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An attempt to model the demand for new cars in Poland and its spatial differences¹

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Abstract: The article seeks to identify socio-economic conditions that affect the demand of individual consumers for cars and to analyse the spatial differences of those conditions. To achieve this objective use was made of methods and models of spatial econometrics. The analysis conducted embraced all poviats in Poland (the second-level unit of the Polish administrative division, equivalent to LAU-1, previously called NUTS-4) and covered the years 2010-2015. The findings show that the primary factor affecting the demand for new cars in Poland, other than the price, was the level of wealth of potential consumers. A complementary role was played by the demographic situation, the level of local development and the level of satisfaction of the needs for a motor vehicle. An in-depth analysis in the form of geographically weighted regression (GWR) showed there to be spatial variations in the conditions identified, which might explain the wide differences in the level of motorisation and the demand for new cars in Poland.

Key words: car market, socio-economic determinants of demand, spatial perspective, econometric modelling, geographically weighted regression, Poland.

JEL codes: R41, D12, C31, C30.

Introduction

One of the elements of socio-economic life in Poland that experienced significant changes over the last 25 years has been the level of motorisation. Because

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of historical determinants, even in the early 1990s access to personal cars was limited and was greatly different from the West European standards. Poland's opening to international economic exchange has made the domestic motorisation market part of the world market. In effect, in the years 1990-2015, the level of motorisation grew from 138 to 540 registered personal cars per 1,000 of the population. However, this level varied spatially depending on local and regional socio-economic determinants.

Studies of a broadly understood car sector and the motorisation market in Poland conducted so far follow several research streams. The first deals with the development of the car industry in a historical approach. Those studies describe the rise and development of this sector, beginning with the 1920s and 1930s (Lizak, 2011) until the changes it experienced with the start of the systemic transformation in the country (Strykiewicz, 1999) and its accession to the European Union (Domański, Guzik & Gwosdz, 2005; Jürgens & Krzywdziński, 2009). The next group of publications concerning the car industry includes works about the size and location of production. Here, we can find studies of the spatial structure of manufacturing firms, including their spatial clusters, location factors and effect on the local labour market (Domański et al., 2005).

In recent years scholars have also focused on the impact of the world financial and economic crisis of 2008-2009 on the state and prospects of the production and sale of cars, their components and employment in the car sector. So far relatively little attention has been given to the demand for cars and the socio-economic determinants that influence it. Especially scarce in this field are spatial-economic studies attempting to quantify changes in this demand within a territorial pattern. This paper seeks to fill in this gap. Its goal is to identify socio-economic determinants of individual customers' demand for new cars measured by their sales and to analyse spatial differences in this respect. The attainment of this goal required a multi-stage research procedure. The first step was the identification of potential determinants that, in the light of studies carried out so far, can have an influence on changes in demand. Next, with the help of regression analysis, those determinants were identified that actually affected the demand for new cars in Poland. Finally, in order to determine spatial differences in the role of individual factors affecting the demand on the primary car market, other than the price, a model of geographically weighted regression (GWR) was estimated.

The structure of this article is as follows. Section 1 presents characteristics of the car market in Poland, its features and changes over the last 25 years. Section 2 offers a survey of the literature reporting the research on the determinants of the demand for cars carried out so far. The third section presents sources of data, the methods of analysis employed in the work and the empirical results. The article ends with conclusions deriving from the research.

1. Development and characteristics of the car market in Poland

The present car market in the countries of Central and Eastern Europe (including Poland) has been greatly affected by historical factors (Komornicki, 2011). They caused the rate and directions of the development of motorisation to follow a completely different path than in the other parts of Europe and the world. In the reality of a centrally planned economy, till the early 1990s, the situation on the car market depended in fact on the current policy of the central authorities. Until the 1970s the supply of cars was much limited which translated itself into a very low level of individual motorisation. In effect, according to the data of the Ministry of Transport, in 1970 there were only 15 personal cars per 1,000 inhabitants. In the successive years (the 1970s and 1980s), because of Poland's partial economic opening, the number of personal cars started to rise systematically. However, the level of individual motorisation was still greatly different from that characterising West European countries. In 1990 there were 138 cars per 1,000 inhabitants, while in Western Europe (the EU15) this rate was 406 cars per 1,000 inhabitants (data of the World Bank).

