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The correlation between urban sprawl and the local economy in Poland

The literature has assessed urban sprawl as a negative phenomenon because of the costs it generates. However, various studies have examined the impact of urban sprawl based on only one parameter, such as public expenditures or fuel consumption, instead of taking a more comprehensive approach. Thus, there is a gap in research on the impact of urban sprawl on the local economy from a broader perspective. This article examines the correlation between urban sprawl and the local economy. Urban sprawl is quantified using a modified method based on sprawl indexation. GDP is used as a measure of the local economy. The analysis discussed in the article shows that greater urban sprawl is accompanied by lower GDP in municipalities. Even municipalities with a similar number of houses and varying distribution in space may differ in terms of the level of the local economy. Therefore, houses should be built more densely to achieve a higher level of the local economy. The conclusions show that losses for the local economy resulting from a chaotic spatial structure are unrelated to the distance from the city.

Keywords: urban sprawl, local economy, GDP, correlation

1 Introduction

Urban sprawl is a recognised phenomenon in post-communist European cities and has controversial social, economic and environmental consequences (Nuissl & Rink, 2005; Pichler-Milanović et al., 2007; Sykora & Stanilov, 2014; Rosu & Blăgeanu, 2015). This type of development is mainly caused by people that prefer to settle in suburban areas due to the availability and lower cost of real estate and due to environmental preferences (Lisowski & Wilk, 2002; Sendi, 2013; Grum & Kobal Grum, 2015; Rogatka & Ramos Ribeiro, 2015). Municipalities located near cities are unable to prevent this phenomenon; moreover, they often favour migration from a city because population growth will increase tax revenues (Chmielewski, 2002). At the same time, local governments often implement spatial policies that are not adapted to large-scale migration. The weakness of local spatial planning in Poland is primarily due to the liberalisation of spatial management in the 1990s. This legislation emphasised the protection of private property rights, giving greater freedom to building contractors and invalidating existing spatial plans (Martyniuk-Pęczek, 2005). Until 2003, local governments could not deny building permits on any grounds for the construction of detached homes. Since 2003, local governments have been obliged to develop new spatial plans (Lisowski et al., 2014). Under pressure from landowners, local governments often drew up new local development plans in a rather imprecise manner, mostly as general plans for undeveloped areas, directing growth alongside roads and sometimes in environmentally sensitive areas while avoiding changes to the existing property structure. This lack of vision designed to regulate urban growth has prevented growth control mechanisms as a strategy for combating sprawl (Lisowski et al., 2014; Tsenkova, 2014; Mandič & Filipovič Hrast, 2015). Today houses are built in locations without a compact spatial layout, and this development has economic consequences not only for individual municipalities, but also for the national economy.

The problem of urban sprawl is recognised in government spatial planning documents in central and eastern Europe (Couch et al., 2007); one example is the current Polish government documents – for example, the 2030 National Spatial Development Concept (Pol. *Koncepcja Przestrzennego Zagospodarowania Kraju 2030)*, which dedicates one of its six policy objectives to this issue. At the same time, research on the implications of sprawl for the economy is sparse, especially in Poland (Śleszyński, 2014). Moreover, in the Polish document the diagnosis of sprawl's effects are based on foreign studies, mostly American. However, there are differences between American and post-communist European urban sprawl. In addition, not only in Poland but also in other central and eastern Europe countries there is a lack of studies on how urban sprawl affects the local economy.

Bearing in mind the need for empirical research on urban sprawl, this article assesses the correlation between urban sprawl and the local economy. The hypothesis is that a high degree of urban sprawl is accompanied by a low level of the local economy. In this study, the degree of sprawl refers to fragmented spatial patterns or a chaotic spatial structure. This definition excludes the extent or delimitation of sprawl from the research. The article examines urban sprawl and its economic consequences for selected municipalities – its consequences for the country as a whole are not taken into consideration. Correlation analysis is performed for the suburban areas of the largest Polish cities: Kraków, Wrocław, Łódź and Poznań. The available data do not allow for dynamic analysis across time, and so this study applies only to 2011 (the most recent data). In the future, this could change.

2 Theoretical background

The literature offers no unified definition of urban sprawl; instead, it is presented through the main features that can be applied to a specific urban area (Nelson & Duncan, 1995; Burchell, 1998; Ewing et al., 2002; Knapp, 2002; Wassmer, 2002; Bose, 2004; Neumann, 2005; Lisowski & Grochowski, 2009; Daneshopur & Shakibamanesh, 2011). Thus, the phenomenon of urban sprawl is described as the dispersion of a city's population to more suburban municipalities. Among the features of urban sprawl, the authors mention dispersion of buildings and low density. Urban sprawl is also associated with a sparse, chaotic form of housing and lack of spatial continuity. Very often, the lack of building continuity is referred to as a "leapfrog effect", which applies to housing estates on agricultural land that create a patchwork.

