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Urban Sprawl of Poznań: Morphological and Microeconomic Profile

Abstract: The aim of the article is to assess Poznań’s urban sprawl from the perspective of the morphology of space and financial situation of suburban households. The morphological assessment uses a method based on two grids of squares with a side: 1 km, 500 m; and data on the location of buildings from CCGCD. On the other hand, the assessment of households was carried out on the basis of the CSO Household Budget database. The results of the research indicate that the analyzed communes in the Poznań area are characterized by a moderate degree of disorder in the spatial structure. There are no communes with a completely compact specificity, there are also no communes with an absolutely high degree of spatial disorder. Households causing urban sprawl in Poznań are entities that incur moderate financial losses in order to maximize their housing preferences.

Key words: urban sprawl, morphology, households, net costs, net benefits

Introduction

The debate on urban sprawl and suburbanization has been present in Polish literature for two decades. Sprawl and suburbanization are not the same phenomena. Nevertheless, Polish literature recognized that sprawl is a specific form of suburbanization, meaning the process of developing rural areas, often in a spontaneous and uncontrolled manner, leading to spatial chaos, landscape degradation, and dependence on individual transport (Kaczmarek 2020). Kaczmarek (2020), apart from the spatial consequences of the sprawl, also points to the forms of this phenomenon, such as the dispersion of households and workplaces. But what is spatial chaos or loose form of development, what compact mean? These are not conceptual problems of urban sprawl present only in Polish research. In the international discussion Galster et al. (2001) criticizes the terminological ambiguity of urban sprawl as a term, indicating that much of the literature is lost in the “semantic wilderness”. Galster et al. (2001) indicate that it is used as a noun

to describe the state of space and as a process; the term is also so vague in defining that some researchers admit that they “recognize sprawl when they see it”. Bhatta (2010) notices that discussions on urban sprawl appear in the literature without any description explaining the essence of this issue. Parallel to the considerations of foreign researchers, it should also be noted that the achievements of the Poznań community on suburbanization are also rich (Beim, Tölle 2008, Ponizy et al. 2008, Bajerski 2011, Kacprzak, Staszewska 2011, Kaczmarek, Kisiała 2011, Szczechowiak 2011, Parysek 2013, Kacprzak, Głębocki 2016, Kaczmarek 2017, 2020, Wdowicka, Mierzejewska 2020). These achievements concern the general issues of suburbanization and its specificity, including urban sprawl, as well as its spatial and socio-economic consequences for the Poznań agglomeration. Moreover, Churski (2018) recognizes urban sprawl as one of the most important development challenges for the Poznań agglomeration.

However, both international and local studies dedicated to the suburbanization of Poznań rarely assess urban sprawl from the perspective of the morphology of space and the finances of suburban households. Hence, the aim of the article is to present and evaluate both the morphology of the area around Poznań at risk of urban sprawl, as well as the financial costs and benefits for households causing the phenomenon. The adopted aim is a response to the conceptual needs related to the definition of Poznań’s urban sprawl and the gaps in research on the finances of households causing the phenomenon. Since the goal is quite extensive, as it covers two important issues, it was decided to make the article diagnostic – hence the title uses “profile”. The research results may constitute a starting point for in-depth research on the problems highlighted in the article.

Literature Review

The two title issues require necessary theoretical reflection: the morphology of urban sprawl and the microeconomic basis for assessing the consequences of urban sprawl.

Urban sprawl in terms of morphology can be considered both statically and dynamically. The state of space is expressed in a negatively evaluated spatial structure. The dynamic approach is defined as a sequence of changes in the states of space, ie the transition from one state of space with a specific set of features (eg filling, accessibility, functions) to another (Chojnicki 1999). For the morphological profile of urban sprawl, therefore, the very definition of a set of spatial features that can be ascribed to the phenomenon in question is important. One of the most popular approaches to the spatial features of urban sprawl in the literature is the concept of Galster et al. (2001), which distinguishes eight dimensions of sprawl: density, continuity, concentration, clustering, centrality, nuclearity, mixed uses, proximity. Lisowski and Grochowski (2009) in their theoretical considerations, see the advantages of this approach to measuring urban sprawl as a method reflecting various features of the phenomenon. In Poland, however, this method is not widely used due to the requirements for input data as well as

methodological and empirical processing. Arribas-Bel et al. (2011) see the quantification of the Galster phenomenon as one of the most important and accurate contemporary concepts of specification and measurement of the chaotic spatial structure of agglomerations. The authors develop the method while introducing a hierarchy of features of the phenomenon. In the first place, the categories of urban morphology are mentioned, i.e. scattering, connectivity, availability of open space. They define morphology as “spatial configuration and the existing linkages between the different components of a city, both between each other and within themselves” (Arribas-Bel et al. 2011). Morphology includes the features of the arrangement and coherence of the urban area as a whole, answering the question of what structure we are dealing with? Secondly, the categories of the internal composition of the area are indicated, i.e. density, decentralization, land-use mix, which are a refinement of urban morphology, indicating the way of filling the spatial structure with an already known arrangement.

Urban sprawl should therefore be treated both statically as a means of spatial development, that is, a specific spatial configuration of an urban area at a specific moment; and as a process, i.e. changing the spatial structure of an urban area over time. Urban sprawl in a static approach allows us to understand the spatial distribution of buildings at a given moment; while the dynamic the direction of changes. The dynamic approach, however, is more difficult to evaluate, because a structure with negative spatial features in a specific period, later may show compactness and coherence of development; where the first period was a transitional stage in the process of urban development (Lityński 2019, Torrens, Alberti 2000). The dynamics of the process can be explained from the point of view of the theory of spatial growth of an urban area. According to Herold et al. (2005) the expansion of an urban area begins with a core that spreads into new, single, non-adjacent settlements – which, statically, may signal urban sprawl. In this concept, further development and continuation of the spatial evolution of the urban area is associated with the development of areas between settlements, and thus combining the spatial structure into a more compact and spatially continuous development. This diagram suggests that certain parts of an urban area may undergo an expansion phase before finally forming a compact structure that can no longer be characterized as a sprawl like structure. However, from this point of view, the definition of the place, time and form of urban sprawl becomes ambiguous. Therefore, it cannot be characterized as a process without first considering its state. Rather, the urban sprawl should be considered through the prism of successive states of spatial structure over a period of time. Only the assessment of the direction of changes in the structure of space reveals a positively valued spatial development or changes of a negative nature.

