poland can be divided into the market of new vehicles purchased in Poland and that of second-hand vehicles imported from other countries. The second hypothesis verified in this article assumes that the higher the level of centralisation of an area, the higher the sales of new cars. The analysis of the relationship between the centrality/peripherality index and the sales of new personal cars (excluding fleet cars) per 1000 inhabitants confirms this hypothesis (Fig. 4). The coefficient of determination for the linear function is 0.468, which is quite high for almost 2500 communes and when compared to other car market research. This relatively strong relationship is also confirmed by the

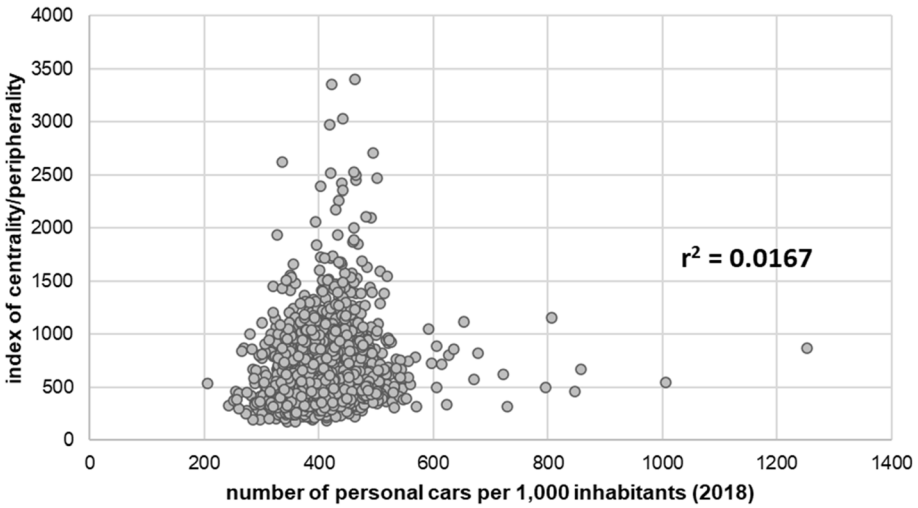

Fig. 2 Relationship between the centrality/peripherality index and car ownership. Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

results of previous surveys for Poland [18] as well as for other countries with a strong role of the second-hand car market and a concentration of sales of new cars in the centres of economic development, usually inhabited by people with high incomes [14].

Separating the analysis of sales of new cars from that focusing on car ownership makes sense, especially in countries where the second-hand market plays an important role. Here the sale of new cars should be more correlated with the population income due to the higher prices of new vehicles [36]. This regularity is confirmed by the study performed for Romania [14], where the coefficient of determination for the linear function of two variables: new car registrations and regional GDP per capita is $r^2 = 0.755$ (in this case, the analysis of data aggregated to the sub-regional level was carried out, which involved a much smaller number of territorial units). Other studies also bear out that in the countries of Central and Eastern Europe the market for the sale of new cars has become less and less important since their accession to the European Union and is mainly targeted at the rich inhabitants of metropolitan areas and large cities [37].

5.3 The import of second-hand cars

Upon the accession to the European Union, Poland has become one of the major importers of second-hand cars [15, 38]. Since 2004, an average of 800,000 such cars per year have been sold on the Polish car market, which means that over the last 15 years nearly 12 million second-hand cars have been imported to Poland, mainly from Germany. Out of all personal cars registered in 2018, over 50% were imported second-hand cars; in 2004 the figure was only 25% (Fig. 5). Changes in the structure of the personal car market (new purchases made in Poland vs. imported second-hand cars) after the accession to the European Union and the removal of institutional barriers limiting imports prove an increasing role of the secondary market. In the first years of EU membership, for every one new car sold in Poland, three used cars were imported. While currently this difference is smaller (1:1.7), we continue to observe the process of inflow of used vehicles from external markets to Poland to the detriment of new car sales.

