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Transport Accessibility in a Suburban Zone and Its Influence on the Local Real Estate Market: A Case Study of the Olsztyn Functional Urban Area (Poland)

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Abstract: The development of real estate markets in the vicinity of cities is linked with suburbanization processes. The migration of the population to suburban areas contributes to the growth of the residential property market (houses, apartments and construction plots). To minimize commuting costs, property buyers opt for locations that are situated close to the urban core. This article analyzes construction plots on the local real estate market in the Olsztyn Functional Urban Area, in terms of their temporal accessibility and demographic changes. Spatial variations in population distribution were analyzed with the use of the Gini index and geostatistical interpolation techniques. Spearman's rank correlation coefficient was calculated to determine the relationships between the analyzed variables. The study revealed differences in the spatial distribution of the population and real estate transactions as well as strong correlations between average transaction price, number of transactions, commuting time and population. The highest number of transactions were observed in cadastral districts situated in the direct vicinity of Olsztyn's administrative boundaries and the major transportation routes due to their high temporal accessibility.

Keywords: transport accessibility; real estate market; population; concentration

1. Introduction

Suburbanization leads to the sprawl of residential areas in the vicinity of an urban core. This process affects the morphology of suburban areas, their functions and the development of suburban infrastructure. The migration of the population to suburban areas contributes to the formation of settlement subsystems around the city center. This process stimulates the growth of local real estate markets, in particular, the number of transactions involving construction plots. City residents migrating to suburbs base their purchasing decisions on a property's location relative to the urban core. Real estate in the city is swapped for much cheaper and more attractively located properties in a suburban zone. Lower prices and a cleaner environment are the main reasons why city dwellers seek property in suburban areas.

Commuting time strongly influences the decisions made by the buyers of suburban property [1,2]. In suburban areas, the share of space intended for residential, commercial and industrial purposes are increasing [3]. The urbanization of rural areas surrounding the city is closely linked with distance to the functional urban core [3] and the availability of transport infrastructure [4–7]. Feedback mechanisms between accessibility, land-use and travel behavior were observed [8]. Buyers search for property in areas with well-developed road networks. Dwellers who migrate to suburbs continue to maintain close links with the city, and commuting entails high costs [9,10]. The cost and time of travel to work [11,12], school or commercial outlets is lower in suburban areas that are easily accessed from the urban core [13,14]. Daily commuting is the consequence of population shift from cities to suburban areas, which increases the demand for locations [15,16] with well-developed transport infrastructure [17–19]. Property buyers hope to maximize benefits and minimize



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Copyright: © 2021 by the author. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). costs by searching for a compromise between the price and quality of property and its distance from the urban core. They strive to minimize both the physical and temporal distance between the place of residence and the city. The above increases the demand for locations characterized by shorter commuting time and lower transportation costs [20–22].

Commuting increases road traffic because passenger vehicles are the main mode of transport for suburban residents [23] since public transport options are limited and do not always cover local transport needs. Daily commuting costs are a significant item in household budgets, but they are compensated by lower property prices in suburban areas. It has been said that the expenditures associated with daily travel are a different form of mortgage carrying costs. Time is also a factor that has specific economic value because it is a limited resource; therefore, commuting time, rather than distance, is the key determinant of transport accessibility [24]. Research studies conducted at various levels have also demonstrated that transport accessibility can influence property prices [25–27]. The balance between transport accessibility and the remaining attributes of real estate in rural areas (specific locations) have also been examined in suburban areas in Poland [28,29]. Therefore, the intensity and the spatial extent of suburbanization are inversely proportional to the demand for real estate, and the demand for and supply of construction plots influences real estate prices and the development of real estate markets in the suburban zone [30]. The demand for construction plots shifts the boundaries of the urban real estate market outwards [31–33]. The intensity and trends of suburbanization are reflected on the suburban real estate market and the accompanying changes in land use, population structure and investments. These processes are mutually interdependent, and they contribute to the formation of the urbanization cycle (Figure 1).