In the light of the discussed concept of spatial growth of the urban area, it is possible to interpret the current research on the development of the Poznań agglomeration. Kaczmarek (2017) shows that since 2004 a clear depopulation trend of Poznań in favor of the suburban area has been visible. He also notes the problem of overestimating residential areas included in spatial plans in relation to demographic forecasts. The research allows Kaczmarek (2017) to conclude

that new residential buildings are dispersed, and this dispersion takes place even in areas designated for construction purposes in spatial plans. Moreover, new residences, even if they are built completely detached from the areas of previous investments and infrastructure networks, cannot be blocked by the interventions of the spatial plan. In turn, Churski (2018) presents the problem of Poznań's urban sprawl prospectively. On the basis of forecasts, he indicates that by 2035 the city of Poznań, as a result of depopulation, will equal the number of inhabitants with the Poznań powiat in which the number of inhabitants is growing. On this basis, he notes that the development challenges of the Poznań agglomeration include, in the first place, a strong process of suburbanization taking the form of urban sprawl. The conclusions of both researchers in the light of the concept of Herold et al. (2005) may suggest that the spatial development of the Poznań agglomeration does not lead to the location of new housing estates between the existing ones and the creation of a compact and coherent spatial structure. Conversely, the random location of individual investments in fact leads to the densification of buildings, creating spatial disorder, i.e. from the morphological side of urban sprawl. This casual location of buildings is most often carried out on agricultural lands. With regard to the Poznań agglomeration, Poniży (2008) signals the intensification of the phenomenon of occupying agricultural land for mainly residential development and describes it as urbanization pressure. Kacprzak and Głębocki (2016) confirm that urban sprawl in the Poznań agglomeration is implemented primarily at the expense of agricultural land. Kacprzak and Staszewska (2011) draw similar conclusions in regards to the Poznań powiat.

The second of the mentioned areas of theoretical considerations are the microeconomic foundations of the assessment of the consequences of urban sprawl. There is agreement among economists that urban sprawl is defined as the excessive decentralization of an urban area imposing greater net costs on households than if development had remained more centralized (Brueckner 2000, Mills 2000, Wassmer 2002). From a microeconomic perspective, the net costs are also used to determine the net benefits of households resulting from suburban location decisions. Thus, evaluating urban sprawl from a microeconomic point of view will be disadvantageous when the net costs exceed the net benefits. This point of view reveals the need to assess the microeconomic costs and benefits of urban sprawl to households in order to demonstrate the effectiveness of sprawl. But, the microeconomic consequences of sprawl are hard to be clearly evaluated, because the benefits collide with the problem of costs. The problem arises from individual and subjective assessment of costs and benefits by households. That's why the implications of the urban sprawl is dominated by a macro- or mezo-economic viewpoint; the microeconomic level is seldom analyzed. In Poland, research on the financial consequences of suburbanization is only just developing and concerns generally the finances of self-governments in the field of education, infrastructure, communal services, health and social services (Bajerski 2011, Kaczmarek, Kisiała 2011, Szczechowiak 2011, Lityński 2019). There are also studies in relation to the Poznań suburbs, signaling the possibility of lowering economic growth as a result of the intensification of urban sprawl (Lityński 2016).

Microeconomic mechanisms, in addition to population growth and weakness in spatial policy, are considered to be one of the most important determinants of urban sprawl (Daneshpur, Shakibamanesh 2011). These mechanisms distinguish preferences and maximization of utility in terms of place of residence as well as financial constraints and possibilities.

Maximizing the utility of households from a suburban location is related to increasing the living space. This mechanism is referred to as the linear-development model (De Vos et al. 2016). In the opinion of the inhabitants of the core city, the space of their functioning related to the area of an apartment, house, plot and surroundings may be insufficient – which influences the decision to relocate to suburbia. In many countries, there has been a transformation in family life related to the departure from the model of joint functioning of many generations in one larger house for the benefit of smaller ones for a single family (Bhatta 2010). These preferences create a new demand for residential properties located in suburban areas, which shifts the boundary of urban sprawl. Similarly, in Poland, urban sprawl was launched after 1989 along with the political changes in the country. Its significant increase dates from the second half of the 1990s (Lisowski 2005, Jakóbczyk-Gryszkiewicz 2011, Zborowski et al. 2012). During this period, a high level of demand for house was reported (Zawadzki 2000, Brade et al. 2009, Martyniuk-Pęczek et al. 2018). With regard to the Poznań agglomeration, Wdowicka and Mierzejewska (2020) indicate that the beginnings of suburbanization processes began in the 1990s, and a significant increase took place in the first half of the 21st century. The results of the surveys of these authors also indicate the possibility of a linear development model in the Poznań agglomeration, because the size of the plot is considered to be the second motive for the suburban location, after the distance from Poznań. This conclusion is also confirmed by the studies by Beim and Tölle (2008), who show that in the Poznań agglomeration the most important factor of relocation to the suburban area is the small size of city apartments.