A real motorisation boom took place in Poland in the 1990s. The opening of the borders allowed the appearance of a much richer offer of car brands and models and the import of used cars from abroad. 1991 was a peak year, with over 800 thousand cars registered. What influenced the rise in the number of cars at that time was mostly an improvement in the country's economic situation (in the years 1990-99 its GDP grew by 88%), which brought about an increase in wages and a gradual improvement in the quality of people's life. Komornicki (2003) also observes that for many people the possession of a car became a mark of prestige and social standing. In effect, over the 1990-1999 decade, the number of cars grew by 76%. In that period Poles bought new cars relatively often (in 1999 their sale exceeded 640 thousand).

This situation changed after Poland's accession to the European Union (Mutrynowski, 2015). In the first year of its membership over 800 thousand used cars were brought from other countries of the Community and in the record year 2008, over 1.1 million. In effect, the number of new cars sold dropped, which automatically meant problems for producers and dealers. This bad situation deteriorated even further because of the worsening business conditions connected with the world economic crisis. In spite of the breakdown of the market, after 2008 the number of personal cars kept growing steadily to reach 540 per 1,000 inhabitants in 2015. It is worth noting that over the last 25 years (1990-2015) the number of vehicles registered in Poland almost quadrupled. As a result, the car stopped being a luxury item and became a basic element of households (cf. Czapiński, 2009). According to reports prepared by the Central Statistical Office, in 2014 as many as 62% of households had their own cars; by

comparison, in 2000 this figure was 47%, and in 1990 only 35%. The highest proportion of households equipped with a car could be found in the voivodeships of Podkarpackie (71%), Wielkopolska (68%) and Lublin (67%), while the lowest percentages were recorded in West Pomerania (52%), Warmia-Mazuria (55%) and Lower Silesia (55%).

The market for new cars in Poland is relatively small. In 2014 there were over twice as many used cars brought from abroad than new cars bought in the country (Polski Związek Przemysłu Motoryzacyjnego [PZPM], 2015). What is more, most new vehicles were bought by so-called fleet customers (enterprises) – in 2015 they accounted for as much as 65%. The 2015 data on the sale of new cars show that the greatest number of cars went to large cities and regions surrounding them. In turn, the smallest number of new cars were bought in the eastern Poland; they also recorded the steepest drop in the number of new cars sold in the years 2010-2015.

2. Socio-economic determinants of the demand for cars in the literature on the subject

The determinants⁴ affecting the demand for cars can be divided into two categories. The first includes attributes of the product itself such as the price, brand, level of security, and level of technological advancement. The other embraces exogenous factors of a socio-economic nature that usually lie outside the zone of impact of car manufacturers but that have a significant effect on the level of the demand for cars.

The first of those groups of determinants has been fairly well explored in the literature on the subject. An obvious attribute of a car as a product that affects the demand is its price (Sung, 2014). An important factor other than the price that predisposes consumers to buy a car is their attachment to a brand (Anderson et al., 2015). In their research on the car market in the USA, Mannering and Winston (1991) found that consumers' weak loyalty to the brand was the cause of General Motors losing over one-third of their share in the market to Japanese producers (Toyota, Honda) in the 1980s. Anderson et al. (2015) also claim that the attachment to a car brand is in a sense hereditary: the analyses they conducted show a mechanism of an inter-generational transference of preferences in the choice of the car brand. Hence, this is an attribute of the product that significantly affects the car demand.

The car sector is put in the group of technologically advanced industries and the innovativeness of cars is listed among the basic factors of competitiveness of their manufacturers. Using an example of 17 global corporations, Tseng and

⁴ In this paper we treat the terms 'determinants' and 'factors' as synonymous, although we are aware that some scholars differentiate between those notions.

Wu (2007) showed that in this industry the number and scope of innovations had a positive effect on the profits of car corporations. What is more, consumers' decisions concerning the purchase of a new car are increasingly dictated by their wish to replace it with one more advanced technologically rather than by the actual tear and wear or age of an old one (Volpato & Stochetti, 2008).