Figure 1. The urbanization cycle. Source: [34].

The suburban real estate market is characterized by a high and growing number of transactions involving vacant land. The supply of and the demand for construction plots continues to increase, which increases property prices. The prices of residential property are influenced by numerous factors, but the prices of suburban property are determined mainly by the size of the town or village and its distance from the urban core. Land prices generally decrease with an increase in distance from the city [35–37], and the development of transport infrastructure drives urbanization and home prices [36,38–40]. This observation is consistent with the new urban economics concept, which postulates

that the prices of residential property are influenced by distance from the city core (land prices decrease as the distance from the city increases).

Urban expansion is thus directly linked to the growth of the real estate market, and real estate prices are determined by numerous factors. Deng et al. [41] proposed the following formula to illustrate differences in urban expansion as a function of economic and geophysical factors:

Urban land area = f (income growth, demographic shifts, agricultural land value, transportation costs, changes in the structure of the economy, other location and geophysical variables) (1)

These factors also influence the real estate market [42,43]. Transportation costs are one of such factors, and the changes in and the reach of functional urban areas are linked with the real estate market [41,44]. Therefore, temporal accessibility is one of the key factors that influence the choice of location and, consequently, the real estate market. Transportation costs, expressed both in time and money, significantly influence property value, and buyers strive to maximize benefits in the process of selecting the optimal location.

Similar processes and interactions are observed in the former Soviet bloc countries of Central-Eastern Europe. In the socialist era, cities were relatively homogeneous functional urban areas with clearly delimited centers, whereas suburban zones were not well developed. The political transformations of 1989 led to changes inside urban areas and their surroundings. Central planning was abandoned, and free market principles were introduced. These changes affected the housing market and introduced a new urban order, which gave rise to capitalist-type cities and urban sprawl. Growing levels of social and economic inequality induced new types of migration, including urban to suburban migration. Rural areas surrounding cities developed rapidly, and suburbanization became one of the most spectacular phenomena in the former Soviet bloc countries [45,46]: Estonia [47], Slovakia [48], Bulgaria [49], Romania [50] and the Czech Republic [51].

The introduction of ground rents and property rights as a result of political and economic transformations also triggered suburbanization processes in Poland [52–55], and real estate purchases in suburban areas increased due to growing affluence. The growth of real estate markets in suburban areas accelerated after the political transformations of 1989 [56,57], especially around big cities [58–60]. Since 1990, spatial planning policies and progressing suburbanization have led to significant changes in land-use structure (increase in residential area), infrastructure development, population and the number of transactions involving residential property. The type and scope of these changes have varied intensity and territorial scope, and they are largely determined by an urban area's status in the hierarchy of cities. The migration of the urban population to suburbia proceeded most rapidly in the largest cities, followed by medium-sized towns.

Suburbanization is a relatively new phenomenon in Poland, and it largely follows the trends observed in other countries. However, this process has certain unique characteristics in Poland [53,61]:

- it proceeds far more rapidly than in Western Europe,
- it is not effectively controlled by planning authorities,
- technical and social infrastructure in suburban areas are extremely inadequate,
- rural municipalities in suburban areas are formally independent of cities and are not a part of their administrative structure,
- the distance from the urban core plays a key role in property purchase decisions, and buyers tend to opt for larger construction plots,
- new homes are built along the existing transport routes,
- the original structure of suburban villages is completely transformed by new development, mostly single-family homes with typical urban design,
- large-scale residential developers have a limited interest in suburban areas, and
- suburban development is homogeneous and linked with the family life cycle.

