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Local car markets in an emerging economy: exploring the dichotomous nature of car ownership growth

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Abstract

The intensive motorization growth observed in emerging and developing economies has attracted increased academic attention. However, many existing studies frequently investigate the car ownership determinants that are typical of Western countries and use aggregate measures that mask the role of imported used cars. This implies that there is an important research gap concerning the role of the second-hand vehicles as a source of car ownership growth in emerging and developing countries. This paper aims to reveal the dichotomous character of car ownership growth in an emerging economy and identify the determinants of local primary (new cars) and secondary (imported used cars) car markets. Using data from the Polish Central Vehicle Register containing entries for more than 20 million cars registered and applying the spatial regression models, we disclose that in addition to well-known determinants of car ownership growth, such as income, population density, and housing types, there may be other factors specific to emerging economies driving this process. Specifically, we test the influence of geographical distance on the source of the car supply and the number of companies and entrepreneurs importing and repairing used cars. The findings suggest that future investigations of motorization processes concerning developing and emerging economies should consider the scale of second-hand car imports and its impact on car ownership and seek country-specific determinants of the phenomenon.

Keywords Local car markets, New cars, Imported used cars, Car ownership growth, Economic and spatial determinants, Spatial econometrics, Emerging economy, Poland

1 Introduction

Academic literature on car ownership has a rich tradition and for a long time has been predominantly focused on developed economies [27, 56, 77]. However, as the centre of motorization growth has been slowly shifting from developed to emerging and developing economies, so has scholars' attention. Indeed, while car ownership rates have been stagnating or even decreasing in Western countries, emerging and developing economies have

witnessed revolutionary changes in this regard. For instance, between 2005 and 2015, the number of passenger cars in China increased from 21 to 135 million, and in Brazil from 19 to 35 million [57]. Likewise, the number of passenger cars in Poland between 1990 and 2020 increased from 4.5 million to almost 19 million (meaning a rise in the car ownership rate from 118 to approximately 480 per 1,000 inhabitants). Hence, it is not surprising that these developments have attracted increased academic interest [2, 39, 62, 74, 76, 79, 81].

In contrast to developed economies where the car market has been supplied mainly by new cars, in many emerging and developing economies car ownership growth has been largely induced by the import of used vehicles[1] from developed countries. According to a United Nations

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[1] In this paper, 'used cars' refer to imported second-hand vehicles.

Environment Programme (UNEP) report [75], between 2015 and 2018, more than 14 million used light vehicles were exported from the European Union (EU), Japan and the US, mainly to Africa, Eastern Europe, Asia-Pacific, the Middle East and Latin America. Poland is a unique and intriguing case illustrating this process. The nation's EU membership eliminated almost all trade and technical barriers, which – reinforced by the huge domestic demand for passenger cars and large economic differences between 'old' and 'new' EU member countries – led to an unmatched import of 13.5 million used vehicles between 2004 and 2020. Used cars from abroad became a primary source of car ownership growth in the emerging Polish economy. Interestingly, the determinants and influence of used car imports on car ownership have hardly been investigated, mainly due to the poor data availability [40, 46].

This paper aims to reveal the dichotomous character of car ownership growth in an emerging economy and identify the determinants of local primary (new cars) and secondary (imported used cars) car markets. Using data from the Central Vehicle Register covering more than 20 million cars registered in Poland as well as spatial econometric models, we test whether the local markets are affected by factors well-recognised in the literature, such as income, population density, and housing types [9, 19, 21, 30, 51, 56, 80], along with factors specific to the emerging economies such as the presence of companies and entrepreneurs importing and repairing used cars as well as proximity to a supply source. This study shows that the influence of conventional determinants of car ownership such as income can differ in regard to primary and secondary markets which, in turn, may be affected by other factors hardly ever acknowledged in the literature concerning developed economies.

This paper is structured as follows: first, we briefly review the academic literature focusing on the determinants of car market size. Then, we present and discuss the dichotomous character of the car revolution in Poland during its systemic transformation and show the importance of used car imports in other emerging and developing economies. Consequently, we demonstrate that an unprecedented inflow of imported used cars mainly drove the Polish car revolution. This process was initiated and reinforced by the country's EU membership and the subsequent liberalization of the trade barriers. In the following section, we present the data and methods used to reveal the factors driving the markets for new and imported used cars. Finally, we discuss the findings and conclude this study.

2 Literature review

Income is the most frequently analysed factor affecting the size of the car market. The results of existing studies usually indicate its positive impact on the volume of car sales [19, 49, 51, 52, 56, 59]. This correlation has been proved by, e.g., Dargay and Gately [20], who pointed to the fact that between 1960 and 1992, the average annual gross domestic product (GDP) growth of 2.6% was accompanied by an increase of 5.8% in the car ownership level. It is worth noting that they investigated the whole car fleet (and not only the sales level). However, Stryjakiewicz et al. [73] emphasized that car ownership growth in developed countries resulted primarily from rising sales of new vehicles. As a result, the factors that were significant when describing changes in car ownership overlapped to a large extent with those affecting the volume of new car sales. Sivak [69] and Dzuro et al. [24] found a positive impact of GDP on car sales in numerous developed and developing countries. Similarly, when analysing the spatial distribution of the number of new cars registered per 1,000 inhabitants, Kudłak et al. [43] and Kisiała et al. [34] confirmed a statistically significant correlation between this indicator and the level of consumers' income as well as local development.