For many years, this phenomenon has been considered a negative one due to the macroeconomic and microeconomic costs it generates. These include an increase in public expenditures for building and maintaining infrastructure and public services, a commercially negative impact on the city centre, an increase in energy and fuel consumption, and a negative impact on household budgets (Real Estate Research Corporation, 1974; Jackson, 1985; Downs, 1994; Bank of America, 1995; Fulton et al., 2002; Gibson & Li, 2013; Shrestha, 2013). On the other hand, some recent studies conducted outside Europe conclude that large-scale urban sprawl can be potentially beneficial from an economic point of view. In many circumstances, decentralisation of a city could be beneficial in relation to maintaining stable and low communication costs, reducing overcrowding and business efficiency. In addition, decentralisation of the city

Table 1: Analysis of the correlation between regional GDP and tax revenues of municipalities (excluding cities with county rights), Poland.

Year	Lesser Poland		Lower Silesia		Łódź		Greater Poland	
	GDP*	PIT, AT*	GDP*	PIT, AT*	GDP*	PIT, AT*	GDP*	PIT, AT*
2000	56,338	402	58,552	422	45,520	322	69,726	493
2001	57,693	397	60,009	426	47,832	304	72,887	477
2002	60,782	375	63,293	410	50,446	303	74,094	479
2003	64,256	390	65,632	440	53,411	319	78,520	493
2004	69,979	510	71,231	571	57,982	412	87,540	660
2005	74,578	586	77,143	663	61,586	466	93,783	758
2006	82,229	661	86,568	752	66,287	520	100,350	861
2007	90,847	826	97,669	951	73,782	647	111,286	1,073
2008	98,621	986	104,254	1,104	79,593	759	120,217	1,252
2009	104,366	915	112,215	1,039	83,358	698	130,960	1,199
2010	109,096	928	122,539	1,023	88,202	699	135,124	1,184
2011	119,539	1,049	134,040	1,127	94,866	784	146,386	1,327
2012	123,832	1,142	138,298	1,250	98,819	855	154,153	1,448
	$r = 0.9820$		$r = 0.9655$		$r = 0.9764$		$r = 0.9797$	
	$p = 0.0000$		$p = 0.0000$		$p = 0.0000$		$p = 0.0000$	
The correlation coefficient for the four provinces together ($r = 0.9768$, $p = 0.000$)								

Note: *PLN million
Source: Own calculations based on Local Data Bank of the Central Statistical Office of Poland (2015).

could be beneficial considering the possible removal of jobs from the overcrowded and expensive CBD (Anas, 2012). The results of various authors presented in the literature may be inconsistent and misleading (Hall, 2001). Peter Hall (2001) points out that various studies assess the impact of urban sprawl with regard to only one parameter instead of taking a more comprehensive approach. There is a gap in the research on the impact of urban sprawl on the economy from a broader perspective; that is, not seen through the prism of individual indicators, but as a wider system. Deficiencies in assessing the impact of urban sprawl on the local economy are due not only to the complexity of urban sprawl, but also to lack of access to GDP ratios at the local level. Bearing this in mind, further discussion concerns ways of measuring these two issues: urban sprawl and the local economy.

Measuring urban sprawl is typically based on indicators of housing densities and residence (Sierra Club, 1998; Pendal, 1999; Fulton et al., 2001; Galster et al., 2001; Gleaser & Khan, 2001; Ewing et al., 2002; Knaap et al., 2005). However, the literature on urban sprawl points to additional significant measures that, in combination with density, may better depict this phenomenon. This suggests the need for a multi-criteria analysis to measure this phenomenon using measures that can present diverse features of urban sprawl. This approach to sprawl can be found in the work of Paul M. Torrens and Marina Alberti (2000), who propose an approach based on density, scatter, aesthetics, ecology and accessibility. Multi-criteria analysis is also suggested by Amnon Frankel and Maya Ashkenazi (2008) to measure sprawl from the perspective of the landscape, using an inventory of land use. According to Frankel and Ashkenazi (2008), sprawl can be measured by growth rates, density, spatial geometry, accessibility and aesthetic measures. Both approaches to measuring sprawl, although appealing, are characterised by high demands in terms of methodological skills and data availability. An interesting approach is presented by George Galster et al. (2001) on the possibility of measuring urban sprawl from the perspective of eight dimensions relating to land use. These are density, continuity, concentration, clustering, centrality, nuclearity, mixed uses and proximity. This method is used to assess the degree of urban sprawl in a given area, but does not serve to delimit the phenomenon. In their work, Galster et al. (2001) proposed a theoretical framework for measuring urban sprawl based on statistical indicators, demonstrating this approach in assessing the degree of urban sprawl in thirteen US metropolitan areas. This method therefore made it possible to present both the overall degree of urban sprawl and differences between the cities studied.

Economists assess the economy mostly through the prism of GDP. In Poland there is no aggregated GDP at the municipal level. The lowest level of aggregation of GDP is the province (Pol. *województwo*). GDP is also estimated at a level lower than the province (i.e., for sub-provinces, or a couple of counties). However, GDP for the provinces is based on primary data, whereas the sub-provinces' GDPs are divided into regional data. The lack of GDP at the municipal level