In Poland, most suburbanization processes are uncontrolled due to the passive stance of urban planning authorities and the relaxation of planning regulations. The above leads to spatial chaos, low economic effectiveness of new settlements and a shortage of vital services. The low spatial accessibility of suburban settlements increases development costs and public expenditures, including transport costs and the time needed to introduce complementary services that are essential for the functioning of territorial and social systems [62–64]. Transport accessibility to the urban core is determined by the daily demand for commuter services, and accessibility tends to decrease over distance from the city [65–67]. Transport accessibility significantly impacts purchase decisions and consumer behavior on property markets. The choices made by real estate buyers can be analyzed based on the information about the location and prices of traded property.

Olsztyn, the city in north-eastern Poland, has a rapidly developing suburban zone. This medium-sized city is the capital of the Warmińsko-Mazurskie Voivodeship, and it occupies a high rank in the hierarchy of Polish cities. The following research hypotheses were tested in the study:

- Suburbanization processes affect the local real estate market. Analyses of local property markets can generate valuable information about the territorial reach and dynamics of suburbanization.
- Distinctive features of Polish suburbanization processes are observed in the vicinity of Olsztyn. Distance from the urban core and commuting time play a key role in property purchase decisions; new homes are built along transport routes, which influences the prices of construction plots; single-family homes are the predominant type of new construction in suburban areas, which affects the prices and availability of land sold for residential development.

The aim of the study was to determine whether suburbanization processes in the vicinity of Olsztyn conform to trends that are characteristic of Poland, and to define the territorial reach and dynamics of suburbanization based on local market data. The areas most affected by suburbanization were identified, and the demand for and supply of construction plots were analyzed. In this article, the number of transactions involving construction plots on the suburban real estate market was analyzed based on commuting time and distance from the city core. The observed processes were linked with demographic changes, which are the key determinant of suburbanization. The links between temporal accessibility expressed by commuting time, the prices on the local real estate market and demographic processes were identified, and their spatial distribution was described based on data for 2007–2018.

2. Materials and Methods

2.1. Study Area

The studied area was the Olsztyn Functional Urban Area (FUA) composed of six municipalities that are directly adjacent to the city: Barczewo, Dywity, Gietrzwałd, Jonkowo, Purda and Stawiguda (Figure 2). Olsztyn is the capital city of the Warmińsko-Mazurskie Voivodeship in north-eastern Poland and is an important regional hub. Olsztyn had a population of around 170,000 in 2018. The population of the suburban zone was estimated at 44,000.

The residents of the Olsztyn FUA were surveyed in 2014, and the results were published in a report entitled "Spatial relations in public and private transport in the Olsztyn Functional Urban Area in the context of urban mobility" [68]. The study revealed that private cars were the preferred mode of transportation for suburban residents commuting to the city. Passenger cars are widely available [69,70], and they are the main means of transport [71] between suburban zones and the urban core. The surveyed respondents relied on private means of transport to commute to work, school and commercial outlets, and the choice of private cars was dictated mainly by shorter commuting time. As a result, the number of passenger cars registered in the county of Olsztyn increased from 48,013 in 2009 to 71,549 in 2018 (data from the Central Statistical Office). The study also revealed considerable differences in access to residential areas in the Olsztyn FUA, and temporal accessibility was highest in towns and villages located along the main transportation routes. Nearly a third of the towns and villages in the Olsztyn FUA were characterized by low transport accessibility.



Figure 2. Study area. Source: own elaboration.

Public transport services include bus lines operated by the municipalities (public bus lines reach only 11 out of 138 towns and villages, some of them only on a seasonal basis) and, to a limited extent, by railway lines. Bus lines are also operated by commercial carriers, but they only target the most highly populated towns and villages. The vast majority of suburban settlements have to rely on private means of transport which are characterized by the shortest commuting time and the highest travel comfort [72–74].

Integrated Territorial Projects (ITP) are one of the priority goals of the Strategy of the Olsztyn FUA, and they were initiated to improve the quality of transportation in that area. This development tool was introduced to implement territorial strategies in an integrated manner. The initiative enables local authorities to launch joint projects that are co-financed

by the European Regional Development Fund and the Social Fund as part of the European Union's Regional Operational Programs.

