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Dynamics of urban space

Abstract

This study analyzes urban areas which comprise an urban center and neighboring municipalities. As an administrative unit, a city is an organism full of internal and external connections, and it undergoes constant change at the micro and macro level. A city's internal structure is modified over time in response to changes in the local environment, and those changes often affect the surrounding territories. This article proposes a methodology for analyzing the dynamics of urban space in five Polish cities (Białystok, Kielce, Olsztyn, Toruń and Rzeszów) which were surveyed in 2002-2010.

The analysis was based on the assumption that dwellings constitute the largest part of a city, and that they are most susceptible to change. An observer examining the city from within will note that a critical level has been reached (an observer positioned in a rural area will report a decrease in the surface tension of the urban/rural boundary). In consequence, progressing residential development in areas adjacent to the city contributes to urban sprawl. In view of the above, a research hypothesis was proposed that residential area per capita is the most robust indicator of economic and spatial changes in an urban area.

Keywords: urban space, dynamics, residential area, spatial structure.
JEL Classification: J1.

Introduction – structure of urban space

Europe, including Poland, is characterized by significant diversity of urban areas, and the structure of dwellings changes over time and subject to demand. European cities face challenges of the 21st century such as globalization, economic restructuring, social changes and problems of social exclusion. Cities exert considerable pressure on suburban areas which are incorporated into the urban structure (Rząd 2005).

The diversity of urban structures and zoning requirements influence the directions of urban growth. The compact city is a popular urban design concept in Europe which promotes the preservation of the existing urban boundaries. Urban structures are carefully managed to prevent urban sprawl. Growth is concentrated in the urban center to encourage mixed land use in cities and create attractive and user-friendly environments for the local community. New and planned structures should blend into their surroundings. A state of equilibrium has to be maintained by introducing new planning standards to improve living conditions, reduce commuting time, lower energy consumption and improve urban economics (Bajwoluk 2008).

The expansion of development outside the administrative boundaries of a city is an opposite trend in urban planning. The suburban zone is closely bound to the urban center, and it is an attractive location for investors. Regardless of the existing planning concept, investors are increasingly likely to embark on development projects outside the urban center due to the ease of land acquisition, the availability of mixed land-use options and lower costs. Attractive locations and the proximity of nature encourage many people to buy and build their homes in suburban areas (Stachura 2012).

The dynamics and directions of urban growth have to be investigated in relation to both urban sprawl and inner-city development. Analyses of urban growth have to rely on certain paradigms. The growth process has to be closely correlated with living standards in the urban center. The concept of development is strongly linked with the quality of life, the residents' expectations and aspirations, their level of cultural and technological development and the fulfillment of their needs. The first group of developmental factors is related to the size of the urban area, the second category of factors is associated with demographics, and the third – with social and economic growth. Each group of factors has to be analyzed to identify current trends and phenomena in contemporary cities (Mironowicz 2010, pp. 120-127).

This study relies on the assumption that evaluations of urban growth dynamics should not rely solely on the size of the urban area. Changes in size are not directly correlated with the discussed concept of urban development. This observation can be illustrated with an example of two cities, Karachi (area of 3527 km^2, population of 21.2 million) and New York (area of 1213 km^2, population of 8.2 million), which clearly shows that social and economic growth is not directly linked with territorial expansion. It should, however, be noted that urban development does require space.

An analysis of urban demographics over time reveals characteristic developmental trends. It is a reflection upon historical events and long-term phenom-

ena that contribute to our understanding of the significance and background of growth processes (Chandler 1987).

Territory and population size are not direct indicators of urban growth. For this reason, other developmental factors, including social and economic growth, have to be considered. Mercer Human Resource Consulting conducts annual Quality of Living surveys based on detailed assessments of 39 criteria grouped in 10 key categories:

– political and social environment,
– economic environment,
– socio-cultural environment,
– medical and health considerations,
– schools and education,
– public services and transport,
– recreation,
– consumer goods,
– housing,
– natural environment.