The preferences of living in the suburban area are also explained by another model, the systemic model. De Vos et al. (2016) indicates that the systemic model results from the anti-urban values of the inhabitants: some inhabitants have preferences for a higher level of silence, peace and solitude, and perceive the rural lifestyle as meeting these criteria. Due to the diversity of preferences of various social groups, an agglomeration may have both systemic and linear-development models. It seems that in the case of the Poznań agglomeration it is also the case, because according to the already cited research by Wdowicka and Mierzejewska (2020), the third motive of suburban location is the value of the natural environment. Thus, universal in the international scale is the conclusion of Barnes et al. (2001) that, as long as living conditions in cities do not meet residential ones, this perception will not change and urban sprawl will continue.

Satisfying housing preferences is, however, limited by financial possibilities. Household incomes are among the primary budget constraints (Mattingly, Morrissey 2014). Hołuj (2018) notes that a spill-over effect is observed in communes in urban sprawl zone. This effect is related to the similar level of salary in the sprawl zone to the core city. The possibilities and budgetary constraints of households

are also determined by the costs of daily operation, real estate purchase and the lack of financially accessible houses in the core city (Ewing, Cervero 2010). Most often, residents of urban areas look for a location in the city, but lower costs of operating and purchasing real estate encourage them to a rural location. Parysek (2013) notes, however, that individual households relocating to the suburban area, pursuing and satisfying their own needs, ambitions and life priorities; however, they do not fully take into account future operating costs. The perception of households with lower daily living costs in the suburban area may be disturbed by higher transport loads in the long run. Urban sprawl, by extending the distance from the suburbs to the center, increases household transport expenses. There is an opinion among many economists that higher budget burdens result from the more frequent use of cars for traveling, increasing congestion and, consequently, much higher fuel consumption (Travisi et al. 2010, Young et al. 2016, Litman 2020). Lityński and Hołuj (2017) calculate the losses of households due to commuting to work from suburban communes to Poznań, which may potentially reach annually € 4.4k per household, and in the perspective of 14 years € 83k per household. The phenomenon of longer travel times is also accompanied by tiredness, which reduces work productivity (Litman 2020). However, there is evidence in studies that urban sprawl does not always increase household communication costs. Anas (2012) proves that the average vehicle use is reduced due to the adaptation of the workplace location to the place of residence and the development of public transport.

Materials and Methods

The research relates to the spatial and economic processes taking place in Wielkopolska in the past decade. The research focused on the communes around Poznań, which according to Lityński and Hołuj (2020) are under urban sprawl risk. The study area is illustrated in Fig. 1.

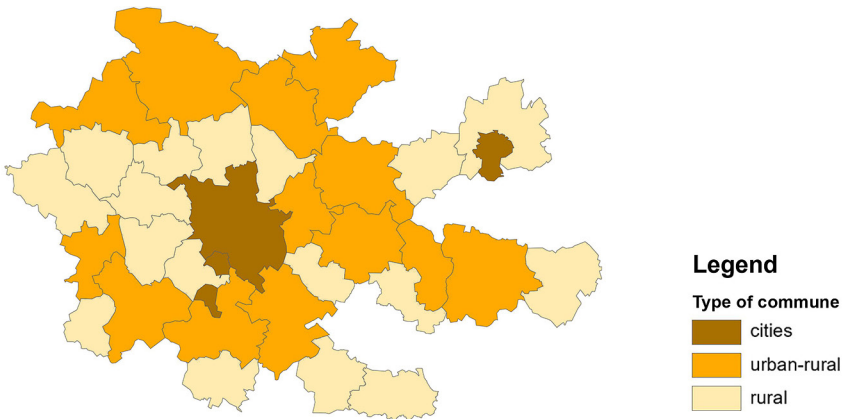


Fig. 1. Study area: Poznań and surrounding communes within urban sprawl
Source: own study based on Lityński and Hołuj (2020).

The presentation of the method and materials was divided into two parts: morphological and microeconomic.

Morphological Profile

The morphological profile of urban sprawl around Poznań was based on selected six indicators assessing the spatial structure (Galster et al. 2001). These indicators reflect the specificity of the development of space, which can be attributed to the features of a disorder, i.e. an area with low density and clustering of buildings, with no continuity and concentration between developed plots, large distance from the center and urbanization pressure on agricultural areas. Morphological indicators and their formulas are presented in Table 1.

Table 1. Urban morphology indicators

| Morphological indicator | Formula |
|-------------------------|---|
| Density | $D_{iu} = \frac{T_{iu}}{A_u} = \sum_{m=1}^M \frac{T_{im}}{A_u}$ |
| Continuity | $C_{iu} = \sum_{s=1}^S [D_{is} > 5 \text{ buildings} = 1; \text{ otherwise} = 0] / S,$ [min = 0; max = 1] |
| Concentration | $COV_{iu} = (\sum_{m=1}^M [D_{im} - D_{iu}]^2 / M)^{1/2} / [\sum_{m=1}^M D_{im} / M],$ |
| Clustering | $CLUS_{iu} = \frac{[\sum_{m=1}^M (\sum_{s=1}^4 [D_{is} - D_{im}]^2 / 4)^{1/2} / M]}{[\sum_{m=1}^M D_{im} / M]},$ |
| Centrality | $CEN_{im} = \frac{T_{iu} \times (A^{1/2})}{\sum_{m=1}^M F[k,m] \times T_{im}}$ |
| Urbanization pressure | $UP_{(j-i)} = \sum_{m=1}^M (D_{im} \left[\frac{D_{jm}}{T_{ju}} \right]) / D_{iu}$ [min = 0; max = max D_{im} observed in each area occupied by j] |

Notes:

i – adopted type of land use or specific space observation, i.e. residential buildings;

j – agricultural buildings;

u – the biggest spatial unit adopted in the analysis, urban area;

m – mid-size spatial unit: 1 km²; 1, 2, m, M of mid-sized units constitute the urban area u;

s – the smallest spatial unit: 1/4 km²; 1, 2, s, S of the smallest units of the urban area u;

D_{is} – density of the ith land use in the surface area of the sth spatial unit $D_{is} = T_{is}/A_s$;

D_{im} – density of the ith land use in the surface area of the mth spatial unit; $D_{im} = T_{im}/A_m$;

D_{jm} – density of the jth land use (agricultural buildings) in the area of the mth spatial unit;

T_{iu} – total number of observations of the ith land use in the urban area u;

T_{im} – total number of observations of the ith land use in the area of the mth spatial unit;

T_{ju} – total number of observations of the jth land use (agricultural buildings) in the area u;

T_{ia} – total number of observations of the ith land use in the central area;

A_u – total surface area of DL in the urban area u;

A_m – total surface area of DL in the mth spatial unit m;

F(k,m) – distance between centroids of the geographical grid k and m;

P_m – percentage of the mth spatial unit in u.

