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Metropolitan Urban Sprawl and Mobility: Core City Estimation of Financial Losses due to Commuting

Abstract: The subject of the article situates the research in the field of the costs of uncontrolled suburbanisation. The purpose of the article is an attempt to estimate the losses from commuting residents to a workplace in the core city. The calculations were carried out for the Cracow Metropolitan Area, Poland. It was pointed out that social losses from commuting to work are high and exceed PLN 400 million annually. These losses are a consequence of a non-functional road system being a derivative of the chaotic spatial structure caused by urban sprawl.

Keywords: space, mobility, metropolitan area, costs, commuting to work, road network

Introduction

The phenomenon of chaotic suburbanisation in Polish metropolises is a fact confirmed both in scientific research and strategic documents of public entities. Negative consequences of urban sprawl affect the functioning of entities in space, and further have an impact on the economy. The disorder of the spatial structure limits the possibilities of internal transport accessibility of the metropolitan area, which is a factor of socio-economic and spatial development. It should be noted that internal transport accessibility affects productivity, employment, the vitality of an area, the quality of life and overall well-being. In Polish research, not many papers are devoted to the calculation of financial losses due to urban sprawl. Some attempts of estimates are made, but often conclusions are based on foreign surveys. Therefore, the purpose of the article is to attempt to assess losses caused by metropolitan car commuting to work in the core city. The territorial scope is the external zone of the Cracow Metropolitan Area (CMA), Poland. The issue of the article concerns the influence of geometry and extent of space on travel costs, and is part of the trend of research into the costs of uncontrolled suburbanisation in Poland.

Literature Review

The phenomenon of urban sprawl is related to the process of decentralization on population in the city in favor of a larger number of suburban municipalities (Arribas-Bel et al. 2011, Perrisky, Wiewel 2012). Among the most important features of the phenomenon are: the chaotic dispersion of buildings, low rates of residence density, lack of spatial continuity in buildings, dependence of society and the economy on car transport. From the middle of the last century, negative consequences of the phenomenon, including economic costs, began to be exposed in Western literature. The most frequent indicated consequence was the increase in public expenditure on infrastructure and public services; inefficiency of energy and fuel consumption; negative impact on the budget of households; negative market impact on the city center (Frenkel, Ashkenazi 2008, Brueckner, Largey 2008, Daneshpur, Shakibamanesh 2011, Organisation for Economic Co-operation and Development 2012). In Poland, the phenomenon of sprawl is also perceived and generally evaluated negatively (Lisowski, Grochowski 2007). It should be noted, however, that in Polish literature the assessments regarding the phenomenon are formulated on the basis of foreign research – mainly American. Only a few studies attempt to estimate the costs of uncontrolled suburbanisation. Kowalewski and others (2013) admit that some of the costs are able to be counted in Polish conditions, but some can only be estimated based on foreign research.

Urban sprawl resulting in spatial separation of various types of places (residence, work, services, etc.) limits their transport accessibility and determines not only the quality of life but also economic development (Gibbons et al. 2012). Therefore, one of the more widely recognized spatial dysfunctions in metropolitan areas is limited transport accessibility, which affects the lengthening of travel times (Śleszyński 2017, Lityński, Hołuj 2017, Metz 2008, van Ommeren et al. 1999). The causes of the phenomenon may be many, often co-occurring in space, for example: a growing population in the outer zone of a metropolitan city, the need to move metropolitan residents for various purposes, an anachronistic road system, etc.

Spatial accessibility is one of the most important research issues of the metropolis's impact. Śleszyński (2017) indicates that the analyzes are most often focused on temporal availability, and to a lesser extent on the cost side. The cost dimension is, however, an up-to-date research topic in Western countries (Ford et al. 2015, El-Genaidy et al. 2016, Mouter, Chorus 2016, Ojeda-Cabral, Chorus 2016). The research challenge in Poland is in determining the financial consequences of spontaneous suburbanization processes, including mainly transport service costs (Kowalewski et al. 2014). In relation to urban sprawl vs. costs, one of the basic features of space which should be noted, is resistance. From the economic point of view, overcoming the resistance of space requires the involvement of financial outlays. It is not a problem necessary financial expenditures to overcome it, but rather above-average costs or losses being the difference between the necessary and additional expenses. Therefore, the loss due to urban sprawl can

be determined by a way of a space structure, that will impose additional costs on its users, than if it was organized in an optimal way. In foreign economic studies on losses related to pathological spatial structures in metropolitan areas (eg urban sprawl), it is specified that over-normative costs should be defined as: losses, net costs or marginal costs (Gordon, Richardson 1996, Mills 1999, Brueckner 2000; Wassmer 2002).