The urban development process encompasses changes that affect many areas of life. Housing is a priority which supports the fulfillment of physiological needs, including shelter, sleep, consumption of meals and relaxation. Housing also satisfies the need for security: it protects an individual's privacy and creates a supportive environment for family life and social contact (Bartkowicz 2005, p. 10).

Residential area per capita is a robust indicator of living standards. It has been assumed that changes in this metric reflect changes in urban development. Evaluations of urban growth should not rely solely on **changes in the usable residential area per capita** because a steady drop in the urban population will increase residential area per inhabitant. The above is not indicative of an improvement in living standards. The reverse applies – a progressing decrease in living standards prompts local residents to migrate from the urban center and abandon residential property. The **urban population** has to be analyzed in conjunction with **total residential area** in the city to avoid interpretational errors.

1. Analytical methods in studies of urban dynamics

Indicators for monitoring urban dynamics were used to evaluate the rate of changes in dependent variables over time. In statistics, an indicator is a metric or a measure which characterizes a dependent variable in time or space, where an independent variable represents time. Indices are characteristic metrics of urban

dynamics, and they are popularly used in surveys of social and economic well-being (Timofiejuk 2006). Indices are relative measures which can be applied in analyses of irregular changes. The discussed metrics are intuitive and comparable regardless of the type of the evaluated process and its magnitude (Okólski, Timofiejuk 1983, pp. 26-27).

The first step in the analysis involved the calculation of a series of chain indices. The term preceding the analyzed term was adopted as the base unit in a time series.

$$X_{\frac{1}{0}} = \frac{X_1}{X_0}; \ X_{\frac{2}{1}} = \frac{X_2}{X_1}; \ \dots \dots; \ X_{\frac{n}{n-1}} = \frac{X_n}{X_{n-1}}$$

In successive stages, the dynamics (changes in indicator) of the examined variables was analyzed in a time interval, where the base period of time was the first year of observations (series of fixed base indices). It has been assumed that in the first year of the study (2002), the analyzed phenomena (population, residential area per capita, total residential area) have the value of one, and in successive years of the analysis, the value of the indicator will be a product of a dimensionless quantity in a given year and the change indicator.

Table 1. Algorithm for the determination of change dynamics

	Year 1	Year 2	Year 3	……	Year 11
Observed value	X_1	X_2	X_3		X_{11}
Series of chain indices		$X_{2/1} = \frac{X_2}{X_1}$	$X_{3/2} = \frac{X_3}{X_2}$	……	$X_{11/10} = \frac{X_{11}}{X_{10}}$
Change dynamics from the value of 1	1	$1 * X_{2/1}$	$1 * X_{2/1} * X_{3/2}$	……	$1 * X_{2/1} * X_{3/2} * \dots * X_{11/10}$

Table 2. Dynamics of changes in residential area per capita in the city of Olsztyn

	Year								
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Residential area per capita	20.3	20.8	21.2	21.5	22.0	22.4	23.0	23.3	23.8
Series of chain indices	----	1.025	1.019	1.014	1.023	1.018	1.027	1.013	1.021
Change dynamics from 2002	1	1.025	1.044	1.059	1.084	1.103	1.133	1.148	1.172

2. Surveyed urban areas

This study analyzed five urban areas of Olsztyn, Bielsko-Biała, Kielce, Rzeszów and Toruń (the geographical location of the surveyed cities is shown in

Fig. 1). The studied areas comprise the territory situated within the cities' administrative boundaries and the neighboring municipalities. The surveyed objects were characterized by similar area, population and residential area (Table 3).

Figure 1. Geographic location of the surveyed areas

Table 3. Specification of the surveyed cities – data for 2002

City	Administrative area [km²]	Residential area [m²]	Population	Residential area per capita [m²/person]
Olsztyn	88	3 501 080	172 177	20.3
Bielsko-Biała	125	3 912 370	177 835	22.0
Kielce	109	4 193 838	211 810	19.8
Rzeszów	54*	3 179 841	159 791	19.9
Toruń	116	4 235 110	210 702	20.1

* In 2011, the city's area increased to 116 km² following the incorporation of neighboring territories.