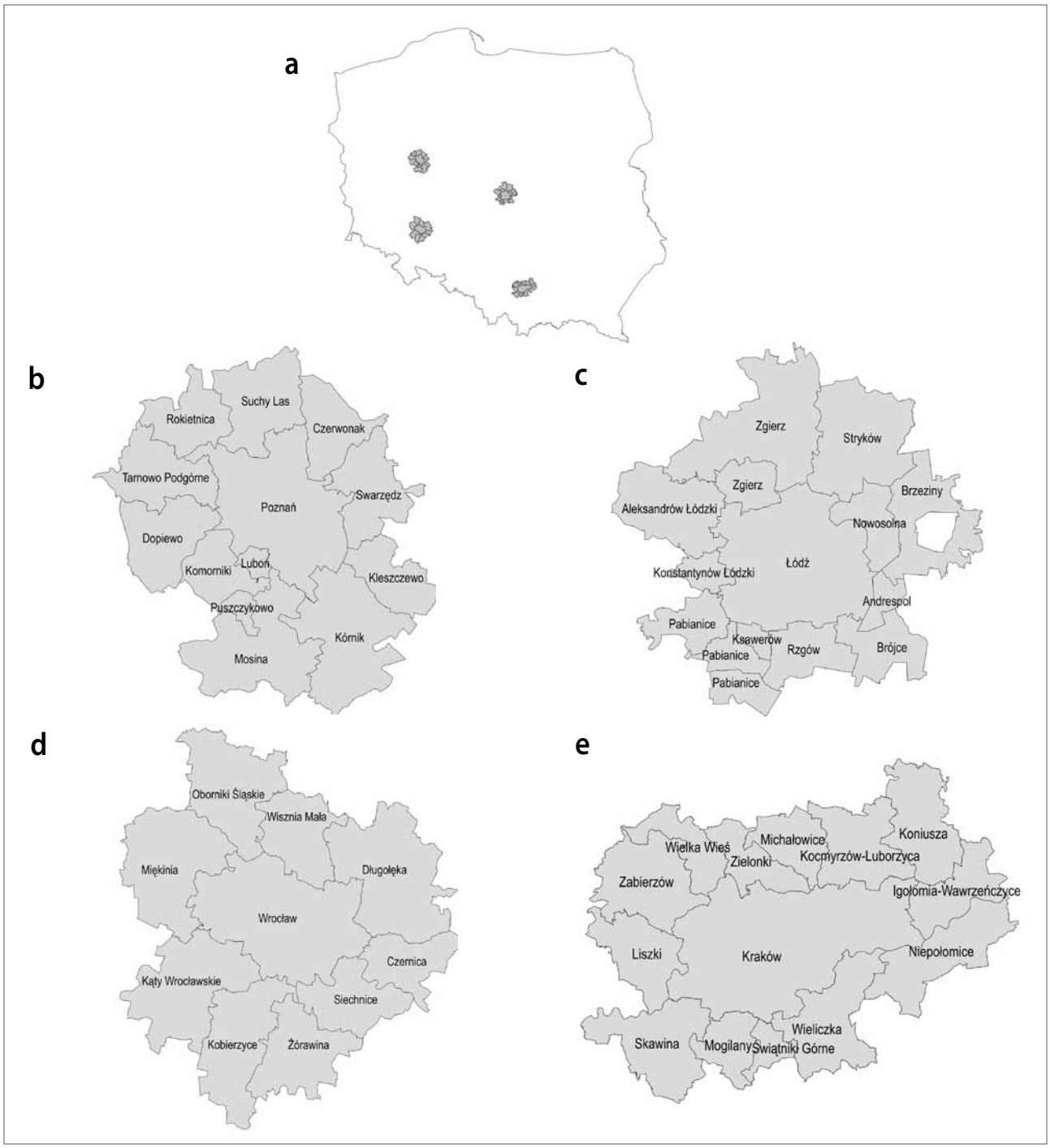

Figure 1: Study area: a) Poland with selected cities; b) Poznań with surrounding municipalities; c) Łódź with surrounding municipalities; d) Wrocław with surrounding municipalities; e) Kraków with surrounding municipalities (illustration: Piotr Lityński).

forces a substitution measure. In one Polish study, tax revenues of municipalities are used interchangeably (Zaucha et al., 2015). Jacek Zaucha et al. (2015) argue that taxes are associated with production in a territory. In this light, corporate income tax (CIT) would be the most appropriate measure. However, the complexity of the Polish tax system prevents such an approach for several reasons: a) taxes are paid at the place of the headquarters and not at the site of the product or service, b) the existence of tax exemptions (e.g., special economic zones) and c) the ability to cover losses from one year to the next tax year. In contrast, personal income tax (PIT) shows less interference, despite the fact that it has some shortcomings (e.g., payment of the tax at the place of registration and not the site of the product or service). In addition, Zaucha et al. (2015) propose adding the sum of PIT revenue and agricultural tax to revenues due to the fact that agricultural holdings do not pay PIT, but only agricultural tax (AT).