In addition, it should be noted that financial estimates play an important role in the decision-making process both in the areas of settlements' deconcentrating as well as in depopulation areas (Śleszyński 2017). Hence, in Polish economic and geographic studies, there are still issues that need to be developed, also from the methodological side. Therefore, research approaches in the scope of economic accessibility of cities in cost aspects are just beginning to be formulated, eg the publication Śleszyński (2017) examining the economic accessibility of voivodship cities in the light of the costs of commuting by car.

From the point of view of the subject, it is also important to emphasize terminological differences in terms of accessibility and mobility. Accessibility is a chance to take advantage of certain functions or a chance of spatial interaction. Mobility, on the other hand, is an actual moving in space in order to achieve a specific goal (Guzik 2016). Thus, while the accessibility costs will indicate potential expenses related to mobility, the costs of mobility reflect the actual expenditure incurred.

Method

In the presented study it was assumed that the research area – the Cracow Metropolitan Area (CMA), urban sprawl is present. The basic characteristics of CMA are shown in Fig. 1.

There are separate studies confirming the phenomenon in this area (Hołuj, Lityński 2016). The methodological proposal will therefore refer to transport mobility and will take into account both direct losses and time lost values. At the same time, losses will be understood as additional expenditures that would not exist under ideal conditions; and will be expressed in monetary values (current gross prices). In addition, the losses will be calculated for car commuting and returning from work to Cracow City from all communes of CMA.

Estimating the financial losses of transport mobility includes car commuting to work and returning from the communes of the metropolitan area to Cracow. For this purpose, the Central Statistical Office (CSO) statistics on commuting to work were used (CSO 2014). This value was referred to the estimated loss in the distance [km] generated by the spatial structure of the metropolitan area. As a loss the difference between the real distance between a commune and Cracow along the roads using Google Maps was adapted (function: car – distance) and the perfect distance. The perfect distance was defined as the distance in a straight line, avoiding significant spatial barriers (eg: lakes, national parks, airport, etc.). The presentation of losses in commuting in monetary terms required

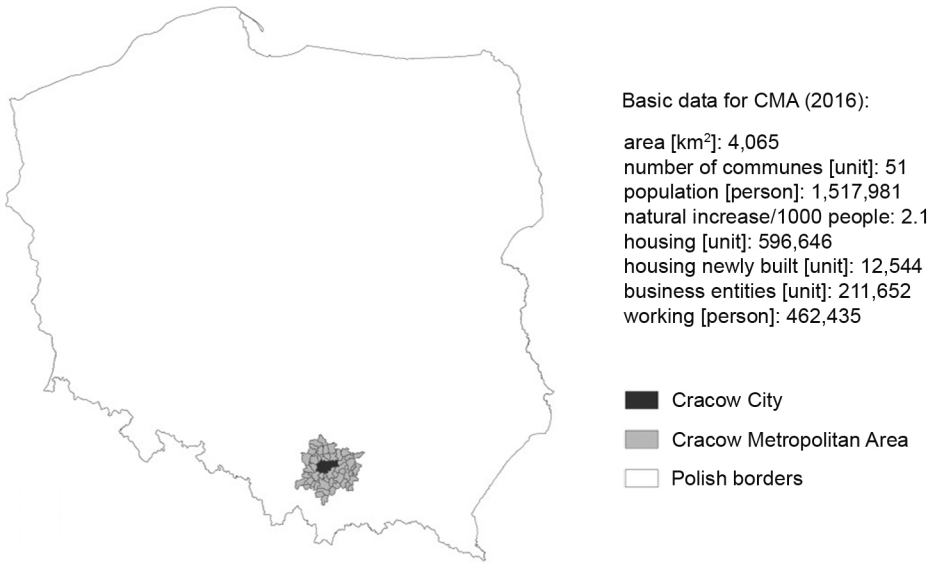


Fig. 1. Basic CMA characteristics
Source: own based on CSO.

the adoption of a specific financial multiplier, which would take into account the car amortization (fuel, tires, oil, brakes etc.). Therefore, for the estimates The Regulation of the Minister of Transport on the Reimbursement of the Costs of Using Personal Cars for Business Purposes (2007) was used, which sets the amortization rate for a vehicle with an engine capacity of over 900 cm³ at the level of 0.8358 PLN/km (PLN it's a code of International Organization for Standardization for polish currency). This amount should cover the car's amortization along with the fuel costs.