Source: own based on Galster et al. (2001).

The method used in the research uses three GIS softwares (SpatiaLite, QGIS, ArcGIS) and Excel and consists of five steps:

1. The basis for the analyzes is a map of the area including the description of the land and the location of buildings from the database of topographic objects of the Central Center for Geodetic and Cartographic Documentation (BDOT10k, CCGCD). Data for the two periods 2015 and 2017 were used. These are data on a specific location with a description of the specificity of buildings; the data also indicate the legal status and function of the land.
2. On the map of the studied areas, taking into account the location of the buildings, two grids of squares were imposed: the first with a side of 1 km, the second with a side of 500 m.
3. Determination of the so-called developable land (DL), which is the basis for calculating morphological indicators instead of the traditional total area of the commune. DL is understood as an area without natural features and development barriers that prevent constructions. DL was calculated in each of the squares of the grid with sides of 1 km and 500 m by subtracting from the total square area, the areas determined by the buffer around: national, regional, powiat and communal roads; rivers, streams, flowing and stagnant waters; protected areas, including national parks and reserves. In Polish legal regulations, it is absolutely forbidden to carry out construction investments in the above-mentioned areas. In other areas, on the other hand, one can find examples of construction investments, although on such areas cannot be built (e.g. agricultural land, forests).
4. The spatial structure of the analyzed area is quantified through the prism of the combination of the distribution of squares with different numbers of buildings. This quantification was made on the basis of the indicators in Table 1. Some adaptations were made to the method of Galster et al. (2001) to local conditions. Metric system changed from miles to km. Due to the change in the metric system, continuity has reduced the number of buildings from 9 to 5. Moreover, the indicator that Galster et al. (2001) name mixed uses was replaced with the name of urbanization pressure, due to the use of data for residential and agricultural land use. According to the quoted literature (Poniży 2008, Kacprzak, Staszewska 2011, Kacprzak, Głębocki 2016), residential buildings in the suburbs of Poznań are built in agricultural areas, which is referred to as urbanization pressure.
5. Interpretation of morphological indicators shows that the lower the value, the more favorable the organization of space, i.e. the higher the degree of urban sprawl. The exception is the Urbanization pressure, the interpretation of which is opposite.
6. Calculation of the Sprawl Index (SI) which assesses the degree of urban sprawl. The Perkal method was used to build the SI. The SI interpretation indicates that the lower its value, the higher the degree of urban sprawl, i.e. negatively valued spatial development. In addition, SI also has the same interpretation as the Prekal method, i.e. it is in the range (-3; +3). Urban areas with a high degree of urban sprawl will show values below 0, areas with a moderate degree

of phenomenon will oscillate around 0, and areas with a relatively low degree will have values above 0. Similar areas are considered to have similar index values. SI is calculated according to the formula in Table 2.

Table 2. Sprawl Index

| Formula | Normalization |
|--|--|
| $SI_i = \frac{1}{p} \sum_{j=1}^p z_{ij}$ | $z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j} \text{ for stimulants}$ |
| | $z_{ij} = \frac{\bar{x}_j - x_{ij}}{s_j} \text{ for destimulants}$ |

Notes:

z_{ij} – normalized variable

x_{ij} – value of j for object i

\bar{x}_j – average value of j variable

s_j – standard deviation of the variable j

p – number of partial indicators

Microeconomic Profile

Using the purchased databases from the Household Budget Survey of the Central Statistical Office (HBS), analyzes of the components of household budgets included in Table 3.

Table 3. Household budget variables

| Variables | HBS code |
|--|----------|
| Net receipts | PGDN |
| Available income | DOCH |
| Disposable income | DDP |
| Net outgoings | RGDN |
| Expenditures | WYD |
| Expenditures on consumer goods, sarvices | WTUK |
| Other expenditures | WP |
| Mortgage | D5_7 |

The main goal of the microeconomic profile analysis is to try to indicate the financial effects for households living in sprawl zones. Financial effects are understood here as net losses or gains for the household budget. For the net valuation of financial effects, a quasi-experimental approach, which can be used, *inter alia*, synthetic control method, is applicable. The essence of such research is the identification of a control group, i.e. an abstract construct against which the consequences of the studied phenomenon are assessed. The research may therefore be based on comparing the income and expenditure of households living in urban sprawl area (analyzed group) with that of a control group. Using HBS, the group analyzed as, jointly meet the following conditions: house/apartment construction period after 2007; income from non-agricultural activities; located in com-

munes with a population below 20k inhabitants, in villages and communes with a population of 20–99k. The control group, on the other hand, was similar households, but located in Poznań. The selection of households for the control group was determined by two criteria: a house/apartment built after 2007, income from non-agricultural activities. The rationale for both criteria is mentioned in theory, the mechanism of household preferences and utility maximization in terms of the place of residence, as well as financial constraints and possibilities. Those households were selected which, instead of living in a new house in the sprawl zone, chose a location in a new house in the city. A new house in this case means a building built after 2007. The comparison of both sets was made using the *d* Cohena indicator (Livingston et al. 2009):

$$d \text{ Cohena} = \frac{\bar{x}_{AG} - \bar{x}_{CG}}{s}$$

Notes:

\bar{x}_{AG} – average for the analyzed group

\bar{x}_{CG} – average for the control group

s – standard deviation in the population

In this method, the net effect is assessed in the following ranges: 0 is no effect; 0–0.2 small; 0.2–0.5 moderate; 0.5–0.8 large and statistically significant; >0.8 very high. When *d* Cohena occurs with “+” then the effect is assessed positively as net benefit, and when it occurs with “–” it is assessed negatively as net cost.