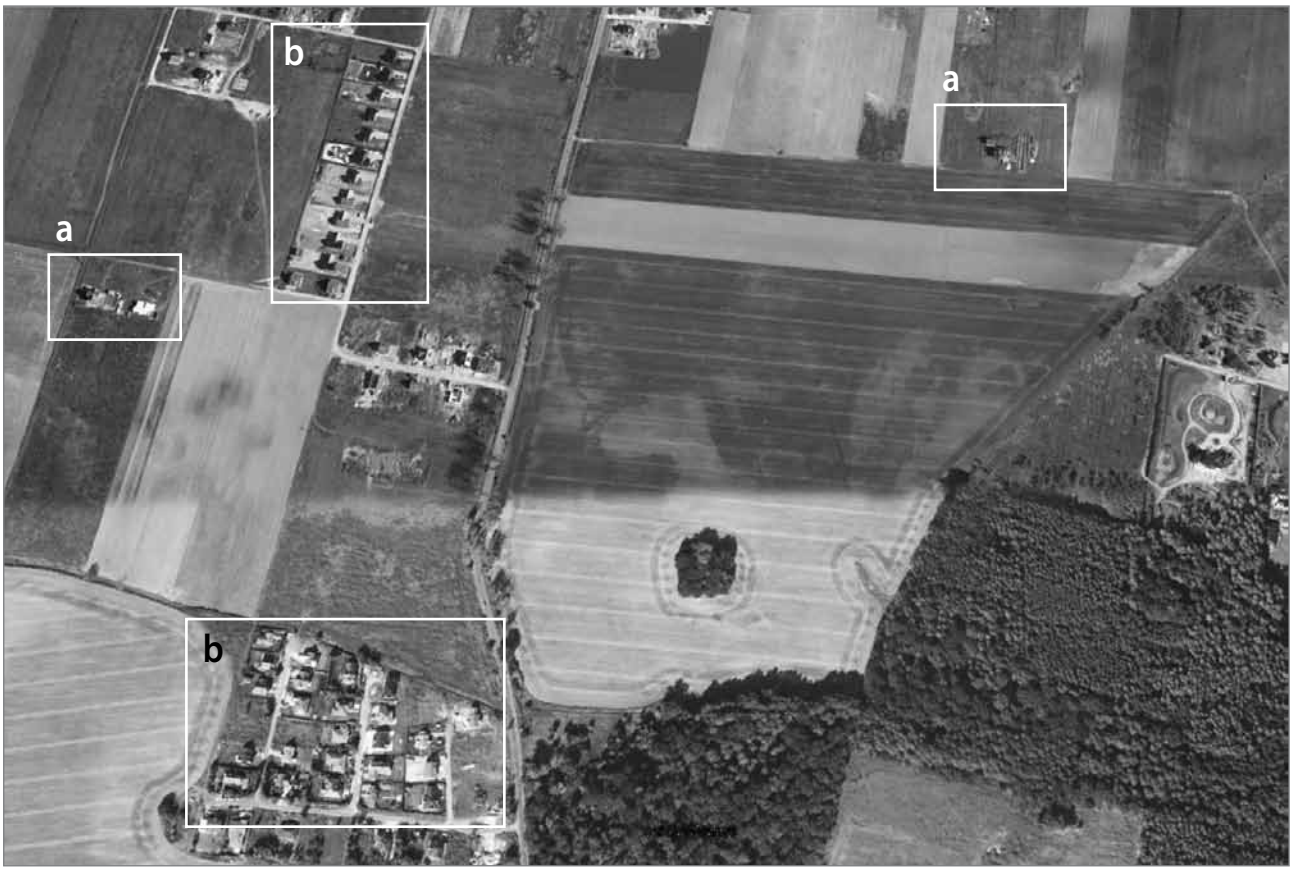

Figure 2: The Wrocław area as an example of chaotic spatial structure referring to the dimensions of urban sprawl: low centrality = residential houses far from the city (20 km away); a) low continuity "leapfrog"; b) low concentration = residential houses built on agricultural areas (source: Google Earth, 2011).

Using replacement revenue from PIT and agricultural tax instead of GDP also has statistical justification. The correlation coefficient between GDP at the regional level and these tax revenues for municipalities indicates a full correlation. The results of the analysis of the correlation between regional GDP and tax revenues are shown in Table 1. The analysis in Table 1 shows the provinces for the cities analysed in this article.

3 Methodology

This article applies an approach to evaluating sprawl proposed by Galster et al. (2001) modified to accommodate the availability of free data from the Local Data Bank of the Central Statistical Office of Poland and Google Earth. The assessment of urban sprawl refers to the following housing indicators: density, continuity, concentration, clustering and centrality. The study was conducted for the municipalities neighbouring four cities: Kraków, Wrocław, Łódź and Poznań. These cities are among the largest in the country after the capital, Warsaw. The spatial extent of the analysis is presented in Figure 1.

The method used in this paper assesses urban sprawl based on the following indicators: 1. density, 2. continuity, 3. concentration, 4. clustering and 5. centrality. Higher ratios indicate less urban sprawl:

1. Density is the number of housing units (single-family homes, apartments in multi-family buildings, etc.) per hectare of developable land. Developable land (DL) is an area that does not have natural features or barriers to housing development. In this study, DL is the difference between the total area of a municipality and the sum of the land covered by water, forest, recreation areas and roads, and land reserved for ecological uses.
2. Continuity is the degree to which the DL has been developed in an unbroken fashion. Research is conducted on the smallest possible spatial units: in this case, villages. For each village, the average housing density in its DL is determined. A certain village is considered developed if the density is greater than five housing units per hectare. The proportion of all of the villages that are this developed is a measure of continuity.
3. Concentration is the degree to which housing units are disproportionately located in a relatively small area rather than spread throughout the area. The analysis is conducted at the municipal level. A Delta Index was used to calculate this concentration; it is the share of housing units that

Table 2: Correlation analysis data: income tax, raw indicators/dimensions of Urban Sprawl, *Z*-score of Urban Sprawl Dimensions, Sprawl Composite Index (SCI), 2011.