Figure 2. Residential area in the surveyed cities
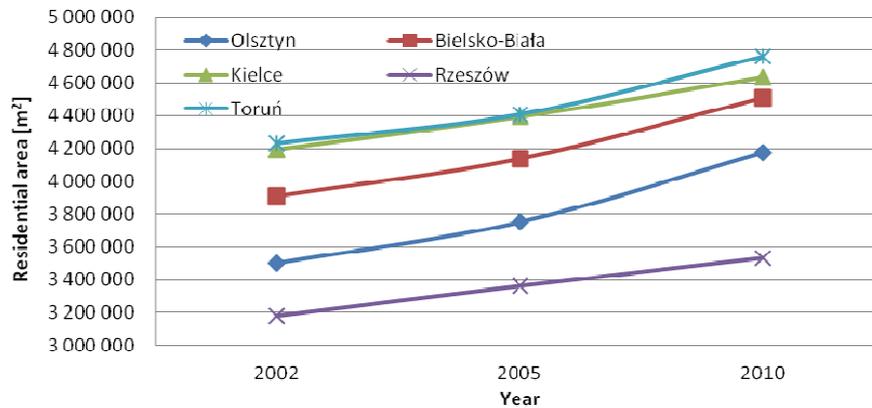
Olsztyn is the administrative capital of the Region of Warmia and Mazury. It is situated in the central part of the region, and it has a population of 175 420 (Central Statistical Office 2011). As an urban county, Olsztyn does not have administrative boundaries, and it comprises 22 residential estates. Olsztyn has the area of 87.9 km^2, and the predominant forms of land use include developed and urban land (39%), forests and woodlands (25%). The city does not have a ring road, which significantly increases traffic intensity in downtown and peripheral areas. This study analyzed the administrative area of Olsztyn and six neighboring munici-palities (Dywity, Barczewo, Purda, Stawiguda, Gietrzwałd, Jonkowo).

Bielsko-Biała is a city with county status in the Region of Silesia. It was the capital of Bielsko-Biała region until 1998, and it is presently the capital of Bielsko-Biała county. In 2011, the city had the population of 174 503 (Central Statistical Office). It has the area of 125 km^2, and it incorporates 30 residential estates. Bielsko-Biała is one of the most highly developed areas in Poland with low unemployment. Bielsko-Biała has a well-developed transport infrastructure. It is intersected by major roads, including expressway S1, European route E75, national road No. 1 and route E462 connecting the city with the Upper Silesian urban area. The Western Urban Ring Road connects the urban center with expressway S1. This study analyzed the administrative area of Bielsko-Biała with ten neigh-boring municipalities (Szczyrk, Bestwina, Czechowice-Dziedzice, Jasienica, Jaworze, Kozy, Wilamowice, Wilkowice, Brenna, Czernichów).

Kielce is the capital of the Świętokrzyskie Region and the seat of county authorities. It has the population of 201 814, and it is the center of the Kielce Metropolitan Area. The city has not been divided into administrative districts, and it features 55 area units which occupy the total area of 109.45 km^2. Kielce is a major transportation hub which is intersected by international roads S7 and S74 and national road No. 73. The city features a railway junction converging

routes to Warsaw, Krakow and Częstochowa. This study analyzed the adminis-
trative area of Kielce with seven neighboring municipalities (Daleszyce, Górno,
Masłów, Miedziana Góra, Morawica, Piekoszów, Sitkówka-Nowiny).