Another factor affecting the car sales volume is the size of the population and its spatial concentration [55, 58, 66, 68, 70, 80, 81]. The results of the existing research show that the higher the population density, the greater the car sales volume. It is worth emphasizing, however, that in the case of car ownership, the described correlation is the reverse. In highly developed countries, intensely populated areas (mostly cities) usually have a relatively lower car ownership level compared to the surrounding ones. This results from better access to public transport, policies for limiting car traffic in cities and the negative externalities of using vehicles (such as time loss, congestion or environmental pollution [12, 14, 20, 47]).

The existing research shows that the car sales volume is also related to housing type [9]. In areas with dispersed detached and semi-detached housing, inhabitants must cover larger distances traveling to work and services [23, 51]. Moreover, it is far more difficult to organize public transport in such locations, which increases the scale of individual mobility and the number of owned cars [48, 63]. On the other hand, in places with predominantly condensed multi-family housing (usually highly urbanized areas), good access to public transport and proximity to workplaces and service providers usually deter a tendency to individual mobility, reducing the demand for cars [13, 25, 27, 56].

The experiences of emerging economies show that next to the conventional factors, there are other country-specific determinants that affect the primary (new cars) and secondary car markets (imported, second-hand vehicles) and their effects differ between the two types of market. One such factor is geographical location, which determines the distance to car supply sources (either

the distance to a large city where new cars dealers are located or to a developed country with a high car ownership level). Previous studies have so far proved that in developing countries, a significant role in this respect is played by the physical or historical-cultural distance from mature car markets [7, 18, 73]. In Poland, for instance, the main source of used car imports has been Germany, as a result of its geographical proximity and large car market, as well as the historically formed social relationships developed through economic migrations from Poland to Germany [36]. The importance of the distance between the country importing second-hand vehicles and the source of the imports was also emphasized by Golunov [28] with the example of Japan and Russia, as well as Davis and Kahn [22] with the case of the USA and Mexico. On the other hand, the distance to large urban centres, where the majority of showrooms and car plants are located, is significant for the primary market [60, 61]. Kołsut and Stryjakiewicz [38] and Kisiała et al. [35] have demonstrated that demand for new vehicles is primarily the domain of central areas (so-called cores or growth poles).

Finally, the presence of small companies and individual entrepreneurs engaged in shipping, repairing and maintaining cars plays a substantial role in the secondary market [10, 36, 40]. Spatial units where these businesses are located perform the function of hubs or 'gateways' concentrating a significant proportion of the imports, through which foreign cars 'spill over' to the neighbouring areas. At the global level, a similar function is fulfilled, for example, by the United Arab Emirates [17]. These small businesses and individual entrepreneurs specialize in the import and repair of used cars which then satisfy the demand for cars in local markets.

3 Car ownership growth in emerging economies and the role of second-hand car import

While in developed economies, car ownership is fuelled mainly by the supply of new cars, in many emerging and developing economies it has been largely growing through the import of second-hand vehicles [45]. This is well illustrated by the case of Poland and the car revolution it has witnessed over the last three decades. The systemic transformation from command and control to a free market economy and democracy that began in Poland in the late 1980s significantly affected many economic, social and political processes, including the transportation system and individual mobility. Owing to ideological reasons and economic inefficiencies, communist governments strongly supported the public transport system and severely restricted the possibility of owning and using a private car [41, 42, 65, 72]. The car ownership rate in 1990 was 118 cars per 1,000 inhabitants, which

was noticeably lower than in Western and other Central and Eastern European countries. At the same time, most individual trips were made by public transport [64]. The systemic transformation caused the decline of the public transport system and spurred a preference for individual mobility. Over the next three decades, the car revolution quadrupled the car ownership rate in Poland (from 118 to 484 cars per 1,000 inhabitants in 2020 [45]). It is, however, very interesting to recognize that this massive car ownership growth was powered mainly by the import of used cars.

During the first decade of the systemic transformation, the demand for cars was predominantly satisfied by the domestic car industry. Foreign car manufacturers such as Fiat, Volkswagen, Daewoo and Opel took over the existing production plants or launched greenfield-type investments. At the same time, successive governments in Poland carried out protectionist trade policies restricting the import of used cars [45]. This, however, changed dramatically with Poland's incoming EU membership. As part of that process, Poland was required to abolish or reduce technical and fiscal barriers that impeded the inflow of used cars. As a consequence, in only the first year of EU membership (i.e., in 2004), more than 700,000 used cars were imported from the 'old' EU countries and registered in Poland. In the same year, Poles bought slightly more than 280,000 new cars by comparison (Fig. 1). Over the following years, the import of second-hand cars increased even more (in 2008, it exceeded 1 million cars) and significantly changed the car ownership structure for the years to come. Overall, between 2004 and 2020, Poland imported approximately 13.5 million used vehicles [38, 39].