Another factor indicated in studies of consumers' decisions on the motorisation market is their growing tendency to buy environmentally friendly cars, i.e. ones driven by alternative kinds of fuel and emitting less pollution into the atmosphere (Willander, 2007). The motives behind these kind of decisions vary. On the one hand, we can observe consumers' growing ecological awareness. On the other hand, Nayum and Klöckner (2014) indicate that what affects the choice of energy-saving cars is the policy of the state and its financial incentives offered as part of public assistance. Another, perhaps the most important factor is people's propensity to save. The rising prices of petrol were one of the reasons for a decline in the sale of cars with high fuel consumption typical of American customers (Train & Winston, 2007).

It seems, however, that apart from strictly price-related determinants and specific attributes of cars (like their make, level of safety or impact on the natural environment), the demand for new cars on the market of individual customers can be affected by other factors characterising the socio-economic environment. Hence, the identification of at least some of those factors would allow an explanation for changes taking place on the car market, including the demand for new cars, and would facilitate the anticipation of those changes in the future. This, in turn, can be significant not only from the point of view of vehicle manufacturers but also from the point of view of an economic policy (e.g. concerning the labour market). In this paper an attempt is made to identify those factors and to analyse their effect on the car market in Poland.

The choice of factors for further analysis was made on the basis of a survey of the literature. One of the first works intended to identify and analyse determinants of the development of individual motorisation was Button, Pearman and Fowkes (1982), who found them to include incomes, the size and structure of households, fuel prices and accessibility by public transport. Ingram and Zhi (1999) analysed similar factors, i.e. incomes, prices of the fuel and cars, demographic trends, the transport policy and urbanisation. In the Polish literature a position worth noting is Komornicki (2011) who studied changes in the mobility of Poles and its spatial dimension.

Given the information supplied by the above works, the socio-economic characteristics of Poland and the accessibility of data, the following factors were chosen for analysis in this paper: demographic factors, consumers' incomes, the level of local development, the level of urbanisation, the level of market saturation and prices of complementary goods.

As the results of earlier studies show, an analysis of the current and anticipated demand for cars should also accommodate demographic factors.

According to Prskawetz, Leiwen and O'Neill (2004), in the years 1996-2046 the annual increase in the demand for cars in Vienna will be 3% and will be largely determined by the size of households and the age of their members. In turn, Carlsson-Kanyama and Linden (1999) demonstrated that in Sweden older women and people with lower incomes drove cars more rarely than middle-aged men and people with higher incomes. One can therefore conclude that some demographic factors, such as age and sex, may influence the willingness to buy and use a car. Another important, demographic factor is migration. Both oscillatory movements of the population, such as daily journeys to work (Motte-Baumvol, Massot & Byrd, 2010) and permanent migrations affect the demand for cars because they generate additional motorisation needs or affect the size of the population. Some of the Polish regions and towns have been especially hit by population outflows following Poland's membership of the EU (GUS, 2013), but also as a result of outflows to big urban centres with their better-developed labour markets and a higher standard of living. However, irrespective of the type of migration and its causes, its result can be a change in the size and needs of the population in the field of movement, which can translate itself into changes in the demand for new cars.

The next determinant of the demand on the car market analysed in this paper is income. The income is one of the basic factors, other than the price, the influence of which on the market demand curve is analysed by economists (Samuelson & Nordhaus, 2010). However, since access to data concerning the incomes of people buying new cars in Poland is highly limited, hence in the research presented in this article the focus was on the relationship between mean incomes of the population living in an administrative unit (a poviát) and the demand for cars recorded there. Similar studies conducted earlier have demonstrated quite unequivocally the presence of this type of relationship (see e.g. Dargay & Gately, 1999; Nolan, 2010).

What seems another obvious factor affecting the demand for cars is the level of socio-economic development. Its high level is connected with a high level of employment in non-agricultural sectors of the economy, low unemployment, an above-average level of entrepreneurship and high incomes, both in the public and the private sector. All these consequences of socio-economic development have a stimulating effect on the level of people's needs concerning movement, including individual travel by car. There are many empirical studies corroborating the relationship between socio-economic development and the demand for cars. For example, Lescaroux (2010) showed there to be a connection between the income (reflecting the development level) and the demand for cars. However, it should be noted that this relationship depends on the price flexibility of the demand and on the level of market saturation. Thus, this relationship differs among countries and regions. In this paper it is assumed that it also occurs on the subregional scale, i.e. at the level of poviats.