Results and Discussion

Morphological Profile

Table 4 presents the value of morphological indicators broken down into three categories of communes: cities, urban-rural and rural.

From the point of view of morphology evaluation of the first group of communes, the most important are: density, continuity, clustering and concentration. Cities show high rates of density and continuity. This means that these areas are characterized by dense development, where subsequent built-up plots maintain significant spatial continuity. Except for Luboń, the analyzed cities represent high values of the concentration, which is a desirable feature from the morphological point of view. The city area can be built up continuously, but no urban area is completely densified. However, the density indicators do not indicate the distribution of buildings in space. Thus, the high concentration for Poznań and Gniezno, and a little less for Puszczykowo, indicates that the buildings are located in a small number of smaller parts of the city with a relatively high density. This indicates a higher density of areas that are considered built-up. On the other hand, the concentration values for Luboń (0.53) indicate that the development, although dense and continuous, is evenly distributed in space. However, the buildings in

Table 4. Value of morphological indicators in 2015 and 2017

| | D_{is} | | C_{iu} | | COV_{iu} | | $CLUS_{iu}$ | | CEN_{im} | | $UP_{(j-i)}$ | |
|----------------------|----------|--------|----------|------|------------|------|-------------|------|------------|------|--------------|------|
| | '15 | '17 | '15 | '17 | '15 | '17 | '15 | '17 | '15 | '17 | '15 | '17 |
| Cities | | | | | | | | | | | | |
| Poznań | 325.66 | 324.83 | 0.89 | 0.89 | 0.97 | 0.97 | 0.62 | 0.62 | 2.88 | 2.87 | 6.96 | 7.05 |
| Gniezno | 331.79 | 332.46 | 0.93 | 0.92 | 0.87 | 0.90 | 0.62 | 0.62 | 0.14 | 0.14 | 5.15 | 5.01 |
| Luboń | 817.16 | 823.44 | 0.96 | 0.96 | 0.53 | 0.53 | 0.54 | 0.54 | 0.44 | 0.44 | 2.88 | 2.91 |
| Puszczykowo | 511.57 | 512.45 | 0.93 | 0.93 | 0.71 | 0.70 | 0.35 | 0.35 | 0.27 | 0.27 | 7.46 | 7.44 |
| Urban-rural communes | | | | | | | | | | | | |
| Oborniki | 56.70 | 56.73 | 0.71 | 0.71 | 1.83 | 1.83 | 0.71 | 0.71 | 0.64 | 0.64 | 4.24 | 4.24 |
| Buk | 82.82 | 82.89 | 0.75 | 0.75 | 1.87 | 1.87 | 0.89 | 0.89 | 0.34 | 0.34 | 4.02 | 4.02 |
| Kostrzyn | 64.57 | 64.57 | 0.75 | 0.75 | 2.34 | 2.34 | 0.74 | 0.74 | 0.60 | 0.60 | 7.93 | 7.93 |
| Kórnik | 82.46 | 82.83 | 0.77 | 0.78 | 1.47 | 1.46 | 0.75 | 0.75 | 0.73 | 0.73 | 6.20 | 6.25 |
| Mosina | 130.85 | 132.14 | 0.76 | 0.76 | 1.49 | 1.48 | 0.73 | 0.73 | 0.69 | 0.69 | 8.02 | 8.08 |
| Murwana Goślina | 58.99 | 58.99 | 0.71 | 0.71 | 1.87 | 1.87 | 0.84 | 0.84 | 0.62 | 0.62 | 5.90 | 5.90 |
| Pobiedziska | 76.99 | 76.99 | 0.72 | 0.72 | 1.75 | 1.75 | 0.78 | 0.78 | 0.62 | 0.62 | 7.28 | 7.28 |
| Stęszew | 97.05 | 97.05 | 0.79 | 0.79 | 1.82 | 1.82 | 1.10 | 1.10 | 0.57 | 0.57 | 6.75 | 6.75 |
| Swarzędz | 170.42 | 171.23 | 0.78 | 0.77 | 1.77 | 1.76 | 0.62 | 0.62 | 0.98 | 0.98 | 9.26 | 9.34 |
| Szamotuły | 85.66 | 85.66 | 0.76 | 0.76 | 1.87 | 1.87 | 0.70 | 0.70 | 0.41 | 0.41 | 5.05 | 5.05 |
| Skoki | 33.79 | 33.79 | 0.64 | 0.64 | 1.76 | 1.76 | 0.84 | 0.84 | 0.43 | 0.43 | 5.04 | 5.04 |
| Nekla | 60.16 | 60.16 | 0.76 | 0.76 | 1.85 | 1.85 | 0.68 | 0.68 | 0.29 | 0.29 | 3.92 | 3.92 |
| Września | 92.60 | 92.65 | 0.80 | 0.80 | 2.02 | 2.02 | 0.75 | 0.75 | 0.33 | 0.33 | 5.26 | 5.27 |
| Rural communes | | | | | | | | | | | | |
| Gniezno | 47.64 | 48.39 | 0.80 | 0.79 | 0.96 | 0.97 | 0.83 | 0.84 | 0.27 | 0.27 | 1.50 | 1.51 |
| Łubowo | 44.14 | 44.15 | 0.70 | 0.70 | 1.05 | 1.06 | 0.75 | 0.75 | 0.30 | 0.30 | 1.55 | 1.56 |
| Granowo | 79.96 | 79.96 | 0.83 | 0.83 | 1.81 | 1.81 | 0.71 | 0.71 | 0.25 | 0.25 | 2.71 | 2.71 |
| Czerwonak | 107.13 | 105.46 | 0.80 | 0.79 | 1.19 | 1.21 | 0.71 | 0.71 | 0.86 | 0.86 | 5.52 | 5.61 |
| Dopiewo | 131.74 | 135.79 | 0.79 | 0.78 | 1.47 | 1.46 | 0.67 | 0.68 | 0.73 | 0.73 | 6.45 | 6.48 |
| Kleszczewo | 58.20 | 57.51 | 0.73 | 0.73 | 1.38 | 1.38 | 0.81 | 0.80 | 0.56 | 0.55 | 2.54 | 2.52 |
| Komorniki | 242.19 | 241.88 | 0.86 | 0.85 | 1.05 | 1.08 | 0.67 | 0.67 | 0.74 | 0.74 | 6.47 | 6.76 |
| Rokietnica | 109.74 | 111.44 | 0.82 | 0.82 | 1.18 | 1.18 | 0.71 | 0.71 | 0.52 | 0.52 | 4.82 | 4.81 |
| Suchy Las | 116.09 | 117.89 | 0.74 | 0.74 | 1.44 | 1.45 | 0.77 | 0.77 | 0.85 | 0.86 | 5.78 | 5.75 |
| Tarnowo Podgórne | 143.85 | 146.39 | 0.82 | 0.82 | 1.53 | 1.52 | 0.57 | 0.56 | 0.66 | 0.67 | 5.71 | 5.68 |
| Strzałkowo | 55.00 | 55.00 | 0.77 | 0.77 | 2.09 | 2.09 | 0.75 | 0.74 | 0.20 | 0.20 | 3.40 | 3.40 |
| Duszniki | 45.43 | 45.43 | 0.73 | 0.73 | 1.49 | 1.49 | 0.75 | 0.75 | 0.37 | 0.37 | 2.20 | 2.20 |
| Każmierz | 42.73 | 42.73 | 0.76 | 0.76 | 1.85 | 1.85 | 0.66 | 0.66 | 0.40 | 0.40 | 4.51 | 4.51 |
| Dominowo | 34.69 | 34.69 | 0.78 | 0.78 | 1.05 | 1.05 | 0.81 | 0.81 | 0.27 | 0.27 | 1.09 | 1.09 |
| Krzykosy | 60.07 | 60.07 | 0.73 | 0.73 | 1.62 | 1.62 | 0.77 | 0.77 | 0.25 | 0.25 | 2.52 | 2.52 |
| Zaniemyśl | 56.08 | 56.08 | 0.73 | 0.73 | 2.09 | 2.09 | 0.74 | 0.74 | 0.32 | 0.32 | 5.86 | 5.86 |
| Brodnica | 36.44 | 36.42 | 0.71 | 0.71 | 1.20 | 1.20 | 0.87 | 0.87 | 0.33 | 0.33 | 1.37 | 1.37 |