Rzeszów is the capital of the Region of Podkarpacie and the rural county of
Rzeszów. Situated in south-eastern Poland, the city has the population of 182 232
(Central Statistical Office 2011). In recent years, neighboring areas have been grad-
ually incorporated into the urban structure, and Rzeszów's area was expanded from
53.69 km^2 in 2006 to 116.37 km^2 in 2011. Rzeszów is intersected by the planned A4
motorway (Dresden–Kiev) and expressway S19 (Suwałki–Barwinek). This study
analyzed the administrative area of Rzeszów with six neighboring municipalities
(Boguchwała, Chmielnik, Krasne, Świlcza, Trzebownisko, Tyczyn).

Toruń, a city with county status, is the capital of the Kujawsko-Pomorskie
Region and Toruń county. It has the area of 115.75 km^2 which is divided into 24
administrative districts. In 2011, Toruń had the population of 204 921 (Central
Statistical Office 2011). The city is intersected by rivers Vistula and Drwęca,
motorway A1, expressway S10 and national roads No. 10, 15, 80 and 91. This
study analyzed the administrative area of Toruń with four neighboring munici-
palities (Lubicz, Łysomice, Wielka Nieszawka, Zławieś Wielka).

3. Results

In the first stage of the study, the dynamics of changes in population (Fig. 3),
residential area (Fig. 4) and residential area per capita (Fig. 5) were compared in
the surveyed cities (within the administrative boundaries).

Figure 3. Population dynamics
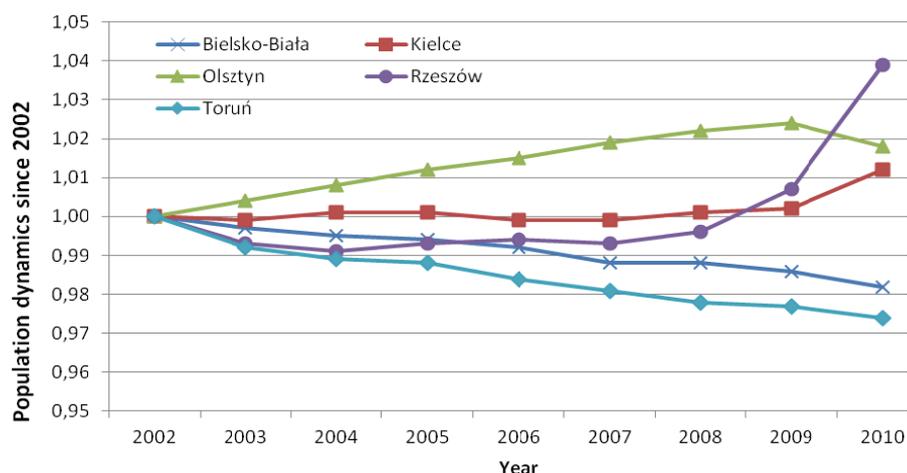
In the analyzed period (2002-2010), the most rapid increase in population (around 5%) was observed in Rzeszów in 2008-2010. The previous period (2002-2008) was marked by stagnant population growth and a 1% population decline in selected years. More stable population trends were noted in the remaining cities. Olsztyn's population increased steadily between 2002 and 2009, and a 1% decrease in the local population was observed in 2010. Kielce's population remained relatively stable, and an increase of 1% was reported in 2010. Bielsko-Biała and Toruń were characterized by a steady population decline which reached 2.5% in Toruń.

An in-depth evaluation of population changes in the surveyed cities (Fig. 3) requires an analysis of changes in local residential area (Fig. 4).