2.2. Methods

Temporal accessibility is evaluated based on physical distance as well as travel time. Travel time in the existing road network of the Olsztyn FUA was determined with the use of the Google Maps application. Travel time was measured from the administrative center of Olsztyn (City Hall) to different locations (cadastral districts) in the suburban zone. The analysis was carried out for travel by passenger car on the same date and at the same time (Wednesday, averaged result for 5 and 19 September 2018, 6 p.m.). Commuting times were interpolated for the entire studied area. The spatial distribution of the unit prices of construction plots in 2007 and 2018 were interpolated in the next stage of the analysis.

The information about the prices of construction plots (Register of Real Estate Prices and Values) and their location (base maps in the Land and Building Register, data in dxf format for cadastral plots in Barczewo, Dywity, Gietrzwałd, Jonkowo, Purda and Stawiguda) were obtained from the County Center for Geodetic and Cartographic Documentation in Olsztyn.

In both cases (temporal accessibility and prices of construction plots), data were interpolated by kriging. This method is widely applied to interpolate the spatial distribution of data, in particular, prices [75–81]. Kriging is the main method for estimating continuous surfaces based on the measured points. The estimated value is calculated as the weighted average of n measured points surrounding the estimated location. The kriging estimate (Formula (2)) is a realization of the random function Z(si):

$$Z^{*}(S_{o}) = \sum_{i=1}^{n} w_{i} Z(s_{i}),$$
(2)

where w_i denotes kriging weights, $Z^*(S_o)$ is the value at the interpolated point and $Z(S_o)$ is the value at the measured point.

Kriging is used to define the range and anisotropy of spatial correlations and to identify directional changes in spatial phenomena. Data were interpolated in ArcGIS software.

Spearman's rank correlation coefficient was calculated (Formula (3)) to describe the relationships between the number of transactions, average unit price, population and temporal accessibility. This ranking method is not highly sensitive to outliers.

$$r_{s} = \frac{\frac{1}{6}(n^{3}-n) - (\sum_{i=1}^{n}d_{i}^{2}) - T_{z} - T_{y}}{\sqrt{\left(\frac{1}{6}(n^{3}-n) - 2T_{z}\right)\left(\frac{1}{6}(n^{3}-n) - 2T_{y}\right)}},$$
(3)

where r_s is Spearman's rank correlation coefficient, $d_i = R_{x_i} - R_{y_i}$ is the difference between the ith rank of variable x and the *i*th rank of variable y, T_z and T_y are the coefficients of tied ranks expressed as $T = \frac{1}{12} \sum_j (t_j^3 - t_j)$ and t_j is the number of observations with the *j*th rank in the analyzed dataset.

Spearman's rank correlation coefficient was calculated, and scatter plots were generated in the Statistica program.

The Gini index, which measures concentration relative to uniform distribution in the overall set of values of the analyzed variable, was calculated to determine the inequality in the spatial distribution of the analyzed variables (Formula (4)).

$$G_{i} = \frac{\sum_{i=1}^{n} (2i - n - 1)y_{i}}{n^{2} \overline{y}},$$
(4)

where G_i is the Gini index, y_i is the value of the ith observation, \overline{y} is the average value of all observations and n is the total number of observations.

The Gini index was computed with the use of an online calculator available at [82].

The construction of the Olsztyn ring road commenced during the analyzed period. Planning and design work began in 2005. The contracts for the construction of the first and second segment of the ring road were signed in 2015 and 2016, and the first segment was commissioned for use in December 2018. The construction of the Olsztyn–Olsztynek express road intersecting Stawiguda municipality took place in the same period, and it improved transport accessibility in Stawiguda which already had the most highly developed road infrastructure in the Olsztyn suburban zone. The ring road considerably improved transport conditions, in particular, by diverting heavy transit traffic away from downtown Olsztyn. Despite the above, the ring road had only a minor impact on the temporal accessibility of suburban settlements.