Similar processes could be observed in other emerging and developing economies. While complete and reliable statistics for these countries are difficult to obtain, the existing publications shed some light on the size and dynamics of global trade in used vehicles. According to the UNEP [75] report, between 2015 and 2020, approximately 23 million used light-duty vehicles were exported to 208 countries. Two thirds of these cars were traded to developing and transitional countries. African countries imported 25% of these vehicles, Eastern Europe, Caucasus, and Central Asia 14%, the Asia-Pacific region 12%, the Middle East 10%, and Latin America and the Caribbean 8%. The EU remains the world's largest exporter of used cars. Between 2015 and 2020, the EU traded approximately 11.5 million used vehicles, of which approximately 44% were received by Poland. Likewise, other publications explore the flow and scale of trade in second-hand cars worldwide. Coffin et al. [17] examined barriers to trade in used vehicles and showed that the United Arab Emirates was one of the major importers
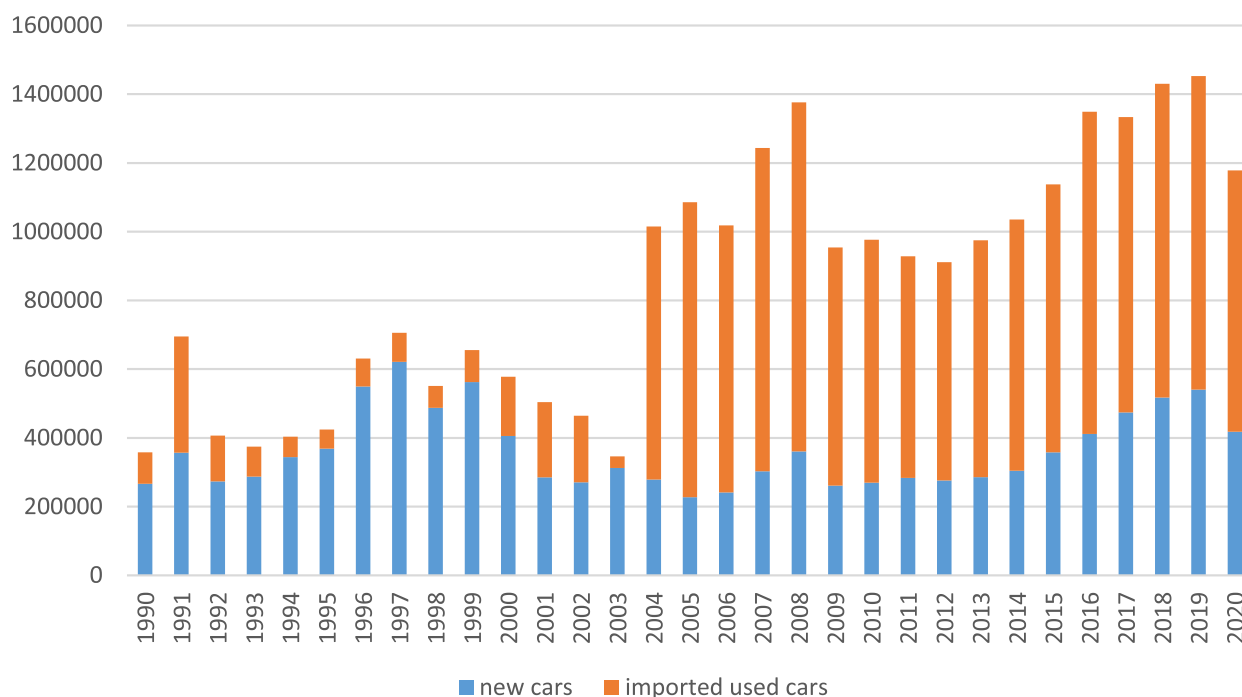
Fig. 1 The number of new and imported used cars registered in Poland between 1990 and 2020. Source: own compilation based on Central Vehicle Register (CVR) and Statistics Poland (GUS) data

of used passenger vehicles, with approximately 1.4 million cars imported between 2010 and 2014. However, this number might be slightly misleading, as a large share of these cars were re-exported to other countries in the region. Golunov [28] revealed that Japan traded between 400,000 and 1.3 million used cars annually to New Zealand, Myanmar, Sri Lanka, South Africa, Kenya, and Tanzania, but also right-hand traffic countries like Russia (more than 500,000 cars in 2008). According to the US International Trade Administration [32], over the 2005–2020 period, Mexico imported approximately 8.8 used vehicles from the US, with more than 1.6 million at its peak in 2016. These numbers show that in the case of emerging and developing economies, the import of used cars plays a significant role in car ownership growth.

Despite many inconsistencies related to the data, the above-mentioned studies clearly show that car ownership growth in emerging and developing economies is dichotomous, i.e., fuelled simultaneously by new cars purchased and registered in a given country as well as, most importantly, by used vehicles imported from abroad. Owing to relatively low income levels and limited access to the primary market (e.g., in many developing African regions), inhabitants of these countries frequently cannot afford new vehicles. Therefore, they satisfy their needs for individual mobility by purchasing imported used cars. This fact, however, is often overlooked by scholars as they tend to analyse car ownership at the aggregate level,

which conceals the importance and determinants of used car imports. In this paper, we fill this gap by revealing and comparing two sides of this phenomenon in Poland, through scrutinizing the primary and secondary car markets at the local level.