Area	Municipality	Adjusted GDP	Urban Sprawl Dimensions					*Z*-score of Urban Sprawl Dimensions					SCI
			Dens.	Cont.	Conc.	Clust.	Centr.	Dens.	Cont.	Conc.	Clust.	Centr.	
Kraków	Igołomia	2,672,002	0.33	0.00	0.13	0.37	2.51	−1.17	−0.28	−0.71	0.12	−0.98	−3.02
	Kocmyrzów	7,995,981	0.50	0.00	0.22	0.57	4.08	−0.84	−0.28	0.39	1.15	0.33	0.75
	Liszki	8,449,830	0.69	0.00	0.15	0.36	4.65	−0.46	−0.28	−0.42	0.10	0.80	−0.26
	Michałowice	6,319,467	0.54	0.00	0.18	0.43	4.36	−0.77	−0.28	−0.13	0.43	0.56	−0.18
	Mogilany	11,367,548	0.99	0.00	0.36	0.56	3.82	0.12	−0.28	2.16	1.07	0.11	3.19
	Skawina	22,826,969	1.54	0.00	0.19	0.04	3.12	1.20	−0.28	0.00	−1.51	−0.47	−1.06
	Świątniki Górne	6,877,184	1.50	0.00	0.06	0.09	1.61	1.13	−0.28	−1.60	−1.24	−1.72	−3.72
	Wielka Wieś	9,220,544	0.60	0.00	0.10	0.29	4.15	−0.64	−0.28	−1.05	−0.27	0.39	−1.85
	Zabierzów	19,501,453	0.91	0.00	0.27	0.64	4.78	−0.04	−0.28	1.06	1.50	0.91	3.16
	Zielonki	19,740,027	1.23	0.00	0.25	0.52	6.02	0.60	−0.28	0.86	0.87	1.94	4.00
	Koniusza	3,389,684	0.33	0.00	0.11	0.34	2.92	−1.18	−0.28	−0.92	−0.03	−0.63	−3.04
	Niepołomnice	14,492,882	0.94	0.00	0.20	0.14	2.15	0.02	−0.28	0.19	−1.01	−1.27	−2.36
	Wieliczka	34,060,543	1.97	0.03	0.20	0.11	3.69	2.06	3.33	0.18	−1.18	0.00	4.39
Wrocław	Miękinia	8,676,812	0.29	0.00	0.24	0.55	5.07	−0.94	−0.33	−0.82	−0.35	0.18	−2.28
	Oborniki Śląskie	11,927,783	0.61	0.00	0.50	0.06	2.20	1.22	−0.33	0.58	−0.70	−2.00	−1.23
	Wisznia Mała	6,357,466	0.33	0.00	0.22	0.69	5.83	−0.66	−0.33	−0.91	−0.25	0.76	−1.40
	Czernica	8,821,713	0.61	0.00	0.23	0.59	4.26	1.19	−0.33	−0.85	−0.33	−0.44	−0.76
	Długołęka	18,765,808	0.40	0.02	0.74	4.65	4.39	−0.21	2.67	1.90	2.50	−0.34	6.52
	Kąty Wrocławskie	15,312,563	0.40	0.00	0.27	0.08	4.74	−0.24	−0.33	−0.65	−0.68	−0.07	−1.97
	Kobierzyce	21,040,032	0.38	0.00	0.45	1.77	6.84	−0.37	−0.33	0.32	0.49	1.52	1.64
	Siechnice	13,594,862	0.63	0.00	0.57	0.39	4.33	1.33	−0.33	0.99	−0.47	−0.38	1.14
	Żórawina	6,054,948	0.23	0.00	0.29	0.75	5.86	−1.33	−0.33	−0.55	−0.21	0.78	−1.66
Łódź	Andrespol	8,297,586	2.92	0.22	0.26	0.85	2.21	0.21	0.13	−0.11	1.08	−1.92	−0.61
	Brójce	2,856,592	0.27	0.00	0.23	0.49	3.75	−0.61	−0.47	−0.61	−0.30	−0.20	−2.18
	Nowosolna	6,827,454	0.35	0.00	0.23	0.69	4.12	−0.58	−0.47	−0.58	0.48	0.21	−0.95
	Rzgów	7,477,305	0.51	0.00	0.32	0.48	4.15	−0.54	−0.47	0.89	−0.32	0.25	−0.19
	Konstantynów Łódzki	10,336,980	2.83	0.00	0.24	0.59	4.54	0.18	−0.47	−0.35	0.09	0.68	0.14
	Pabianice	38,402,783	10.76	1.00	0.24	0.59	3.09	2.63	2.22	−0.35	0.09	−0.93	3.66
	Ksawerów	4,258,934	1.83	0.00	0.21	0.75	3.15	−0.13	−0.47	−0.87	0.70	−0.87	−1.63
	Pabianice	4,521,550	0.31	0.00	0.30	0.74	4.36	−0.60	−0.47	0.64	0.65	0.48	0.71
	Zgierz	33,075,301	7.31	1.00	0.24	0.59	5.03	1.56	2.22	−0.35	0.09	1.23	4.75
	Aleksandrów Łódzki	16,507,727	1.26	0.04	0.41	0.09	3.26	−0.30	−0.37	2.35	−1.77	−0.75	−0.83
	Stryków	5,815,305	0.31	0.00	0.20	0.05	4.07	−0.60	−0.47	−0.96	−1.93	0.16	−3.80
	Zgierz	6,921,363	0.33	0.00	0.34	0.98	5.65	−0.59	−0.47	1.26	1.57	1.92	3.69
	Brzeziny	2,188,116	0.17	0.00	0.21	0.45	3.70	−0.64	−0.47	−0.96	−0.44	−0.26	−2.76
Poznań	Luboń	21,592,379	8.69	1.00	0.43	1.61	3.63	2.85	3.13	−0.48	−0.29	−0.89	4.33
	Puszczykowo	12,906,121	4.22	0.00	0.74	3.41	1.70	1.01	−0.41	2.10	1.83	−2.21	2.32
	Czerwonak	20,303,830	1.73	0.08	0.56	2.94	6.37	−0.02	−0.11	0.85	1.55	0.98	3.25
	Dopiewo	19,082,988	0.60	0.00	0.43	1.34	5.12	−0.48	−0.41	0.19	−0.11	0.13	−0.67
	Kleszczewo	5,315,885	0.25	0.00	0.39	1.12	4.96	−0.63	−0.41	0.02	−0.33	0.02	−1.32
	Komorniki	17,600,794	1.07	0.00	0.38	0.89	4.81	−0.29	−0.41	−0.02	−0.57	−0.08	−1.37
	Kórnik	17,989,392	0.49	0.04	0.43	2.05	5.06	−0.53	−0.26	0.19	0.64	0.09	0.12
	Mosina	18,502,121	0.75	0.00	0.52	1.33	4.84	−0.42	−0.41	0.65	−0.12	−0.06	−0.36
	Rokietnica	9,471,848	0.47	0.00	0.33	0.84	3.88	−0.54	−0.41	−0.31	−0.63	−0.72	−2.59
	Suchy Las	19,829,090	0.65	0.14	0.56	2.94	6.29	−0.47	0.10	0.85	1.55	0.93	2.97
	Swarzędz	41,180,380	1.68	0.05	0.65	1.89	7.43	−0.04	−0.24	1.28	0.46	1.71	3.18
	Tarnowo Podgórne	30,027,843	0.71	0.06	0.41	1.95	5.05	−0.44	−0.18	0.12	0.53	0.09	0.11