Another group of determinants analysed in this paper is connected with the level of urbanisation. On the one hand a high concentration of the population in some places affects the size of the market, which can obviously lead to an increase in the sale of cars (Daganzo, 2014). On the other hand, the advancing process of suburbanisation leads to changes in people's lifestyles, which manifests itself in an increase in their mobility and motorisation needs (Sheller & Urry, 2000). In a situation where the development of suburban areas occurs in a barely controlled and is not followed by the development of functions other than housing (i.e. public transport, public services, workplaces, etc.), the population's need for everyday movement grows steeply, largely satisfied by individual car transport. Its development leads to an increase in the demand for cars.

Finally, the research conducted also embraced two determinants connected directly with the demand for cars, i.e. the level of market saturation and the price of complementary goods. The most obvious complementary good, the price of which can affect the demand for new cars among individual customers, is the price of petrol. In the light of the demand law, lower petrol prices boost the demand for cars, *ceteris paribus*. This dependence is reversible. In contrast, the effect of the saturation of the car market on the demand for new cars is ambiguous. On the one hand, a high level of saturation can presumably reduce consumers' demand for cars. On the other, however, this high level can lead to a situation when the demand is higher because of their wish to replace their cars with new ones (replacement demand). As earlier studies show the motorisation market today is stimulated primarily by this kind of demand (Volpato & Stochetti, 2008). In this paper we also seek to verify the significance of this factor.

3. Data and methods

The research procedure designed to identify socio-economic determinants affecting non-corporate customers' demand on the primary car market in Poland and to analyse the spatial differences in those determinants was performed with the use of spatial econometrics models. In accordance with procedures proper for this group of models, the first to be conducted was an analysis of global dependences in the set of the units studied (poviats), followed by a verification of the criteria concerning the random component and deriving from the so-called standard stochastic assumptions adopted in the ordinary least squares method (OLS) and an estimation, in the final stage, of local models of geographically weighted regression (GWR) taking into consideration the spatial heterogeneity of the modelled feature.

The specification of a global model (for the entire population) started with the choice of variables characterising Polish poviats in terms of the socio-eco-

nomic features presented earlier. In order to eliminate the problem of random oscillations and spatial differences following from the pattern of business cycles the research was conducted on the basis of data embracing averaged five-year values⁵ of the diagnostic features chosen for modelling.

The explained (endogenous) variable, the values of which represent demand on the primary car market in individual poviats in Poland, was the number of newly registered personal cars per 1,000 inhabitants. The data describing the car market, covering the years 2011-2015, were obtained from Poviats Transport Departments.

In turn, the set of explanatory (exogenous) variables included a wide range of socio-economic indicators describing Polish poviats in terms of the conditions identified. Exogenous indicators for the years 2010-2014 were taken from official publications of the Central Statistical Office. At first the greatest possible number of potential explanatory variables were selected in anticipation of the reduction of this set in the course of verification of the significance of individual variables for the further procedure. What decided the final adoption or rejection of a potential explanatory variable were statistical and formal criteria, extensively described in Grabiński, Wydymus and Zeliaś (1982). In the research use was made exclusively of quantitative variables, hence the absence of variables recognised in the theory of economy and referring to some price-unrelated factors affecting demand, such as fashion, preferences and expectations of consumers, the quality of the product and advertising. A full list and basic statistical characteristics of indicators selected for study representing the explained variable and potential explanatory variables can be found in Table 1.

To eliminate the problem of poor discrimination of the examined units (poviats) by the variables, those for which the coefficient of variation did not exceed 0.1 were eliminated from the initial set. In this way sufficiently wide (in spatial terms) internal differences of the diagnostic features were ensured which was important for an estimate of structural parameters and those of the stochastic structure of econometric models. In turn negative effects of modelling connected with the co-linearity of the explanatory variables were eliminated with the help of graph methods (cf. Grabiński et al., 1982).