4 Empirical analysis
4.1 Spatial differences of new and imported car markets
A spatial analysis of the distribution of the new and used car sales volumes[2] suggests that the size of these two markets is determined by somewhat different factors. The indicator of new cars per 1,000 inhabitants exhibits the highest values in large cities and their suburbs. These included the Katowice conurbation, as well as the agglomerations of Warsaw, Cracow, Poznań, Gdańsk, Wrocław and others. On the other hand, *poviats* with the lowest new car sales are primarily located in less developed peripheries. These can be found in Poland's eastern region, but also in *poviats* far removed from major urban centres (Fig. 2).

The import of second-hand cars has a different spatial structure. The highest indicator of imported cars per 1,000 inhabitants can be observed in Poland's

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[2] The analysis of the distribution was performed by *poviat*. In the Polish three-tier administrative division, the *poviat* (county) is a second-tier unit of local government (between the commune and the region) and is equivalent to a county, district or prefecture (local administrative unit level 1).
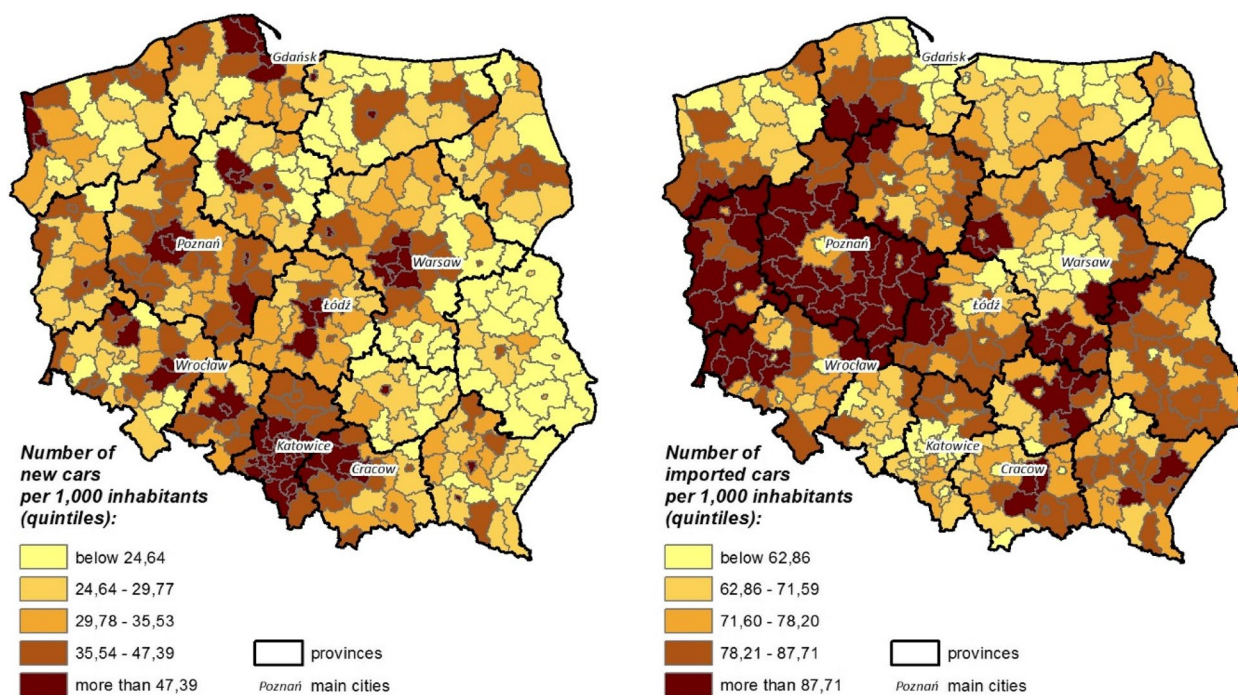
Fig. 2 Spatial differences in the number of new and imported second-hand cars in 2017–2019. Source: own study based on Central Vehicle Register (CVR) and Statistics Poland (GUS) data

western *poviats* (mainly the regions of Wielkopolska and Lubuskie and the western part of Dolnośląskie). The lowest scale of car imports, in contrast to new car sales, has been recorded in areas of high population density and those with a high urbanization level (agglomerations of Warsaw, Cracow, Gdańsk and other major cities).

When referring to the spatial distribution of the analysed indicators, it is worth emphasizing two basic aspects of spatial polarization in Poland's economic development apparent in the patterns: (1) a richer west vs. a poorer east, which reflects long-term historical processes, and (2) metropolitan vs. peripheral areas, which composes a new version of a traditional urban–rural divide [15, 29, 71]. As it turns out, the new car market volume corresponds to both dimensions of the differences in the country's development. New car sales are predominantly concentrated in urban areas. It is in those places that dynamic production and service entities with a high innovative potential and well-paid jobs are located. Moreover, the car showrooms are located almost exclusively near large cities, which also strengthens the primary-market purchasing model. The peripheries, which absorb development impulses from the urban areas with a delay and are usually subject to a drainage of capital and human resources, do not generate considerable demand for relatively expensive new vehicles, but are mostly open

to the secondary market. In addition, the car market for imported second-hand vehicles in Poland is also geographically determined. As the main country of origin of imported cars is Germany, followed by France and Belgium, the west–east dimension of secondary-market differences is clearly visible (with a greater concentration of imports in the west). Here, the historical-cultural relationships of Poland's western regions with Germany are not without significance [40].