The results of previous studies (as mentioned at the beginning of the article) imply that the import of used cars (especially older ones) should be linked to a lower consumer income and the peripherality of a country or region. However, studies for Poland do not confirm this correlation, i.e. there is no definitive relationship between the level of centrality/peripherality of an area and the scale of imports of second-hand personal cars (Fig. 6). This means that while the latter phenomenon helps to identify peripheries at the international level, domestic analyses seem to indicate an important role of other factors. Indeed, it is likely that there are regions or communes which, due to their specific geographical and socio-cultural characteristics, are the gateways for the import of second-hand vehicles to the Polish automotive market. On the other hand, after entering this market, these vehicles are re-distributed to other peripheral areas of Poland as they grow older.

This conclusion can be confirmed by the spatial structure of the index of imported used cars per 1000 inhabitants in the *gminas* (Fig. 7). It clearly shows a very high concentration of new registrations of such vehicles in the Wielkopolska and partially Lubuska Land [39]. On the one hand, it may be related to the proximity of the

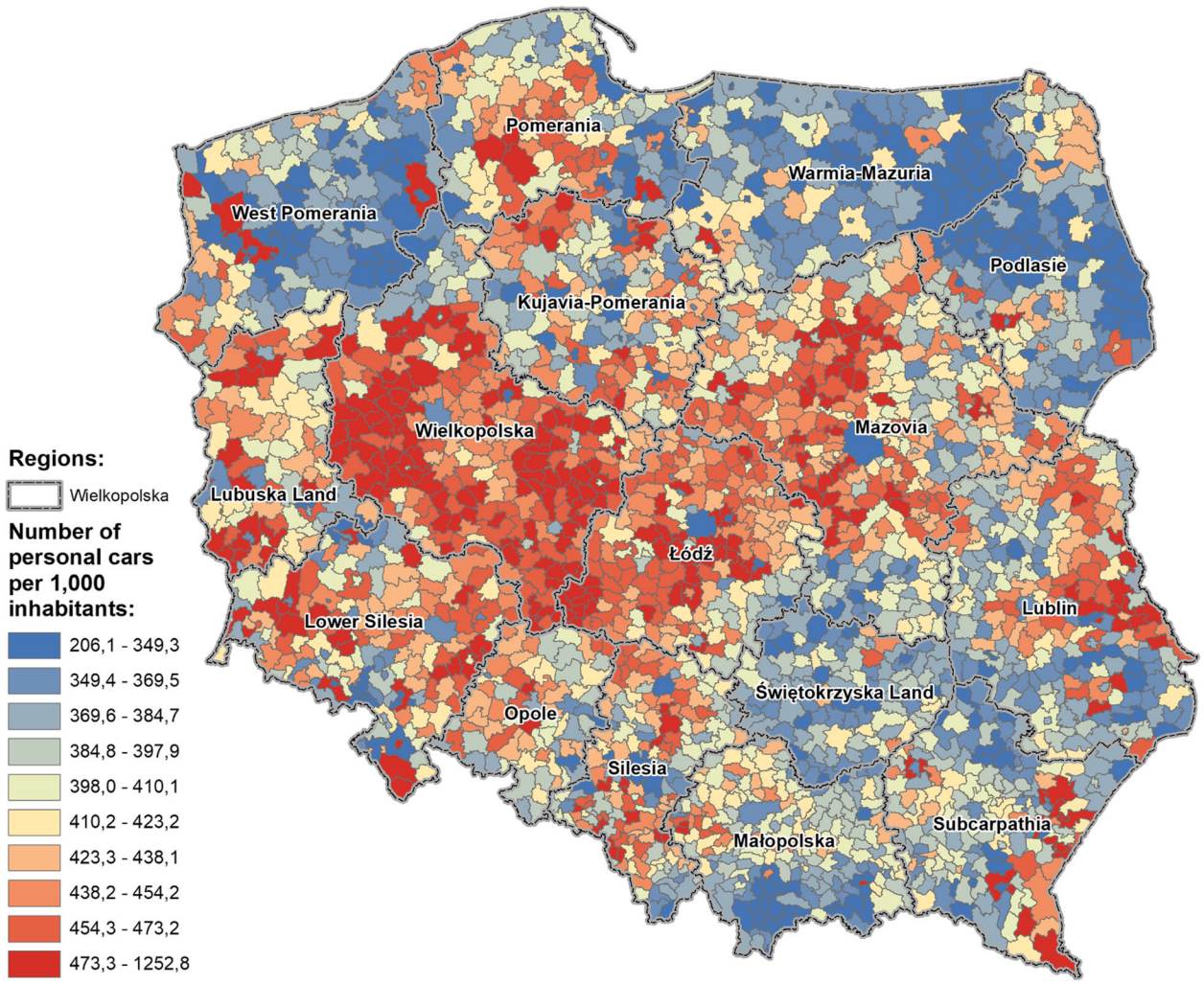

Fig. 3 Spatial structure of car ownership in Poland. Source: own elaboration based on the Central Vehicle Agency data

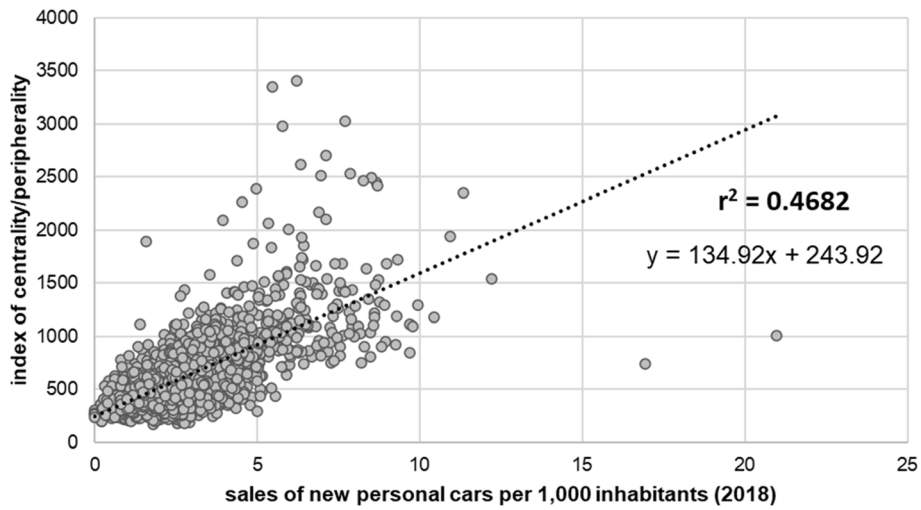

Fig. 4 Relationship between the centrality/peripherality index and the sales of new cars. Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

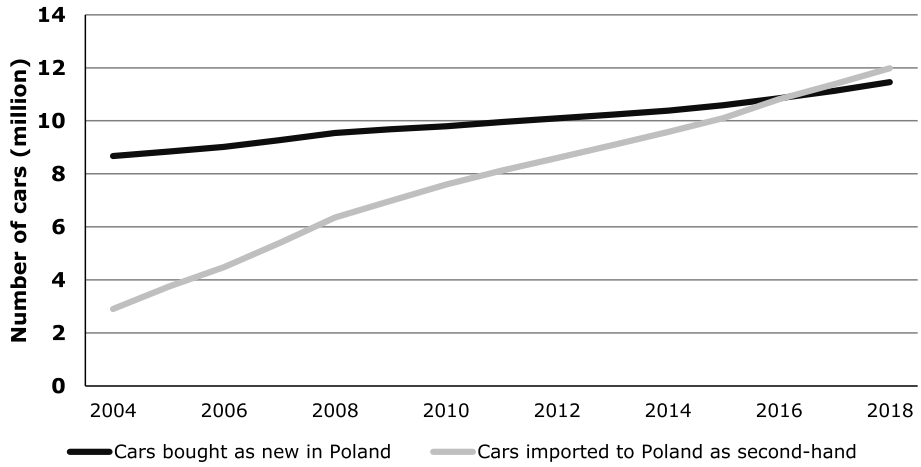

Fig. 5 Change in the dynamics of the number of cars bought as new and imported as second-hand in Polish car fleet after the accession to the EU. Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

border with Germany, i.e. the country from which the majority of used personal cars are imported to Poland [14]. On the other hand, the eastern areas of Wielkopolska are far more distant from the western border than, for example, some communes of Lubuska Land, West Pomerania or Lower Silesia, which may imply that the scale of the import in this region is also connected with cultural factors and the specific characteristics of this area. Wielkopolska is considered to be a region with a higher level of entrepreneurship, and its inhabitants are characterised by greater economic and social activity [40–42]. They may better take advantage of the "windows of opportunities" which emerged after the EU enlargement and opening the state borders.