Source: own study.

the analyzed cities are not clustered to a high degree. The buildings in Poznań and Gniezno are the highest in the analyzed group, while Puszczykowo is characterized by a low degree of clustering of buildings.

In regards to urban-rural communes and rural communes, the scope of inferences is similar. The building density is low, although there are municipalities with densely built-up areas. Buildings in urban-rural and rural communes show a moderate degree of spatial cohesion, due to the levels of the continuity index (+/- 0.8), which means the presence of the so-called leap-frog. At the same time, the arrangement of the space that has already been built up can be assessed as good, due to the levels of clustering and concentration indicators. The comparison of these results with the density indicators and relatively low values of the centrality indicator allows the conclusion that in the analyzed communes the arrangement is manifested by the presence of areas in which residential buildings are located in relatively large areas. At the same time, one advantage is the grouping of buildings into settlements, which confirms the possibility of a leap-frog. Unfortunately, these settlements are located among areas used for agriculture, which is confirmed by indicators of urbanization pressure. Interestingly, indicators of urbanization pressure are particularly high in urban-rural communes.

The discussed morphological indicators show that urban sprawl occurs not only in rural communes, but also in urban-rural communes. Hence, Table 5 presents the ranking of these communes in terms of the degree of urban sprawl. On the basis of the SI index, an order was made of rural and urban-rural communes, where the highest position in the ranking means the lowest degree of urban sprawl. The lower the position in the ranking, the higher the degree of spontaneous spatial structure.

Table 5. Ranking of communes in the outer zone of Poznań (excluding cities) in terms of urban sprawl

| SI '15 | Commune | Ranking* | Commune | SI '17 |
|--------|------------------|----------|------------------|--------|
| 0.736 | Stęszew | 1 | Stęszew | 0.737 |
| 0.592 | Komorniki | 2 | Komorniki | 0.562 |
| 0.262 | Buk | 3 | Buk | 0.260 |
| 0.251 | Swarzędz | 4 | Swarzędz | 0.225 |
| 0.216 | Granowo | 5 | Granowo | 0.222 |
| 0.210 | Września | 6 | Suchy Las | 0.216 |
| 0.176 | Czerwonak | 7 | Września | 0.214 |
| 0.174 | Suchy Las | 8 | Czerwonak | 0.158 |
| 0.121 | Dopiewo | 9 | Tarnowo Podgórne | 0.128 |
| 0.117 | Tarnowo Podgórne | 10 | Dopiewo | 0.102 |
| 0.061 | Kostrzyn | 11 | Kostrzyn | 0.067 |
| 0.046 | Rokietnica | 12 | Rokietnica | 0.062 |
| 0.026 | Kórnik | 13 | Kórnik | 0.049 |
| 0.026 | Strzałkowo | 14 | Strzałkowo | 0.027 |
| 0.008 | Murowana Goślina | 15 | Murowana Goślina | 0.008 |
| -0.002 | Kleszczewo | 16 | Mosina | -0.022 |