The spatial regularities described are also observed on the autocorrelation map constructed based on local Moran's statistics (Fig. 3). A local Moran statistic for an observation i may be defined as:

$$I_i = z_i \sum_{j=1}^{n} w_{ij} z_j$$

where the observations z_i, z_j are in deviations from mean and the summation over j is such that only neighboring values $j \in J_i$ are included [3]. Spatial weights w_{ij} necessary to calculate these measures were determined based on the contiguity of spatial units (*poviats*), constructing a so-called first-order contiguity matrix of the queen type.

The statistically significant clusters of *poviats* with high indicators of new car market sales are located around the largest urban agglomerations. These areas are populated
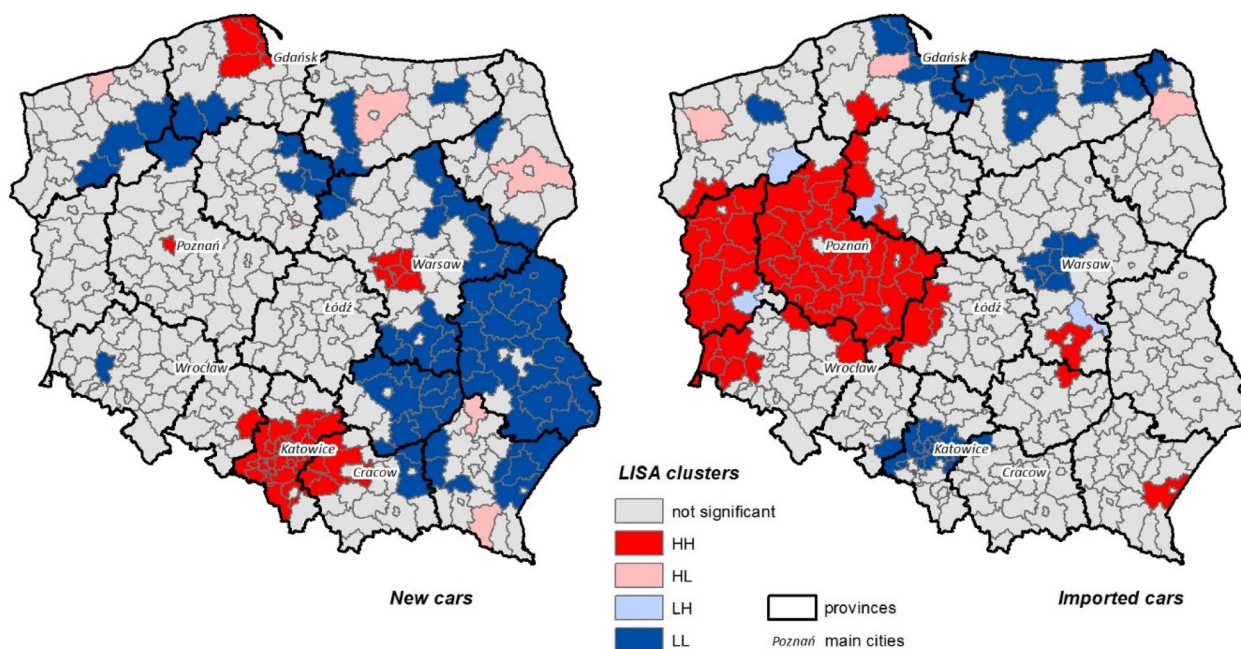
Fig. 3 Visualization of Moran's local statistics calculated based on the indicator of registered new and imported used cars per 1,000 inhabitants in 2017–2019. Source: own study based on CEP and GUS data

by relatively wealthier inhabitants, who more often purchase new vehicles. In contrast, a large proportion of *poviats* situated in eastern Poland creates a statistically significant cluster of low new car sales. Moreover, the low-low type clusters are formed by *poviats* far removed from major cities.

With regard to the secondary market, a substantial proportion of *poviats* located in western regions (mainly in Wielkopolska, Lubuskie and Dolnośląskie) create a statistically significant cluster with high rates of used car imports, the exception being cities located in this area. On the other hand, statistically significant small-import clusters are near the largest urban areas (Warsaw, Gdańsk and Katowice) and in northern Poland, at the Russian and Lithuanian borders.

4.2 Model specification

The assessment of the spatial autocorrelation level of the variables describing new and imported second-hand car registration indicates that a location (or, more precisely, the neighbourhood of the investigated spatial units) determines the mutual relations between local car markets. Thus, to explain the spatial differences in sales of new and imported cars, we modelled cross-sectional series employing spatial econometrics methods.