Several studies on the import of second-hand cars have repeatedly pointed to the role of demographic and socio-cultural factors in determining the scope of this phenomenon [43–45]. A good example is the north-western part of Romania (Transylvania), which is the import centre for second-hand cars in this country. This is mainly due to the large-scale emigration of the local population to Western Europe: Germany, Austria, France, and the Benelux countries [14, 46]. Transylvania has developed a network of social relations between second-hand cars sales markets in Western countries and those in Romania, which, like in Poland, opened up clearly after the lifting of customs duties and taxes upon the accession of this country to the European Union.

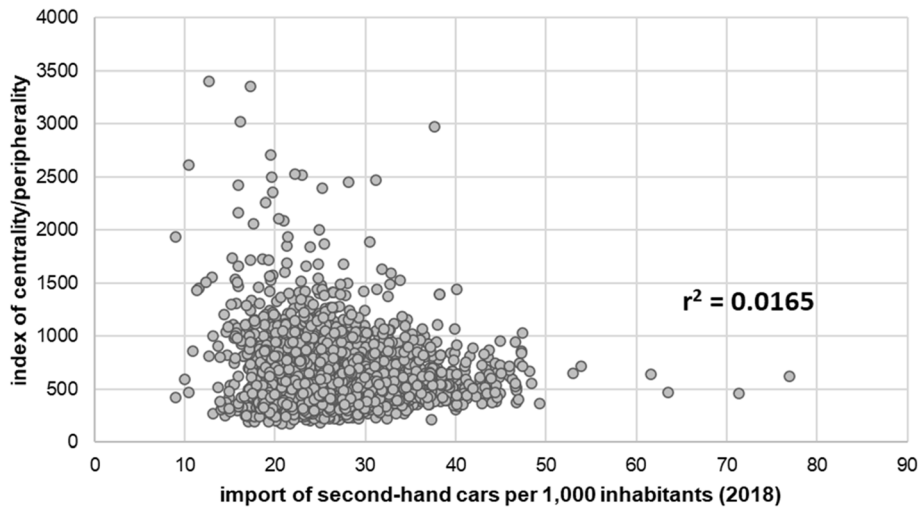

Fig. 6 Relationship between the centrality/peripherality index and the import of second-hand cars. Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