Figure 4. Dynamics of changes in residential area per capita
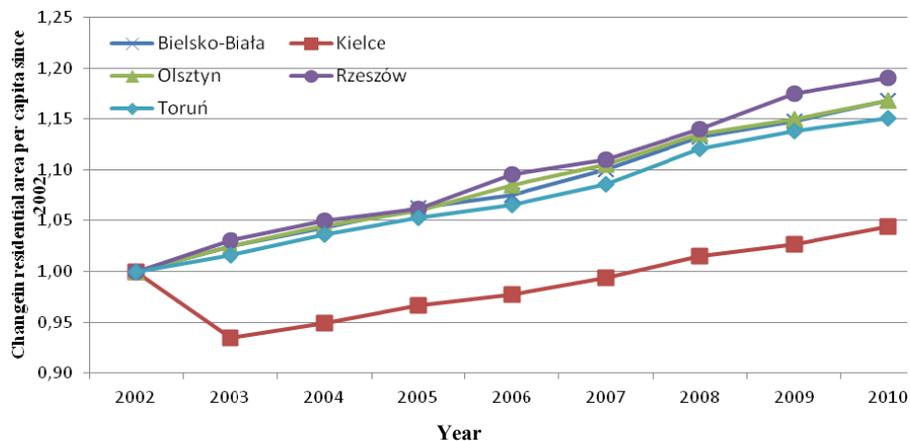
In 2002-2010, total residential area increased in the majority of the surveyed cities (Olsztyn, Bielsko-Biała, Rzeszów, Toruń) by more than 15% regardless of the noted demographic trends. An estimated 5% increase in total residential area was observed in Kielce. The above results indicate that demographic trends are not directly correlated with urban development if the analysis covers only the area within a city's administrative boundaries.

Our findings prompt the search for factors which contribute to an increase in residential area despite a drop in population. The following question arises: what factors or metrics would be indicative of urban growth or urban decay?
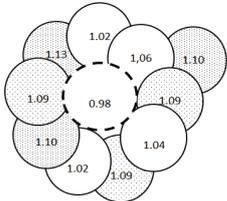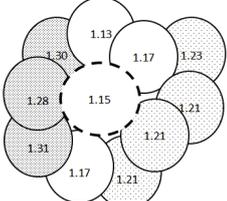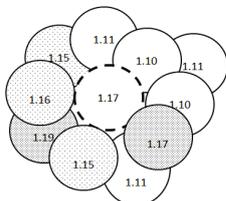
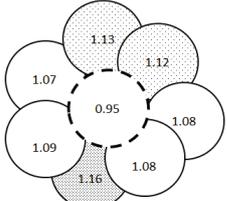**Figure 5.** Dynamics of changes in residential area
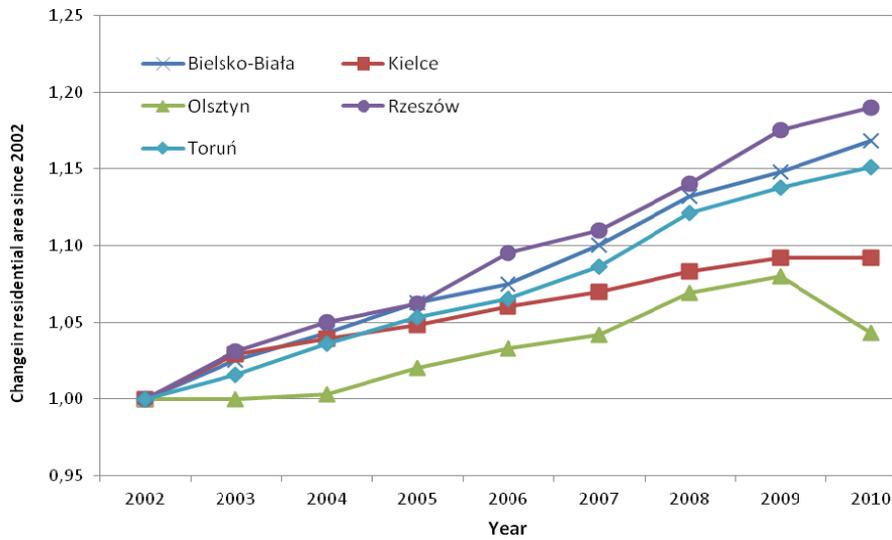
The dynamics of changes in residential area per capita are shown in Fig. 5. In 2002-2010, a significant increase in residential area per capita was noted in all of the analyzed cities. Reliable conclusions about the d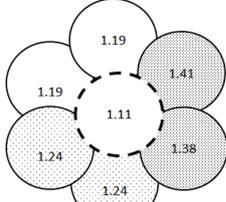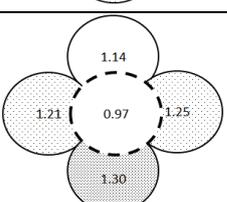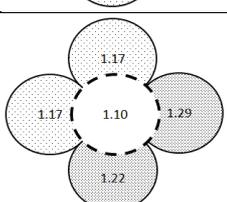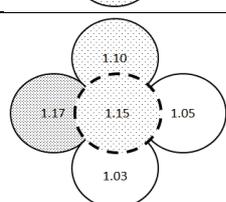irections and dynamics of urban growth cannot be formulated based only on the above data because an increase in residential area per capita can also result from a population decline, as it is the case in Bielsko-Biała and Toruń.