In the spatio-econometric analysis, we used the specific-to-general modelling strategy [26]. This relies on the so-called classic approach [5], in which the basic model of ordinary least squares (OLS) is estimated in the first

stage[3]. Consequently, this model is tested using residuals, e.g., in terms of spatial autocorrelation. Verification of the latter was conducted using Moran's global statistics [16, 50]:

$$ I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(e_i - \overline{e})(e_j - \overline{e})}{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} \sum_{i=1}^{n} (e_i - \overline{e})^2} $$

where n is a number of observations (*poviats*), e_i, e_j are residuals from the OLS model and w_{ij} are elements of the spatial weight matrix.

The choice of an appropriate spatial regression model was made with a so-called hybrid approach that included Lagrange multiplier (LM) tests in the first place, and in case their results were inconclusive, their robust versions (RLM) as well, which are resilient to local errors in the model specification [4, 6]. LM and RLM tests for the spatial autoregression model (SAR) allowed for verifying if the spatial model should include the spatial dependency of the explained variable. In this case, a spatial autoregressive model was estimated (SAR) in the form of:

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[3] Specific-to-general modelling strategy was often used in analogous spatial studies in the field of labor (i.a. [53], real estate (i.a. [78]) and car markets (i.a. [49]), regional economic growth and income convergence (i.a. [8]) as well as spatial epidemiology (i.a. [33]). It is worth mentioning that the academic debate concerning the pros and cons of the two competing approaches in spatial econometric modelling, i.e., specific-to-general vs. general-to-specific, still takes place [11, 26, 31, 54].

$$\mathbf{y} = \rho\mathbf{W}\mathbf{y} + \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\epsilon}$$

where W is a row standardised spatial weights matrix, and parameter ρ (rho) informs about an influence of the value of explained variables from the neighbouring locations (according to the spatial weights matrix) on the value of this variable in a given location.

LM and RLM tests for the spatial error model (SEM) were used for checking the spatial dependency of a random component. It is assumed in SEM models that the identified dependencies result from the existence of spatially autocorrelated variables not included in the model or in the measurement errors. Consequently, the correction of the original random component with spatial autocorrelation μ is needed to achieve independent random error ε:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\mu}$$

$$\boldsymbol{\mu} = \lambda\mathbf{W}\boldsymbol{\mu} + \boldsymbol{\epsilon}, \boldsymbol{\epsilon} \sim \mathrm{N}\left(0, \sigma^2\mathrm{I}\right).$$

The econometric modelling employed the average data from 2017 to 2019 describing all *poviats* in Poland ($n = 380$). Eventually, two models were estimated, separately explaining the variability in new and imported second-hand local car markets. The variable explained in the first model was the number of new passenger vehicles registered per 1,000 inhabitants (NEW) as an indicator illustrating the size of the demand satisfied on the primary market. In the second model, the explained variable was the number of imported used cars registered per 1,000 inhabitants (IMPORT) quantifying the scale of the demand on the secondary market. The values of the variables were calculated using CVR (containing information about over 20 million cars as of the end of 2019) and GUS data.

Explanatory variables were selected based on previous studies. However, since they were predominantly concerned with the developed markets of Western Europe and North America, we decided to test their explanatory value in the case of local primary and secondary car markets in an emerging economy. The set of explanatory variables, applied in both models, included the following indicators:

1. Income per capita (INCOME) calculated on the basis of local budget revenues from personal income tax (PLN/person).
2. Population density (POP_DENS in persons per km^2) as an indicator of the degree of population size concentrated in a given spatial unit.
3. Average size of a dwelling (an apartment or house) (HOUSING_TYPE in m^2) as an indicator of a housing type and the degree of its dispersion.

4. Share of enterprises operating in car trade and repair in the overall number of companies (TRADE_REPAIR in %) as a variable explaining the network of outlets supplying second-hand imported cars[4].
5. Distance from a large city (CITY_DIST in km) as a proxy for the new car supply (as mentioned earlier, most car showrooms are located in large cities and their surroundings). A population of over 100,000 inhabitants was adopted as a criterion of a large city.
6. Distance from Germany (GER_DIST in km) as a variable indicating proximity to Poland's largest supplier of used cars.

The complete list and basic descriptive statistics of the indicators selected for the analysis, representing explained and explanatory variables, was compiled in Table 1. In the modelling, we used logarithms of the original values of the variables.

4.3 Results

The econometric modelling led to two spatial errors models (SEMs[5]), with the first identifying the determinants of the local markets for new cars and the second verifying the determinants of the local secondary market (imported cars). The final models differed in terms of the statistical significance of explanatory variables and the strengths and directions of links between the variables (Table 2). This proved that different factors were affecting the primary and secondary car market.