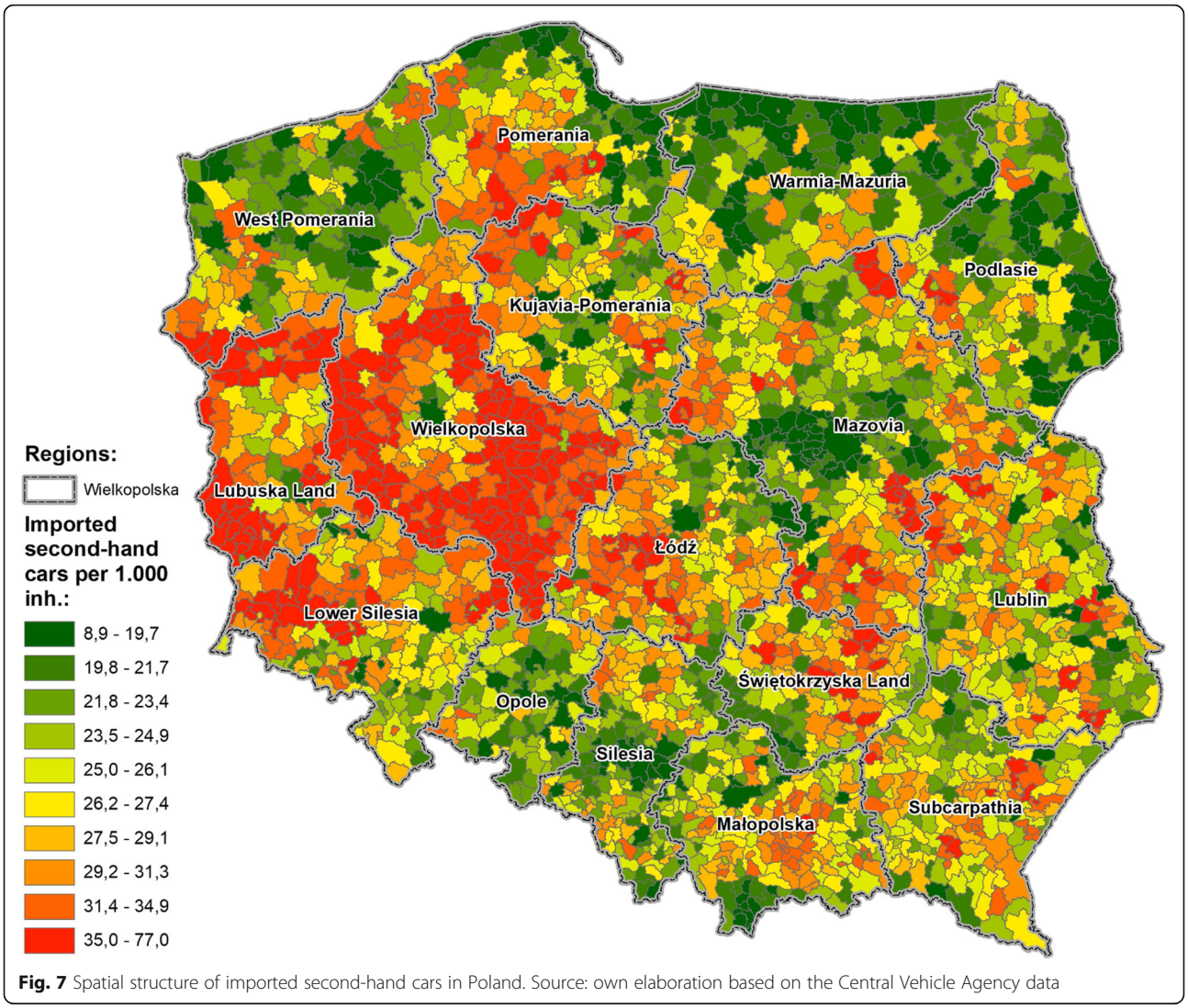

Fig. 7 Spatial structure of imported second-hand cars in Poland. Source: own elaboration based on the Central Vehicle Agency data

From this point of view, it seems that Wielkopolska should be the subject of in-depth social studies explaining such a high concentration of the import of second-hand cars.

5.4 The average age of cars

The last feature of the personal car market to be analysed is the average age of vehicles. It is assumed that the higher the age, the lower the level of centrality of the area. Earlier research gives grounds for such a statement, because the age of a vehicle determines its price on the market, which in turn is one of the main reasons for choosing a car due to the importance of income in making purchase decisions. The analysis of this relationship for Polish *gminas* confirms the above conclusion (Fig. 8). It should be noted, however, that the relation between the centrality/peripherality index of an area and the average age of a vehicle is best described not by a linear function, but by a power function whose fit is $r^2 = 0.557$. This in turn confirms that among the analysed variables it is the best indicator of the centrality/peripherality of an area, as it shows the greatest correlation with the level of personal and corporate income.