The preliminary elimination of potential explanatory variables allowed the reduction of their initial set to four indicators that were used to estimate the econometric model:

- (1) the coefficient of net migration (x_3) as a variable representing the demographic situation (migratory movement determining the dynamics of change of potential buyers);

⁵ In the case of indicators that had the nature of streams the numerator was the sum of five-year values, which was then relativised to a five-year average number of inhabitants; in turn, indicators that had the nature of resources were averaged by calculating the arithmetical mean from values characterising the five-year period studied.

Table 1. Basic characteristics of indicators representing the explained variable and potential explanatory variables

Determinants	Indicator		Min.	Max.	Mean	Std. dev.	Coefficient of variation
	y	newly registered personal cars per 10,000 inhabitants	4.85	46.44	15.90	8.98	0.57
Demographic	x_1	% men	45.48	51.10	48.88	0.89	0.02
	x_2	% population of working age	59.85	67.94	63.90	1.35	0.02
	x_3	net migration coefficient	-45.48	126.80	-5.95	22.47	-
Incomes consumers	x_4	mean monthly gross wages [in PLN]	2,283.49	6,316.68	3,106.03	440.33	0.14
	x_5	per capita budgetary tax incomes of communes and poviats-ranking towns (agricultural tax and share in PIT) [in PLN]	259.28	2081.79	555.72	237.53	0.43
Level of local development	x_6	per capita own budgetary incomes of communes and poviats-ranking towns [in PLN]	668.14	5368.47	1518.16	632.90	0.42
	x_7	economic entities registered in REGON per 10,000 inhabitants	428.49	2,202.31	885.47	266.02	0.30
	x_8	entities newly registered in REGON per 10,000 inhabitants	277.37	1,295.33	501.00	140.25	0.28
	x_9	rate of registered unemployment [%]	3.65	36.58	15.50	6.02	0.39
Level of urbanisation	x_{10}	population density [people per km ²]	19.54	4,049.97	380.43	681.20	1.79
	x_{11}	urbanisation level (% urban population)	0	100	50.71	27.38	0.54
	x_{12}	% population employed in services	14.75	85.85	41.56	14.79	0.36
	x_{13}	% population employed in agriculture	0.33	74.14	30.00	20.48	0.68
lms*	x_{14}	registered personal cars per 1,000 inhabitants	321.2	702.05	477.42	59.39	0.12
pcg**	x_{15}	mean price of 95 petrol [in PLN]	5.03	5.12	5.07	0.02	0.004

* level of market saturation

** price of complementary goods

Source: Own calculations on the basis of data from Poviats Transport Departments (the explained variable) and the Central Statistical Office (explanatory variables).

- (2) per capita budgetary tax incomes of communes and poviats-ranking towns (the agricultural tax and a share in PIT) (x_5) as a variable describing the level of wealth of inhabitants (potential consumers);
- (3) the rate of registered unemployment (x_9) as a variable referring to the state of the local economy and hence affecting the purchasing power of potential buyers; and

- (4) registered personal cars per 1,000 inhabitants (x_{14}) as a variable illustrating the level of market saturation.

The last stage of model specification involved a verification of the nature of the dependence between the explained variable and the final explanatory variables. Since each time it was close to linear, a linear analytical form of the model was adopted and the multiple regression equation was estimated using the ordinary least squares method.

4. Modelling the demand for new cars with the application of the global multiple regression model

The OLS estimation procedure allowed the estimation of a regression model which assumed the form of the following function (cf. also Table 2):

$$\hat{y} = 10.759 + 0.048 \times x_3 + 0.027 \times x_5 - 0.240 \times x_9 - 0.012 \times x_{14}.$$

In accordance with the estimated model the value of newly registered personal cars per 1,000 inhabitants was significantly moulded by all the explanatory variables included in the initial model. The probability of an error in the assessment of statistical significance was close to zero ($p\text{-value} \leq 0.00511$). The explanatory variables x included in the model accounted for more than 70% of variation y ($R^2 = 0.71$).

Table 2. Results of OLS estimation of the multiple regression model

Variable	Standardised coefficients b^*	Coefficients b	Standard error b	t -statistics	p -value
intercept	–	10.75864	2.58714	4.15851	0.00004
x_3	0.12018	0.04806	0.01188	4.04565	0.00006
x_5	0.71240	0.02695	0.00125	21.64377	0.00000
x_9	–0.16090	–0.23993	0.05071	–4.73106	0.00000
x_{14}	–0.08067	–0.01220	0.00433	–2.81667	0.00511

Source: Own calculations.