The results show that income had a statistically significant impact on local car markets (INCOME), but the direction of its impact varied in regard to the primary and secondary markets. While new car sales were higher in *poviats* with a high average income ($b = 0.927$, $p < 0.0001$), the imports of used vehicles declined with increased income ($b = -0.073$, $p = 0.057$). This means that a positive correlation between income and car ownership is more complex than previously recognized [21, 30, 52, 56, 59]. In the reality of emerging economies, the used car market offers cheaper substitutes for new vehicles. The latter often remain beyond the purchasing capabilities

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[4] The data collected and shared by the Polish Main Statistical Office (GUS) does not allow further decomposing of this group of companies into companies/entrepreneurs engaged in importing cars and those responsible for repairing them. However, earlier publications suggest that, in many cases, these companies (i.e. importing and repairing cars) are often located in the same communes and live off each other. In other words, they are complementary companies that often purposefully are located and initiate their operations in close proximity to other companies responsible either for importing or repairing cars. Hence, in our view, the variable we used might be treated as a reasonable proxy of the tested phenomenon.

[5] SEMs were estimated as a result of a high spatial autocorrelation of a random component observed in ordinary least squares models ($I_{NEW} = 0.544$, $I_{IMPORT} = 0.361$). LM and RLM tests pointed to the SEM.

Table 1 Basic statistical characteristics of the indicators used in the econometric modelling

Variables		Min	Max	Mean	Standard deviation	Coefficient of variation
Explained	NEW	2.58	4.82	3.53	0.4	11.19
	IMPORT	3.46	4.98	4.31	0.23	5.3
Explanatory	INCOME	6.26	7.98	6.85	0.28	4.09
	POP_DENS	2.94	8.24	4.92	1.24	25.14
	HOUSING_TYPE	3.94	4.7	4.36	0.15	3.38
	TRADE_REPAIR	0.48	2.27	1.42	0.27	18.66
	CITY_DIST	0	4.85	3.32	1.23	36.96
	GER_DIST	1.72	6.44	5.54	0.81	14.71

Source: own calculations

of the poorer part of society [35]. Owing to the negative income flexibility of demand for lower-tier goods [67], an increase in income translates into a decline in demand in the secondary market.

A statistically significant influence of population density (POP_DENS) was revealed concerning only the primary market. This variable had especially high values in cities and suburban *poviats* surrounding Poland's largest agglomerations. It is therefore a good approximant of the urbanization level and relatively higher income compared to the remaining spatial units. As it turns out, these features were important determinants of new car demand at the local level ($b = 0.062$, $p < 0.0001$). In contrast, population density proved statistically insignificant from the perspective of local markets for second-hand vehicles ($p = 0.23$).

The econometric modelling confirmed the statistically significant impact of housing type measured with the average size of a dwelling (house or apartment) (HOUSING_TYPE). The larger the average dwelling size (typical of rural and suburban areas), the greater the demand for both new ($b = 0.062$, $p < 0.001$) and imported used vehicles ($b = 0.220$, $p < 0.001$). This finding is in line with the existing literature [9, 13, 25, 27, 56, 63]. By contrast, in areas with predominantly multi-family housing (which, on average, correspond to a smaller dwelling size), it is much easier to organize and maintain public transport and there is a greater availability of jobs and services centres. These circumstances limit private car demand.

We also tested the importance of some factors specific to emerging economies, such as the presence of businesses shipping in and repairing used cars (TRADE_REPAIR). These factors proved to be statistically significant for the secondary local markets ($b = 0.326$, $p < 0.0001$) and insignificant for the primary markets ($p = 0.172$). Used cars are usually imported by

Table 2 Spatio-econometric models identifying the factors affecting local car markets

Variable	NEW		IMPORT	
	Coefficient *b*	Probability	Coefficient *b*	Probability
Const	-5.415	0.000[c]	3.488	0.000[c]
INCOME	0.927	0.000[c]	-0.073	0.057[a]
POP_DENS	0.062	0.000[c]	0.013	0.230
HOUSING_TYPE	0.622	0.000[c]	0.220	0.000[c]
TRADE_REPAIR	-0.054	0.172	0.326	0.000[c]
CITY_DIST	-0.028	0.007[c]	0.039	0.000[c]
GER_DIST	-0.046	0.088[a]	-0.050	0.014[b]
LAG_RESIDUALS (λ)	0.739	0.000[c]	0.753	0.000[c]
Pseudo-*R*2	0.874		0.800	

Source: own calculations

Statistically significant at [a]0.1, [b]0.05, [c]0.001

small enterprises or individual entrepreneurs [22, 36] and then these cars diffuse to the neighbouring spatial units. As a result, local markets that are characterized by a high density of such businesses are predominantly supplied by second-hand cars.

Finally, the estimated models have shown that the size of local car markets depended on geographical location, quantified by the distance from a large city (CITY_DIST) and the Polish-German border (GER_DIST). For the primary market, these distances negatively affected the sales level ($b = -0.028$, $p = 0.007$ and $b = -0.046$, $p = 0.088$, respectively). These results confirm earlier observations whereby new cars supply mainly the car markets of cities and their functional zones that are characterized by high concentration of car dealers and related services (authorized service centres, leasing

companies, tire hotels, car washes, etc. [35, 38]). The secondary market, by contrast, develops primarily outside of the largest cities ($b = 0.039$, $p < 0.0001$) and near the German border ($b = -0.050$, $p = 0.014$ [36, 40]).