Source: Own calculations based on Local Data Bank of the Central Statistical Office of Poland (2015).

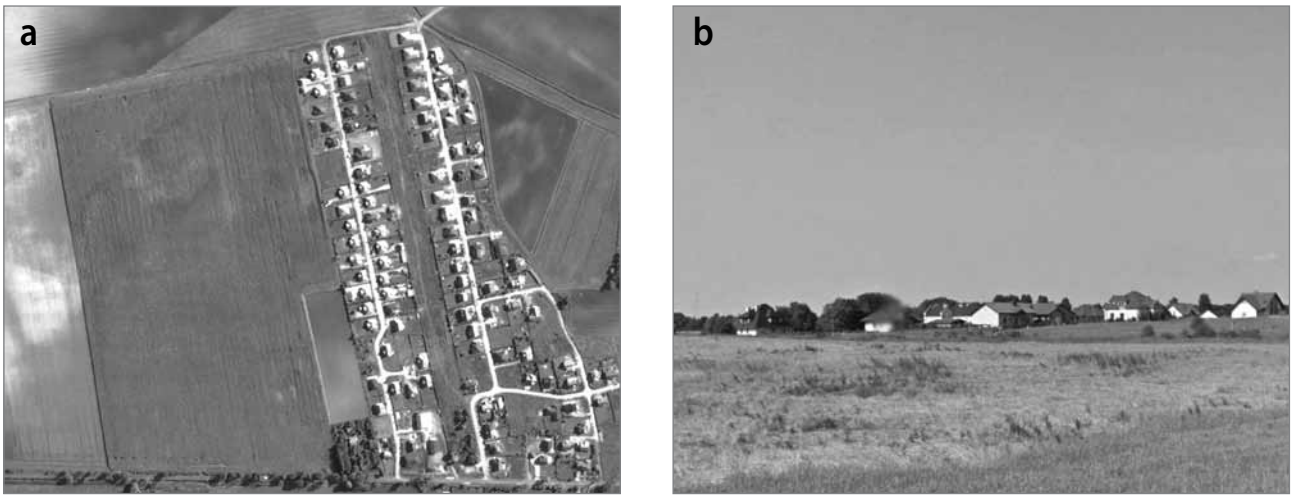

Figure 3: Urban sprawl in Poznań: a) spatial structure; b) street view (source: Google Earth, 2011).

Figure 4: Urban sprawl in Kraków (source: Google Earth, 2011).

would be needed to shift a municipality's unit of scale to achieve a uniform distribution across the entire study area (Massey & Denton, 1988; Galster et al., 2001).

4. Clustering is the degree to which development is tightly bunched to minimise the amount of land in each municipality's DL. The measurement is based on the standard deviations of density among villages, standardised by the average density of a municipality.
5. Centrality is the degree to which buildings are located in relation to the city centre. The measurement is based on a calculation of the inverse of the average sum of distance from the city centre to the village centre weighted by the number of housing units in the village, with the resulting average standardised by the square root of the DL.