As follows from the estimated regression equation, the part of variations explained in the number of newly registered cars in individual poviats (on the assumption of their constant prices) was affected by a combination of linear variables characterising poviats in terms of their demographic structure (variable x_3), consumers' incomes (x_5), the condition of the local economy (x_9) and the level of market saturation (x_{14}). The directions of impact of the variables

were in agreement with the theory of economy and the logic of cause-effect relationships.

The key factor affecting demand on local car markets was the level of wealth of potential consumers. As follows from the model higher incomes meant greater purchases of cars. The income effect was the strongest in the case of the demand for new cars (at each price level), and the remaining factors were of a complementary nature. A stimulating effect on the explained variable was net migration. As the basic factor controlling the population size, an increase in migration can be regarded as a determinant of the size of the market (as measured by the population size). Thus a population increase meant an increase in demand and hence in the sale of new cars. In turn the rate of unemployment registered in individual poviats played a destimulating role in the number of newly registered cars. In places where it was high, the turnover on the primary car market declined because of the smaller purchasing power of potential buyers. For jobless people a new car often becomes an unattainable good and they tend to satisfy their needs in this field relying on the market of used cars. Problems on the labour market that result in a rising unemployment rate can also limit demand because of potential consumers' fear of losing their jobs, a decline in their future incomes, and in consequence, their inability to use a car (e.g. because of the cost of petrol, insurance, surveys, etc.). Finally, the indicator that had an adverse effect on the endogenous variable was the number of registered cars per 1,000 inhabitants. This means that in poviats where the level of market saturation was high, consumers bought and registered new cars statistically more rarely. On the one hand, a great number of cars in an area can induce a drop in their price on the secondary market, encouraging the purchase of used cars. On the other, areas where the number of registered cars is high often experience transport congestion and difficulties in finding free parking places. These are factors limiting the demand for new cars.

5. Modelling spatial differences in the identified determinants with the application of the geographically weighted regression

The assumption adopted in OLS regression analysis is that the modelled features or processes are independent of their location. In practice this is an assumption of the stability of relationships among the phenomena examined, which means that at each of the observation points considered in the analysis (each *i*-th location) there occur the same (constant) relationships between the endogenous variable and the explanatory ones. But in the case of localised spatial observations there are often differences in relationships at individual observation points. This is due to the fact that socio-economic phenomena are different in metropolitan and peripheral areas, in highly and poorly developed regions,

in highly urbanised and rural areas, in industrial and agricultural regions, etc. Instability in the space of economic relations is termed spatial heterogeneity (Fotheringham, Brunsdon & Charlton, 2002; Suchecki, 2010).

Heterogeneity is an effect of the absence of spatial stationarity (Suchecki & Olejnik, 2010). This can make OLS estimates of the parameters of regression functions imprecise and the significance of tests of the strength and directions of links low. To eliminate the negative effect of spatial heterogeneity on those estimates, spatial regression models can be used. If there is heterogeneity, the models to choose are those with the instability of structural parameters, which include geographically weighted regression (Suchecki, 2010).

The GWR method allows the collection of the variations of coefficients of regression in space for each observation (Suchecki, 2010, p. 264). On this assumption model parameters are estimated separately for each observation for which the values of endo- and exogenous variables are known. In assessing the parameters of local regression models use is made of characteristics (explanatory variables) coming primarily from observations of neighbouring poviats, the significance of successive observations decreasing with distance (Fotheringham et al., 2002).

The parameters of a model of geographically weighted regression are connected with a location and the equation in a typical local model accommodating a greater number of explanatory variables can take the form (Fotheringham et al., 2002):

$$y_i = b_{0i}(x_i, y_i) + b_{1i}(x_i, y_i)x_{1i} + b_{2i}(x_i, y_i)x_{2i} + \dots + b_{ki}(x_i, y_i)x_{ki} + \varepsilon_i$$

(for $i = 1, 2, \dots, n$),

where (x_i, y_i) are co-ordinates of the i -th location (observation), y – the explained variable, $x_1, x_2, \dots, x_k$ – explanatory variables, $b_0, b_1, b_2, \dots, b_k$ – estimates of unknown structural parameters of the regression function, and ε – a random component (a model error, random disturbances).