| SI '15 | Commune | Ranking* | Commune | SI '17 |
|--------|-------------|----------|-------------|--------|
| -0.021 | Mosina | 17 | Kleszczewo | -0.027 |
| -0.064 | Szamotuły | 18 | Szamotuły | -0.061 |
| -0.097 | Gniezno | 19 | Gniezno | -0.089 |
| -0.105 | Oborniki | 20 | Oborniki | -0.104 |
| -0.146 | Pobiedziska | 21 | Pobiedziska | -0.145 |
| -0.192 | Nekla | 22 | Nekla | -0.188 |
| -0.194 | Dominowo | 23 | Dominowo | -0.194 |
| -0.196 | Krzykosy | 24 | Krzykosy | -0.196 |
| -0.221 | Duszniki | 25 | Duszniki | -0.221 |
| -0.231 | Brodnica | 26 | Brodnica | -0.233 |
| -0.241 | Zaniemyśl | 27 | Zaniemyśl | -0.238 |
| -0.277 | Każmierz | 28 | Każmierz | -0.272 |
| -0.496 | Skoki | 29 | Skoki | -0.500 |
| -0.538 | Łubowo | 30 | Łubowo | -0.545 |

Notes: * the lower the rank, the higher the urban sprawl

Source: own study.

Overall, the SI in the analyzed urban areas varies between -0.55 to $+0.74$, with a scale from -3 to $+3$. In this approach, Poznań's urban sprawl is characterized by a moderate degree of disorder in the spatial structure. There are no communes with a completely compact specificity, there are also no areas with an absolutely high degree of spatial structure disorder. The commune with the highest degree of urban sprawl is Łubowo, showing an index of -0.538 in 2015, and -0.545 in 2017. On the other hand, the most favorable configuration of the spatial structure features can be attributed to the Stręszew commune, for which the SI in 2015 was 0.736 , and in 2017 it was 0.737 .

Microeconomic Profile

Table 6 presents the list of basic income and expenditure categories of households in the analyzed group of communes (AG) and the control group (CG).

Table 7 shows Cohen's d factor assessing the difference between the finances of the analyzed group and the control group. This ratio can be considered as an assessment of the net effect of the costs or benefits of households in the sprawl zone. The range between $0-0.2$ means no or little effect, i.e. no significant differences in the benefits or losses of households living in the suburban area. The range $0.2-0.5$ represents the moderate effect shaded in gray in Table 6. No major or very high effect was identified in the study.

Net receipts (PGDN) on average for 2013–2016 do not represent a significant net effect. However, it points out that in 2013 they represented a moderate net benefit, and in the following years the benefit decreased, so that in 2016 there was a moderate net loss. This signals an emerging negative trend of increasing household losses in terms of income. This does not mean that these households receive less and less income to the household budget, but that they do not keep

Table 6. Income and expenditures of households in the urban sprawl zone of Poznań

| Variables | | 2013 | 2014 | 2015 | 2016 |
|-----------|----|------|------|------|------|
| PGDN | AG | 6581 | 6453 | 6460 | 6918 |
| | CG | 5692 | 5869 | 6078 | 7805 |
| DOCH | AG | 5073 | 5280 | 5398 | 5807 |
| | CG | 4675 | 4893 | 5389 | 6635 |
| DDP | AG | 4962 | 5147 | 5282 | 5701 |
| | CG | 4555 | 4789 | 5309 | 6540 |
| RGDN | AG | 6517 | 6523 | 6673 | 7036 |
| | CG | 5817 | 5658 | 6119 | 8183 |
| WYD | AG | 3911 | 3976 | 4097 | 4329 |
| | CG | 3310 | 3445 | 3376 | 4339 |
| WTUK | AG | 3800 | 3844 | 3981 | 4223 |
| | CG | 3189 | 3342 | 3297 | 4244 |
| WP | AG | 111 | 133 | 116 | 106 |
| | CG | 120 | 103 | 80 | 95 |
| N | AG | 292 | 336 | 173 | 212 |
| | CG | 89 | 106 | 35 | 28 |

Source: own study.

Table 7. Cohen's d for household income and expenditures

| Variables | 2013 | 2014 | 2015 | 2016 | |
|-----------|------|------|------|------|-------|
| PGDN | 0.2 | 0.1 | 0.1 | -0.3 | 0.07 |
| DOCH | 0.1 | 0.1 | 0.0 | -0.3 | 0.02 |
| DDP | 0.1 | 0.1 | 0.0 | -0.3 | 0.02 |
| RGDN | -0.2 | -0.2 | -0.1 | 0.3 | -0.09 |
| WYD | -0.3 | -0.2 | -0.3 | 0.0 | -0.22 |
| WTUK | -0.3 | -0.2 | -0.3 | 0.0 | -0.21 |
| WP | 0.0 | -0.1 | -0.1 | -0.1 | -0.06 |

Notes: – weighted by N an average value of j variable

Source: own study.

up with the income trends set by the residents of control group i.e. Poznań. PGDN includes, among others available income (DOCH) and disposable income (DDP) and in this respect the assessment of d Cohena coefficient confirms the conclusion. The average for DOCH and DDP as well as changes in the following years are slightly lower than for PGDN, but their direction is similar. The differences result from the fact that the PGDN additionally includes savings income. Thus, the increased dynamics of the loss of net benefits results from the unfavorable trends of savings income. Based on the above, it can be concluded that in households causing urban sprawl, income erosion of the household budget is observed.