The level of urban sprawl for each municipality can be calculated by summing up these dimensions included in the rates. To be able to add these indicators for each dimension of sprawl, a *z*-score was developed (the ratio of the difference between the indicator value and the average to the standard deviation). The lower the value of the *z*-score, the higher the degree of sprawl. Consequently the five *z*-scores for each city were summed to provide the Sprawl Composite Index (SCI). *Z*-scores are used only to obtain the SCI, but not used for correlation analysis. The research in the article relates to the estimate of correlations between tax revenues from PIT and agricultural tax, which represent the local GDP, and the SCI. The article also takes into consideration correlations between the various dimensions of urban sprawl (raw data of dimension,

Table 3: Results of the correlation analysis: Adjusted GDP vs. SCI, adjusted GDP vs. Urban Sprawl Dimensions

	The four areas together (n = 47)	Kraków (n = 13)	Wrocław (n = 9)	Łódź (n = 13)	Poznań (n = 12)
SCI	0.64 (p = 0.00)	0.68 (p = 0.01)	0.69 (p = 0.02)	0.72 (p = 0.00)	0.50 (p = 0.04)
Density	0.53 (p = 0.00)	0.82 (p = 0.00)	0.18 (p = 0.33)	0.94 (p = 0.00)	0.10 (p = 0.38)
Continuity	0.50 (p = 0.00)	0.71 (p = 0.00)	0.45 (p = 0.11)	0.94 (p = 0.00)	0.13 (p = 0.34)
Concentration	0.38 (p = 0.00)	0.41 (p = 0.08)	0.68 (p = 0.02)	0.08 (p = 0.40)	0.34 (p = 0.14)
Clustering	0.29 (p = 0.03)	–0.27 (p = 0.19)	0.55 (p = 0.06)	–0.06 (p = 0.42)	0.17 (p = 0.29)
Centrality	0.31 (p = 0.02)	0.26 (p = 0.19)	0.06 (p = 0.44)	–0.01 (p = 0.49)	0.58 (p = 0.02)

Figure 5: Spatial structure of urban sprawl in Łódź (source: Google Earth, 2011).

not z-score) and the local GDP. It calculates the Pearson correlation coefficient and its significance level. Given the above, it should be emphasised that the correlation analysis applies to the local GDP and the degree of urban sprawl. The correlation between the degree of urban sprawl and chaotic spatial structure is expressed by five indicators that were included in the SCI. The correlation between local GDP and the extent of urban sprawl was not analysed.

4 Results and discussion

Table 2 presents the data on which the correlation analysis is based. The column "Adjusted GDP" represents the local economy and is the aggregation of revenue to the budgets of municipalities with respect to PIT and agricultural tax. The columns under "Urban Sprawl Dimensions" include raw results of the evaluation indicators: density, continuity, concentration, clustering and centrality. The column "Z-score of Urban Sprawl Dimensions" collects these indicators processed in such a way that the Sprawl Composite Index can be constructed. The column "Sprawl Composite Index" (SCI) includes the sum of the degree of urban sprawl: the higher the index, the lower degree of sprawl. The summation of the degree of urban sprawl in the SCI is justified for the following reason: urban sprawl is a phenomenon with many aspects relating to spatial structure, which combines these dimensions, and excluding any of these from the analysis narrows the phenomenon. Correlation analysis was performed with respect to a) adjusted local GDP versus SCI and b) adjusted local GDP versus Urban Sprawl Dimensions (raw value). The results of the correlation analysis are presented in Table 3.

To interpret the results, it is necessary to note that in the correlation analysis greater SCI means less urban sprawl. Given the above assumptions and the results of the correlation, Table 3

shows that there is a significant relationship between the level of urban sprawl and the level of the local economy because the correlation coefficient is 0.64. The correlation coefficient's value is significantly different from zero at $p < 0.00$. Therefore it can be concluded with a significant probability that a smaller degree of urban sprawl is accompanied by higher levels of local economies. This means that municipalities with a similar number of houses and varying distribution in space may differ in terms of level of the local economy. Consequently, the more compactly the houses in a given municipality are built across its space, the higher the level of the local economy, regardless of the distance from the city.

The correlations between adjusted GDP and Urban Sprawl Dimensions are: density = 0.53, continuity = 0.50, concentration = 0.38, clustering = 0.29 and centrality = 0.31. The significance for the correlation coefficients is satisfactory. The results therefore offer interesting conclusions. None of the correlation coefficients are higher than the correlation between GDP and SCI. These results have a substantive justification. Urban sprawl is a complex phenomenon that cannot be the result of only low density, lack of concentration, decentralisation and so on because individual indicators point to a lower correlation between individual dimensions of sprawl and GDP. For example, there may be a situation where there is urban sprawl despite the lack of building clustering. Hence, urban sprawl should be recognised as an aggregate comprising several features.

The correlation of GDP with sprawl indicators shows that, if phenomena such as high density living, continuity of buildings (no leapfrogging), concentration and grouping of buildings, and the proximity to the city centre occur individually, then their intensity will be at moderate or low levels and will correlate with GDP. Only when all of these indicators or dimensions occur together does one deal with the phenomenon of anti-sprawl (e.g., compactness) and have to deal with higher levels of the local economy. These applications are essential for spatial policy, which has promoted anti-sprawl solutions that do not focus on only one indicator (e.g., density). Urban sprawl is a complex phenomenon, and so such monitoring should offer multidimensionality.