The result of GWR modelling is an n -element set of localised estimates of parameters (n local regression equations) and measures of the goodness-of-fit of local models (e.g. local standard estimation errors or local R^2). The GWR results allow the assessment of the spatial differences in the relationship between the explained and the explanatory variables as well as the establishment of the role of individual variables at various locations.

In order to identify spatial differences in the role of factors – other than the price – controlling the demand for new cars in Poland the GWR model was estimated. The result was a set of 379 localised regression equations and local measures of the goodness-of-fit. The basic characteristics of the estimated GWR model are presented in Table 3.

The equations, estimated separately for each observation (location) and accommodating features (explanatory variables) coming from the observations

Table 3. Results of the estimation of the GWR model

Statistic	b_0 (intercept)	$b_1(x_3)$	$b_2(x_5)$	$b_3(x_9)$	$b_4(x_{14})$	local R^2
Min.	6.0846	0.0343	0.0238	-0.3272	-0.0189	0.6833
Max.	14.5585	0.0688	0.0294	-0.1294	-0.0035	0.8932
Mean	10.3966	0.0460	0.0269	-0.2285	-0.0118	0.7185
Standard deviation	2.0610	0.0081	0.0013	0.0510	0.0035	0.0296
Module of coefficient of variation	0.1982	0.1765	0.0475	0.2231	0.2976	0.0412

Source: Own calculations.

(locations) of neighbouring units, fundamentally improved the goodness-of-fit of the model to the empirical data. The global coefficient of determination in the GWR model was 0.85, higher than the R^2 value calculated for the OLS model (0.71). In turn the locally weighted R^2 , which shows how well the variability of the explained variable in a location is accounted for by an equation proper to this location (estimated taking into account explanatory variables from the 'local surroundings'), varied from 0.68 to 0.89.

The GWR model supplied information about differences in the significance of individual explanatory variables. The highest relative differences between the values of GWR coefficients (as measured by the module of the coefficient of variation) occurred in the case of the variable standing for the level of need satisfaction concerning new cars (variable x_{14} – the number of registered personal cars per 1,000 inhabitants). The differences were smaller in the case of estimators referring, in turn, to the rate of registered unemployment (x_9), the coefficient of net migration (x_3) and the per capita budgetary tax incomes of communes and poviats-ranking towns (the agricultural tax and a share in PIT) (x_5). This information is significant because the modelling of global dependencies showed that the level of wealth of potential consumers (variable x_5) was the most important determinant of the demand for new cars. This variable illustrated the smallest differences in the poviat pattern.

The maps illustrating spatial differences in the values of local GWR coefficients (Fig. 1) show that the influence of the determinants examined on variations in the number of newly registered personal cars differed. In the case of the coefficient of net migration (x_3), spatial variations ran from the north (a relatively greater impact) to the south (a lesser importance of the factor). The role of consumers' mean income (x_5) was the strongest in poviats located along Poland's southern border and decreased in a north-easterly direction. The rate of unemployment (x_9) destimulated demand on the market of new cars most