A city's administrative area does not support a reliable evaluation of urban dynamics because administrative boundaries do not constitute physical barriers that obstruct the construction of residential and commercial property. Urban development can be effectively regulated through legal measures. The dynamics of changes in urban areas, comprising the urban center and the neighboring municipalities, are presented in Table 4. Every circle represents an administrative unit, and the circle in the center marked with a dashed line represents the administrative area of the city.

Table 4. Series of chain indices (dynamics) where 2002 is the base unit. The respective calculations were performed for 2010 data

City	Population	Residential area	Residential area per capita
1	2	3	4
Olsztyn			

Table 4 cont.

1	2	3	4
Bielsko-Biała	1.02, 1.13, 1,06, 1.10, 1.09, 0.98, 1.09, 1.10, 1.04, 1.02, 1.09	1.13, 1.30, 1.17, 1.23, 1.28, 1.15, 1.21, 1.31, 1.21, 1.17, 1.21	1.11, 1.15, 1.10, 1.11, 1.16, 1.17, 1.10, 1.19, 1.17, 1.15, 1.11
Kielce	1.13, 1.12, 1.07, 0.95, 1.08, 1.09, 1.08, 1.16	1.32, 1.22, 1.18, 1.10, 1.14, 1.23, 1.16, 1.30	1.16, 1.09, 1.10, 1.15, 1.05, 1.13, 1.07, 1.11
Rzeszów	1.09, 1.09, 1.10, 1.01, 1.13, 1.02, 1.09	1.19, 1.41, 1.19, 1.11, 1.38, 1.24, 1.24	1.19, 1.41, 1.19, 1.11, 1.38, 1.24, 1.24
Toruń	1.14, 1.21, 0.97, 1.25, 1.30	1.17, 1.17, 1.10, 1.29, 1.22	1.10, 1.17, 1.15, 1.05, 1.03
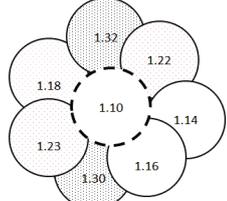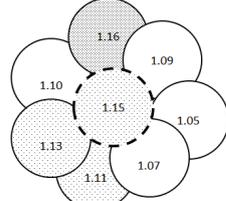
Conclusions

In the surveyed areas, a population drop or population stabilization can be attributed to changes in the structure of urban areas which comprise the urban center and the neighboring municipalities. The above conclusion is justified by a significant increase in the population and residential area in neighboring municipalities. The most dynamic changes in urban space were observed in Olsztyn in 2002-2010 when total residential area increased by more than 50% in three neighboring municipalities and by only 20% in the urban center. The lowest dynamics of changes in residential space were noted in Toruń. The highest increase in residential area (29%) was observed in a municipality which borders the city in the east, whereas the growth in the urban center was estimated at only

10%. Table 4 indicates that a greater increase in residential space was observed in urban areas which are not characterized by a negative growth rate (Olsztyn, Rzeszów). Analyses of the dynamics of urban space in areas comprising an urban center and neighboring municipalities reveal the predominant directions of change in the spatial structure. The results presented in Table 4 do not support conclusive observations regarding the symmetricity of changes in urban areas.

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