5 Discussion and conclusions

This paper aimed to reveal the dichotomous character of car ownership growth in an emerging economy and verify the influence of selected determinants of local markets for new and imported used cars. This dichotomy lies in the two-fold source of car supply: the primary (new cars) and secondary (imported second-hand cars) market. After the EU accession in 2004, more than 13.5 million cars were imported to Poland, representing approximately 70% of newly registered cars in Poland over that period of time. This situation is quite unique and rather unknown in developed economies where car ownership increased mainly through the primary market. After disaggregating the primary and secondary local markets, we showed that they were influenced by the selected determinants in a different way. As predicted in the literature [24, 49, 51, 52, 56, 59], income positively affected the local primary market, but at the same time was negatively related to the secondary market. Our paper also supported the positive influence of population density and average size of a dwelling on the new car market. The latter factor also determined the level of used car imports. This study also revealed some novel determinants of the local car market. The secondary car market was driven by entrepreneurs and companies specializing in importing and repairing second-hand vehicles. Geographical distance to the source of the car supply also mattered. In Poland, the largest number of second-hand cars was sourced from Germany; therefore, the proximity of the latter stimulated the inflow of used cars. The new car market was also fuelled by the proximity to large cities which usually concentrate car sales networks.

This paper offers several interesting contributions. First, it reveals the dichotomous character of car ownership growth in an emerging economy and the importance and specificity of used car imports. The scale of import to Poland clearly suggests that after reducing or abolishing trade barriers, it became the major primary source of car ownership growth, as in other emerging and developing economies [17, 28, 40, 44, 75]. However, the existing literature on car ownership in these countries is either scarce or limited to a few economies such as China that, for many reasons, followed a motorization path similar to that of developed economies (e.g., car ownership growth is predominantly supplied by new cars manufactured domestically [79]). Second, this work expands on the existing literature by showing that next to the well-known determinants of local car markets such as income

or population density [20, 58, 66], there might be other factors specific to emerging and developing economies that drive local primary and secondary car markets. For example, we show that geographical proximity to a developed economy, which might serve as a reservoir of car imports, and the presence of companies specialized in importing and repairing cars explain the volume of imported and registered cars. Third, when disaggregating car ownership data (for 2017–2019) into local primary and secondary markets, commonly acknowledged factors might have a different impact than previously identified. For instance, while in general growing income contributes to increasing car ownership, our study showed that opening a car market for a massive import of second-hand cars made it insensitive to the income level. In other words, car ownership might grow even at a relatively low-income level thanks to a supply of inexpensive imported vehicles. At the same time, the negative relationship between population density and car ownership observed in developed economies takes a positive direction when it comes to population density and sales of new cars.

Our study holds certain limitations. While we attempted to use various variables to explain the car ownership growth in the local markets, a lack of available data limited the possibility of verifying the influence of other potential variables, e.g., those concerning a built environment. The latter is of particular relevance as Polish cities have been experiencing noticeable suburbanization, which was not followed by an adequate provision of public transport, public services, and workplaces. This stimulated a fast growth of car ownership in the suburbs [44]. Hence, it would be interesting to investigate some additional variables illustrating the changes in the built environment. In addition, our study does not include cars registered and used by companies (fleet cars). They represent a significant share of new cars purchased annually in Poland [35]. However, most of them are registered in large cities where corporations have their headquarters or leasing companies [1]. As a consequence, introducing these vehicles to the study would artificially overestimate the car ownership levels in these cities compared to other areas [37]. Unfortunately, the data we use does not allow us to identify the locations where the fleet cars are being used. Another data limitation that restricts our study is that it does not offer information concerning the trade of second-hand cars within the communes[6] (the database only notifies car registrations when they are traded between these spatial units). This, to a degree, might also affect the results of the econometric analysis.

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6 Commune is the basic unit of the administrative division of Poland.

Regardless of these limitation the current study offers a novel view on the car ownership growth and opens avenues for further investigations. We showed that the spatial distribution of imported cars in Poland varied between local and regional markets. For instance, certain parts of the Wielkopolska region (in the western part of Poland) had one of the highest volumes of imported used cars within the region and country-wide. This suggests that place-specific characteristics might be related, for example, to entrepreneurial attitudes and historically developed labour migrations to Germany that can explain spatial differences concerning used car imports. Furthermore, as the UNEP report (2021) suggested, the global trade of used cars carries significant environmental consequences. The lack of trade barriers and environmental regulations in many emerging and developing countries make them susceptible to an inflow of technically and ecologically inferior cars. This might negatively impact these countries' environmental sustainability and health of local communities. Hence, the international trade of second-hand cars might be an exciting case illustrating a global migration of environmental problems. Finally, it would be interesting to investigate the intra-Polish trade of imported used cars. Figure 2 seems to suggest that while some local markets are dominated by second-hand car imports and others by purchases of new vehicles, many markets might be supplied by used cars that circulate within Poland. In such cases, several exciting topics arise, including the spatial patterns of their internal migrations or the role of primary and secondary car markets in supplying the remaining parts of the country. To sum up, we hope our paper represents an interesting contribution to transport literature and will attract more academic attention to unique motorization processes in emerging and developing economies.

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