The travel time for the entire studied area (between downtown Olsztyn and all settlements in the Olsztyn urban functional area) was interpolated based on the calculated commuting times (Figure 3). The location of the construction plots sold between 2007 and 2018 were marked on the temporal accessibility map.



Figure 3. Temporal accessibility and spatial distribution of transactions in the suburban zone of Olsztyn in 2007–2018. Source: own elaboration.

The spatial distribution of temporal accessibility revealed local variations, mostly in the southern and south-western parts of the Olsztyn FUA. These areas are intersected by major roads, including the road linking Olsztyn with the Polish capital of Warsaw. The number of transactions change with an increase in travel time. These results indicate that the density of settlements decreased exponentially with an increase in distance from the urban core, which is consistent with urban development theories [83]. The map in Figure 2 also illustrates the extent to which the quality of transportation routes influences temporal accessibility. The number of transactions concluded in the cadastral districts of the Olsztyn FUA are presented in Figure 4.



Figure 4. Number of transactions concluded in the cadastral districts of the Olsztyn FUA between 2007 and 2018.

The distance to the urban core and the number of real estate transactions are bound by an inversely proportional relationship. The number of transactions decreases with an increase in distance from Olsztyn's administrative boundaries (Figures 2 and 3). The highest number of transactions were concluded in cadastral districts situated in the direct proximity of Olsztyn and along the express road to Warsaw (south-west of Olsztyn). The outlier in the north-eastern part of the studied area is a cadastral district which remains under the influence of another city, Mragowo.

The distribution of the unit prices of construction plots was also analyzed to determine the spatial pattern of real estate transactions on the local market. This is an important consideration because the choice of location is linked with prices, and prices influence decision-making [84]. The spatial distribution of the unit prices of construction plots was interpolated (Figure 5a,b) to identify trends in the development of the suburban zone and prime locations (based on prices).

The results of the interpolation point to an increase in the prices of construction plots between 2007 and 2018 and reveals prime locations with the highest temporal accessibility. The prices of construction plots were highest along the administrative boundaries of Olsztyn and in Stawiguda municipality, followed by the municipality of Gietrzwałd. These areas were characterized by the highest temporal accessibility.

The choices made by real estate buyers influence land use. New residential areas are created, which leads to changes in population [85]. Temporal accessibility induces demographic changes, and differences in commuting time influence population density. In the studied area, changes in population were strongly linked with access to transport infrastructure. As demonstrated in Figure 6, population decreased with an increase in commuting time. More people settle in areas with better accessibility.



Figure 5. Interpolation of the unit prices of construction plots in the Olsztyn FUA in 2007 (**a**) and 2018 (**b**). Source: Own elaboration based on the Register of Real Estate Prices and Values kept by the County Center for Geodetic Documentation and Maps in Olsztyn.



Figure 6. Relationship between population and commuting time in 2018. Source: own elaboration.

Similar population trends were noted in cadastral districts. Relative population growth was highest in the vicinity of Olsztyn and in districts with the highest temporal



accessibility (Figure 7). At the same time, the population of the city of Olsztyn decreased by about 2%.

Figure 7. Relative population growth in the Olsztyn FUA in 2007–2018. Source: own elaboration.

The distribution of transactions, population and unit prices determines the homogeneity of the processes observed in the suburban zone. Therefore, the Gini index was calculated for the above variables (Table 1).

Gini Index	Population		Population Growth	Average Price		Number of Transactions	Number of Transactions	Number of Transactions	Commuting Time
	2007	2018	2017-2018	2007	2018	2007	2018	2007–2018	2018
Olsztyn FUA	0.4934	0.5372	0.8233	0.4298	0.4364	0.5853	0.6110	0.6274	0.4584

Table 1. Gini index of variables in the suburban zone of Olsztyn.