The average age of a vehicle in Poland is about 13.5 years (with the EU average of about 10.5 years) and is one of the highest among European countries [47]. Data on the import of second-hand cars into Poland show that this is probably the main reason for the high average age of personal cars in Poland. The average age of imported vehicles exceeds 12 years and in spite of 15 years since Poland's accession to the European Union, this indicator has not changed significantly. Taking into account the age of imported cars and their share in the current Polish automotive market (Fig. 5), it can be

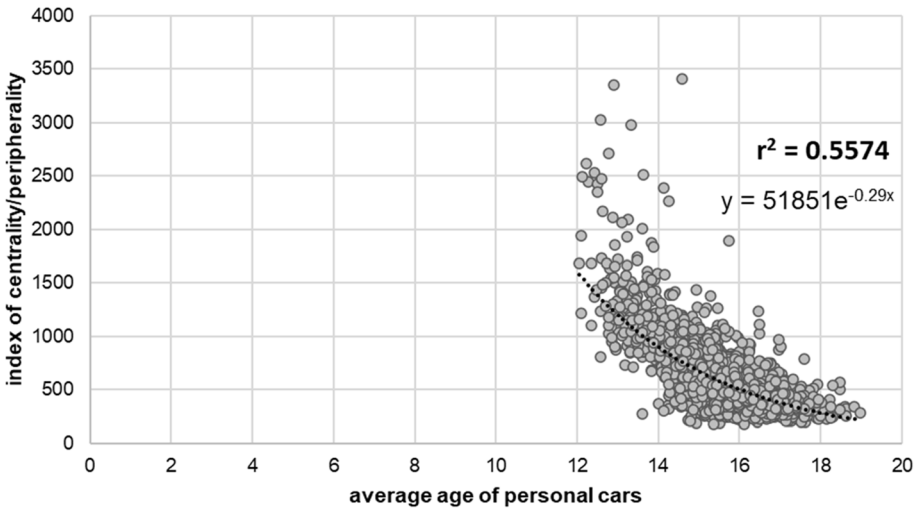

Fig. 8 Relationship between the centrality/peripherality index and the average age of cars. Source: own elaboration based on the Ministry of Finance and Central Vehicle Agency data

assumed that the average age of personal cars in Poland will not decrease rapidly in the near future. Equally interesting and requiring explanation (taking into account the conclusions from section 5.3) is also the process of geographical movement of imported cars to peripheral areas within the country.

6 Conclusion

Selected features and indicators of the personal car market may be related to the centrality/peripherality of an area. This is proven by several studies present in the literature. The results of some of them have been confirmed in this article. First of all, the average age of personal cars is the measure best reflecting the centre-periphery structure in Poland. Indirectly, it is also a measure of cars' value, which, in turn, is connected with the level of income [7, 36]. Older, lower value vehicles are therefore more likely to be present in lower income areas.

Moreover, the results of this study confirm the relationship between the centrality/peripherality of an area and the sales of new personal cars (excluding fleet cars). This correlation (similarly as the relation to the average age of vehicles) is also a derivative of the value of a car. The concentration of sales of new cars in the largest urban agglomerations in Poland makes them the target of automotive corporations' strategies.

In the light of our research, it is not possible to confirm the link between the centrality/peripherality of an area and car ownership. The highest number of personal cars per 1000 inhabitants in Poland is recorded mainly in the regions of Central Poland (Wielkopolska, Łódź, western part of Mazovia). Explanation of this regularity requires further in-depth studies (it may be related to the need for longer commuting to work). A high level of car ownership in Wielkopolska has been observed for at least twenty years, which means that explanations of modern processes and trends should be sought using a long time series of data.

The centre-periphery structure is reflected in the least degree by the import of second-hand cars. Poland is by far the largest importing country in Europe for this type of goods, but the main gateways for second-hand cars are relatively well-developed areas of Wielkopolska. It seems that it is necessary to conduct in-depth research on the socio-cultural factors contributing to this phenomenon. In general, this study confirms that some characteristics of the personal car market may be a useful tool for the analysis of regional structures, including the identification of centres and peripheries.

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Availability of data and materials

The manuscript is based on the Ministry of Finance (Ministerstwo Finansów) and Central Vehicle Agency (Centralna Ewidencja Pojazdów) data. There is an open access to the Ministry of Finance database (https://www.gov.pl/web/finanse/sprawozdania-budzetowe). Data from Central Vehicle Agency are available for fee.

Declarations

Authors' contributions

The authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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