The analysis of the correlations between local economy levels and urban sprawl was broken down into four areas: Kraków, Wrocław, Łódź and Poznań. The significant value of the correlation coefficient (p) allows a cautious interpretation of SCI. High p values are likely to result from the low sample size (n). Thus in the municipalities neighbouring Łódź there is a strong correlation between the increase in urban sprawl and a lower level of the local economy because the correlation coefficient = 0.72 ($p < 0.01$). In the municipalities neighbouring Kraków or Wrocław such a relationship can be noted because the correlation coefficients are 0.68 ($p = 0.01$) and 0.69 ($p = 0.02$), respectively. A slightly lower level of correlation for the phenomena analysed is found for the municipalities surrounding Poznań. The correlation coefficient for this area is 0.50, which allows a connection to be assumed between the high degree of sprawl and low level of the economy in the municipalities.

5 Conclusion

The literature negatively assesses urban sprawl because of the costs it generates, such as increases in public expenditures for building and maintaining infrastructure and public services, a commercially negative impact on the city centre, an increase in energy and fuel consumption, and a negative impact on household budgets. However, many studies assess the impact of urban sprawl based on only one parameter or phenomenon instead of taking a more comprehensive approach. Thus, there is a gap in research on the impact of urban sprawl on the economy from a broader perspective: not seen through the prism of individual indicators, but as a wider system.

This article shows that greater urban sprawl is accompanied by lower GDP in municipalities, which proves the research hypothesis. Based on this model, it can be confirmed that there is a relation between urban sprawl and the local economy. However, urban sprawl has existed for a long time, and so two questions arise: Why was this problem not solved before? What is the difference between the past and future in resolving this issue? In Poland, the transformation of the spatial structure of suburban areas is much more evident now than it was in the past, due to the entry of a new factor: during the past two decades, a rising number of private building contractors have strongly pushed for the creation of a more dispersed metropolitan form and the law favoured those processes. As noted by Andrzej Lisowski et al. (2014), the profile of a new spatial order is beginning to emerge, and conflicts between two citizens' groups with opposite values are highlighted. Citizens with a significant stake in improving their individual quality of life (either through economic gain or through the benefits of residence in locations with better environmental quality) contrast with citizens that defend the principles of responsibility and sustainable development. On top of this, there has been a lack of research on the impact of sprawl in Polish metropolitan areas. Thus, Polish local governments have been reluctant to prevent sprawl, and they remain so. They see only positive impacts of sprawl through tax revenues from new households. The wider consequences of this development, such as growing expenditures on new infrastructure, tend to be difficult not only for the national economy, which is recognised by

the Polish government, but also for the local economy, which is not obvious to the local authorities and needs to be widely publicised.

The implications of this study are important for local authorities because houses should be built more compactly to attain a higher level of the local economy. Compactness is important because even municipalities with a similar number of houses, and at varying distribution in space, may differ in terms of the level of the local economy. The implications for losses for the local economy resulting from a chaotic spatial structure are real regardless of the distance from the city. Thus, it is not about distance, but structure. In this sense, the study contributes to knowledge about the costs of urban sprawl. This may be relevant to local government authorities and municipalities that are located near a large city and favour migration from the city, considering that population growth will increase tax revenues. This is only an apparent benefit. The costs of sprawl seem to be higher than the potential benefits. At the same time, municipalities are not always able to prevent this phenomenon. In this case, it is important to maintain a proper spatial policy that not only accurately diagnoses sprawl, but also offers proper solutions to limit its intensity.

The method for identifying urban sprawl used in this article is based on the approach by Galster et al. (2001). This method is valuable because it not only quantifies the level of this phenomenon, but also quantifies a number of attributes, such as density, continuity, concentration, clustering and centralisation. In addition to the article's most important conclusion – that increasing sprawl is accompanied by lower levels of the economy – it is important to recognise that urban sprawl is a multidimensional phenomenon and evaluating it through the prism of only one feature will prevent an assessment of its economic implications. This somewhat obvious observation should be reflected in spatial policies to prevent the phenomenon of urban sprawl. The point is that sprawl cannot be defined in documents only through the prism of low-density development, and anti-sprawl activities are only aimed at increasing housing density. Sprawl is a phenomenon that also comprises other manifestations that should be diagnosed, measured and monitored. This study has shown that there is a higher correlation with respect to urban sprawl as a complex phenomenon involving several features or indicators than for its individual dimensions – for example, housing density. If one looks at urban sprawl through only one indicator – for example, building decentralisation (correlation with GDP = 0.31) – then one could conclude that, because there is not a high correlation with this, urban sprawl therefore has no significant correlation with the economy. As demonstrated in this study, that is not true, and urban sprawl significantly correlates with the state of the local economy. Urban sprawl is a multidimensional phenomenon and should be evaluated through the prism of many of its manifestations. Such a multidimensional approach to urban sprawl was used in this article and it was demonstrated that there is a significant correlation between a high degree of urban sprawl and low GDP. Thus, from the perspective of spatial policies and the local economy, the method offered by Glaser et al. (2001) is useful for diagnosing urban sprawl and creating spatial plans.

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