Source: own elaboration.

The calculated values of the Gini index revealed growing inequality in population distribution in the Olsztyn FUA (decrease in population uniformity). The number of transactions and the average unit prices in cadastral districts were also characterized by high values of the Gini index, which points to variations in the spatial distribution of these variables. The values of the Gini index also revealed considerable differences in the temporal accessibility of the analyzed districts, which suggests strong links between these variables.

The relationships between the analyzed variables were evaluated by calculating Spearman's rank correlation coefficients (Table 2).

	Spearman's Rank Correlation Coefficients, $p < 0.05$											
Variable	Travel Time 2018	Population Growth 2007–2018	Population 2007	Population 2018	Number of Transactions 2007–2018	Number of Transactions 2007	Number of Transactions 2018	Average Price 2007	Average Price 2018			
Travel time 2018	1.0000	-0.6683	x	-0.5230	-0.5388	х	-0.3851	х	-0.5799			
Population growth 2007–2018	x	1.0000	0.3553	0.5950	0.5897	0.6117	0.2574	0.2842	0.5616			
Population 2007	x	x	1.0000	0.8860	0,6468	0.5650	0.3687	0.1706	0.1411			
Population 2018	x	x	x	1.0000	0.7236	0.6663	0.3961	0.2425	0.3118			
Number of transactions 2007–2018	х	x	x	x	1.0000	0.2825	0.2575	0.2496	0.3750			
Number of transactions 2007	x	х	x	х	х	1.0000	0.4435	0.2241	0.3157			
Number of transactions 2018	x	х	x	х	x	x	1.0000	0.1412	0.1714			
Average price 2007	х	x	x	x	x	x	x	1.0000	0.7015			
Average price 2018	x	х	х	x	х	х	х	x	1.0000			

Table 2. Spearman's rank correlation coefficients for the analyzed variables.

Source: own elaboration.

The calculated values of the Spearman's rank correlation coefficient point to moderate and strong correlations between the analyzed variables (>0.5000). The strongest relationships were noted between the number of transactions and population, between travel time and population growth, and between travel time and average price. Travel time was negatively correlated with the remaining variables.

The results validate the assumption that the local real estate market was directly linked to urbanization processes expressed by demographic data. The analyses also confirmed the presence of cause-and-effect relationships between the evaluated variables.

The correlations between commuting time vs. the number of transactions and average unit prices were illustrated in scatter plots (Figure 8a,b). The scatter plots also present the influence of temporal accessibility on the local real estate market.



Figure 8. Correlations between (**a**) commuting time and the number of transactions, (**b**) commuting time and average unit prices. Source: own elaboration.

4. Discussion

The study demonstrated that suburbanization proceeds rapidly in the areas surrounding Olsztyn, but the spatial distribution of suburban settlements is irregular and characterized by significant local variations. The present findings validate the hypothesis that suburbanization influences the number of transactions on local real estate markets, and that transaction volumes reflect the dynamics and territorial reach of suburbanization. The results of this study also indicate that access to the transportation network significantly influences local real estate markets in suburban areas. Similar observations were made by other authors, who demonstrated that transport accessibility influences prices and transactions on the real estate market [86,87]. The correlations noted in this and other studies were similar, regardless of the size of the urban core [88,89].

Transport accessibility also influences the choice of locations on the real estate market and, consequently, population growth [90]. This feedback mechanism stimulates the growth of the real estate market. Buyers have a greater interest in residential areas with well-developed technical infrastructure and public facilities. Most areas that meet the above requirements are located in the direct vicinity of cities, and their greatest advantage is the proximity of the urban core. However, suburban areas are often deficient in social infrastructure, and many of them feature only basic retail outlets. Local residents have to commute to Olsztyn to satisfy other life needs. In contrast, rural municipalities situated further away from Olsztyn rely on local potential and attributes to develop local infrastructure. These municipalities have schools, healthcare facilities, local government offices and shops. As a result, basic life needs are met locally, and the residents do not have to travel to Olsztyn.