On the basis of the expenditure side average, households causing urban sprawl appear to be posting a net loss. Net outgoings (RGDN) represent a small loss on average. It should also be noted that in 2013–2016 this loss shows a pos-

itive trend of changes, and in 2016 it is an moderate net benefit. Expenditures (WYD), which include consumption expenditures (WTUK) and other expenditures (WP), have slightly different characteristics than the RGDN. Consumer spending is dominant and the average net loss is moderate. This means that households causing urban sprawl lose money on daily operations in the suburban area. In the WTUK category, there are such expenses as: food, property maintenance, fuel and transport, clothing, etc. It should also be noted that the real estate of households causing sprawl are more often mortgage-borne than in the city, as indicated in Table 8. It can therefore be concluded that net losses for suburban households' result, inter alia, from more frequent mortgage.

Table 8. Mortgage of households

| | | 2013 | 2014 | 2015 | 2016 |
|-----------------|----|------|------|------|------|
| Mortgage (D5_7) | AG | 37% | 32% | 48% | 50% |
| | CG | 21% | 25% | 37% | 33% |

Source: own study.

Summarizing the microeconomic profile, it can be concluded that households causing urban sprawl in Poznań appear to be units that incur financial losses in order to maximize their housing preferences. These losses can be assessed as moderate. They are by no means high. The presented research also contradicts the perception of the suburbs common in the literature, as an area where the costs of everyday functioning are lower (Ewing, Cervero 2010). Research rather confirms the thesis of Parysek (2013) that individual households relocating to the suburban area, seeking and satisfying their own needs, ambitions and life priorities; however, they do not fully take into account future operating costs. As a result of the research results, households in the suburban area of Poznań incur losses in consumption expenditure and burdens. An important loss also appears to be the income erosion of the household budget related to lower savings and the lower growth rate of wages. Lower savings are due to the necessity of paying off mortgage obligations. On the other hand, the weaker upward trend in the incomes of households living in the sprawl zone may indicate a decrease in labor productivity due to commuting to work, signaled in the literature (Litman 2004). As a consequence of commuting to work and tiredness, and further lower labor productivity, households achieve lower professional effects than the inhabitants of the control group (Poznań). In the perspective of several years, this results in slower promotion or lower salaries.

Conclusions

Taking into account the aim formulated in the introduction and results of the research, the conclusions can be presented as follows:

First of all, the basic usefulness of morphological analyzes comes down to the assessment of the level of the phenomenon of spontaneous spread of buildings

in the communes around Poznań. In both analyzed years, the basis for this assessment is an index that quantifies the level of urban sprawl degree of a given commune compared to other units. However, a static assessment of spatial structure is valuable not only from a cognitive point of view; it is also a possible reference point for comparisons with subsequent periods, providing knowledge about the directions and dynamics of spatial processes. The presented calculations use two years, i.e. 2015 and 2017, which seem to be too short a period for drawing absolute conclusions about the spatial transformations of analyzed urban area. However, they may prove useful for research in the next decade.

Secondly, the evaluation of spatial features in terms of urban sprawl in the Poznań area shows that the analyzed communes are characterized by a moderate degree of disorder in the spatial structure. There are no communes with a completely compact specificity, there also are no areas with an absolutely high degree of spatial structure disorder. The commune with the highest degree of urban sprawl is Łubowo, while the most favorable configuration of the spatial structure features can be attributed to the commune of Stęszew.

Thirdly, households causing urban sprawl in Poznań are entities that incur financial losses in order to maximize housing preferences. These losses can be assessed as moderate, but they are not high losses. These losses can be attributed to both expenses and income. In terms of expenses, these are losses in consumer spending and mortgage. On the other hand, when it comes to income, the loss seems to be the income erosion of the household budget related to lower savings and the lower growth rate of wages. Lower savings are due to the necessity to pay off the mortgage. On the other hand, the weaker upward trend in the incomes of households living in the sprawl zone may indicate a decline in labor productivity due to commuting.

On the basis of the presented analyzes, it is also possible to formulate two main directions of future research. The first is the morphological research in the next decade, the results of which, in comparison with the current ones, would provide an answer to the evaluation of the dynamics of the spatial morphology. In other words, it would give the answer whether the morphological changes have a positive or negative trend. The second direction concerns economic research, including a detailed analysis of the structure of consumer expenditures. Financial structural analyzes would show the precise type and level of expenditure responsible for the losses of households from living in the suburban area.

Funding: This work was supported by the National Science Centre, Poland under Grant no. UMO-2016/23/D/HS4/02961 (“Financial Mechanisms in the Economy Resulting from the Phenomenon of Urban Sprawl”). Spatial data were generated at the Central Center for Geodetic and Cartographic Documentation, Poland – license DIO.7211.511.2017_PL_N. Statistical data were purchased from the Central Statistical Office, Poland – contract 7/GUS-DI01.601.97.2018MK.

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Żywiłowe rozprzestrzenianie się Poznania: profil morfologiczny i mikroekonomiczny

Zarys treści: Celem artykułu jest ocena *urban sprawl* Poznania z perspektywy morfologii przestrzeni oraz sytuacji finansowej podmiejskich gospodarstw domowych. Ocena morfologiczna wykorzystuje metodę opartą na dwóch siatkach kwadratów o boku: 1 km, 500 m oraz danych o lokalizacji zabudowy z GUGiK. Natomiast ocena gospodarstw domowych przeprowadzona została w oparciu o bazę Budżetów Gospodarstw Domowych GUS. Rezultaty badań wskazują, że analizowane gminy na obszarze poznańskim charakteryzują się umiarkowanym stopniem bezładu struktury przestrzennej. Brak jest gmin o specyfice całkowicie zwartej, brak jest również gmin o bezwzględnie wysokim stopniu bezładu przestrzennego. Gospodarstwa powodujące *urban sprawl* Poznania to jednostki, które dla maksymalizacji preferencji mieszkaniowych ponoszą umiarkowane straty finansowe.

Słowa kluczowe: *urban sprawl*, morfologia, gospodarstwa domowe, koszty netto, korzyści netto