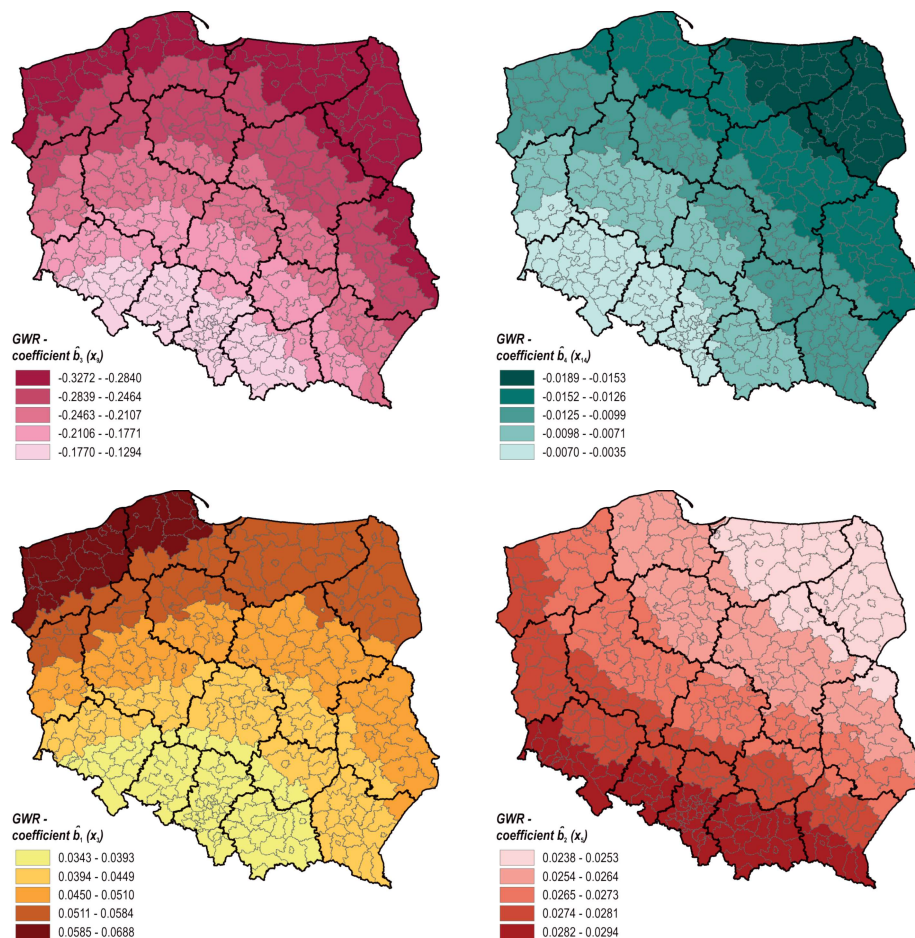


Figure 1. Spatial differences in the local coefficients of the GWR model (classes distinguished on the basis of Jenks' optimisation method)

Source: Own work.

strongly in the poviats of northern and north-eastern Poland, being less and less significant towards the central and southern regions. In turn spatial variations in the value of estimators of the variable describing the number of registered cars (x_{14}) manifested themselves in a north-eastern (a stronger effect) – south-western (a weaker effect) configuration.

Summing up and conclusions

The goal of this article was to identify socio-economic determinants affecting individual customers' demand for new cars in Poland and to analyse spatial differences in those determinants. On the basis of the research conducted, the de-

mand for new cars was found to be determined by consumers' incomes, changes in the number of the population resulting from migration movements, the level of local development as measured by the rate of registered unemployment, and the level of saturation of the market. Thus, it was proved that in the Polish socio-economic conditions of the recent years, the forces responsible for shifts in demand were largely identical with factors – other than the price – affecting the amount of goods bought in accordance with the economic theory and that they largely coincided with the determinants described earlier in academic literature.

The identification of demand factors on the primary car market in Poland, other than the price, is especially significant in the light of current trends involving a steady increase in society's mobility, advancing migratory movements, suburbanisation processes, or changes in the business cycle controlling the level of unemployment and consumers' wealth (cf. Czapiński & Panek, 2015). As the research has proved those developments are accompanied by significant changes in the demand for new cars. Hence, the results of the analyses conducted can be used by car producers planning their production and sales' strategies as well as in the preparation and implementation of public policies, e.g. in the field of public transport.

In the light of our study there are also spatial differences in the role of individual factors controlling the demand for the car market in Poland. It turned out that not all factors influenced the demand for new cars in the same way everywhere. Regression analysis combined with geographical weighting supplied precise information about territorial variations in the value of the parameters estimated so the results of the local modelling equations can be a valuable tool in simulation and prognostic work.

This paper does not exhaust all issues connected with the modelling of demand factors other than the price. What should be kept in mind in the first place is that the analysis covered only the primary market, while most of the motorisation market is secondary. It seems, therefore, that the next works should expand the scope of study so as to include this part of the market. Still, the results presented above, being among the first to identify the quantitative effect of socio-economic determinants on the demand for cars in Poland in their spatial dimension, can provide a basis for further research on the spatial aspects of the car market.

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