Herding behavior can also play an important role in real estate choices. Herding behaviors disrupt rational decision making because individuals follow other people and

imitate group behaviors. Buyers who search for suburban property often follow trends without realizing that the most popular locations are characterized by high levels of urbanization and do not differ considerably from cities (in particular, locations adjacent to city limits). In an attempt to escape the hustle and bustle of urban life, many buyers ultimately pay a high price for locations that resemble the city.

The above factors lead to spatial disruptions. The analyzed variables were not evenly distributed and contributed to disproportions between the evaluated cadastral districts. A comparison of the Gini index for the first and last year of the analyzed period revealed growing differences in population distribution, the number of transactions and average prices, which contributed to disproportions between cadastral districts. Due to similar transport accessibility, cadastral districts adjacent to Olsztyn are characterized by the highest population, the highest number of property transactions and the highest prices of construction plots. However, an analysis of the areas located south-east of Olsztyn revealed considerable deficiencies in transport planning policies both at the local (municipal) and supralocal level. These observations are validated by the spatial distribution of the analyzed variables in the maps presented in Section 3. High values of the Gini index point to uneven distribution, which suggests that the Olsztyn FUA is characterized by considerable fragmentation of the analyzed phenomena. The above generates spatial chaos, and it compromises effective land management. The intensity and spatial concentration of the investigated processes were determined by distance from the city core and the proximity of the main transportation routes, which influences transport accessibility of the studied cadastral districts. Land prices, the number of real estate transactions and changes in the population growth rate decrease with an increase in distance from the urban core. Similar trends were reported by other authors [83,91].

5. Conclusions

Olsztyn is an example of a city where transport accessibility has an influence on the development of the suburban area and the local real estate market. Similar processes are observed in all large cities in Poland, particularly in areas situated in the vicinity of regional capitals and along the main transport corridors, for example, Białystok [31], Toruń-Bydgoszcz [92,93], Kraków [94] and Gdańsk-Gdynia-Sopot [95], because suburban dwellers rely mainly on private transport, whereas other forms of transport play a secondary role [63,96]. The results of this study validate the observations made by Śleszyński [97], who noted that accessibility expressed in monetary terms does not discount the improvement in temporal accessibility resulting from the construction of new roads.

This article presents the results of the first stage of research. The eastern, southern and western fragments of the Olsztyn ring road were commissioned for use in July 2019. The ring road and the accompanying access roads will considerably improve transport accessibility in the Olsztyn FUA. Faster travel and the higher throughput of traffic entering the city will increase temporal accessibility between cadastral districts in the evaluated suburban zone. The new road system will facilitate transport between the urban core and suburban districts, and it will provide suburban commuters with easier access to the city. These changes could stimulate new residential development projects in the suburban zone. Similar observations were made by other authors [98,99], including in Polish cities [100,101].

The new ring road plays a very important role in the 2016 Strategy of the Olsztyn Functional Urban Area. The new route will facilitate transit between Olsztyn and suburban districts, and the residents of the Olsztyn FUA will no longer have to cross the city center when traveling between suburban municipalities. The ring road will eliminate traffic bottlenecks, increase the throughput of the existing transportation routes and make travel between Olsztyn and suburban municipalities more comfortable. These changes could affect local real estate markets in the suburban zone. In the second stage of the research, the real estate markets in the Olsztyn FUA will be evaluated two years after the launch of the ring road.

The added value of the present research is that data were analyzed at the level of cadastral districts, whereas most studies of the type are conducted at the level of municipalities. The adopted approach supports more accurate assessments of the observed changes, which is particularly important in medium-sized (and smaller) cities and towns that exert a weaker effect on the surrounding areas. In contrast, analyses conducted at the level of municipalities produce generalized and less precise observations.

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