The financial loss was expressed by the formula:

$$FL_i = 2 \times \sum_{i=1}^n D_{ij} [(AD_{ij} - PD_{ij}) \times A_m \times R_t]$$

where:

- FL_i – financial losses in commuting (and returns) to the i -th commune from all other communes of the metropolitan area in PLN,
- D_{ij} – number of people commuting to work to the i -th commune from j -th commune,
- AD_{ij} – actual distance (streets) between the i -th and j -th commune in km,
- PD_{ij} – perfect distance (in a straight line, bypassing barriers) between the i -th and j -th commune in km,
- A_m – amortization rate for a vehicle with an engine capacity of 900 cm³ = 0.8358 PLN/km,

- R_t – number of working days in t-this year,
- n – the number of communes in the metropolitan area.

The value of the time lost includes: the number of commuters roundtrip to/from Cracow (CSO 2014). In the case of this calculation losses are expressed in units of time (min). The difference between the real time of car travel during the peak hours (7:30–8:45 and 16:30–18:00 based on: Hołuj, Frączek 2015) using Google Maps (function: car-time) and a perfect trip time was treated as a loss. The perfect trip time is the time needed to overcome the distance between communes in a straight line, avoiding significant spatial barriers with an average speed of 50 km/h. As a financial multiplier CSO statistics were used to calculate the average hourly gross wage. The adopted time equivalent has the argumentation in the potential over time salary that is hypothetically possible to replace the time lost.

The value of the time lost is given by:

$$VL_i = 2 \times \sum_{i=1}^n D_{ij} [(TT_{ij} - PT_{ij}) \times W_i \times R_t]$$

where:

- VL_i – value of time lost due to travel (and return) to work to i-th commune from all other communes of the metropolis in PLN,
- TT_{ij} – travel time by roads between the i-th commune and j-th commune in the peak hours in min.,
- PT_{ij} – time of perfect trip, in a line with the speed of 50 km/h, between the i-th and j-th commune in min.,
- W_i – the average hourly gross wage in the county in which the i-th commune is located in PLN.

Results

Table 1 presents the results and statistical measures of annual losses of CMA commuters travelling for work to Cracow. Moreover, fig. 2–4 show the losses of communes' residents commuting to work in the core city. The basic meaning in figures have global losses, while as a supplement there are figures showing the conversion per 1 commuter.

The losses of CMA residents in commuting to work in Cracow exceeds 401 million PLN annually, 31% of which are financial losses, and the value of the time lost reaches 67%.

Directly incurred losses for commuting to work to Cracow (Fig. 2) exceed 126 PLN million in total annually. The highest losses can be attributed to the road connections of Cracow with Wieliczka and Skawina. The value of losses amounts to 10.0 million PLN and 9.6 million PLN, respectively. But also the residents of other communes, those located south of Cracow, suffer significant losses, for example, Myślenice (PLN 7.9 million) and Gdów (PLN 7.7 million)

Table 1. Statistical measures describing the annual losses of CMA residents due to commuting to work in Cracow in million PLN

Basic statistical measures	Financial losses in commuting to work to Cracow [FL]	The value of the time lost in commuting to work to Cracow [VL]	Total financial losses and value of time lost [FL + VL]
Total	126.30	274.86	401.16
Average	2.53	5.50	8.03
Min	0.27	0.41	1.16
Max	9.97	31.71	41.68
Q1	1.03	1.32	2.62
Q2 (median)	2.20	2.56	5.00
Q3	2.96	7.54	10.55

Source: own.

Analysing the value of time lost (Fig. 3), more than twice as high values are noticed (by 118%) than in the case of directly incurred losses. Such a difference indicates the phenomenon of a large congestion, and because it concerns the communes adjacent to Cracow in practice manifests itself in “traffic jams” at the entrance to the core city. The total of the lost time in travelling to work per year in Cracow reaches PLN 275 million. The largest losses are attributed to communes: Wieliczka (PLN 31.7 million) and Skawina (PLN 22.8 million).

Adding the losses incurred directly and the value of time lost, the annual total loss of the external zone of CMA in terms of commuting for work to Cracow (Fig. 4), as mentioned, may exceed 401 million PLN. The largest losses are noticeable from the southern part of Cracow, ie Wieliczka (PLN 41.7 million) and Skawina (PLN 32.4 million). Therefore, this area from the point of view of the

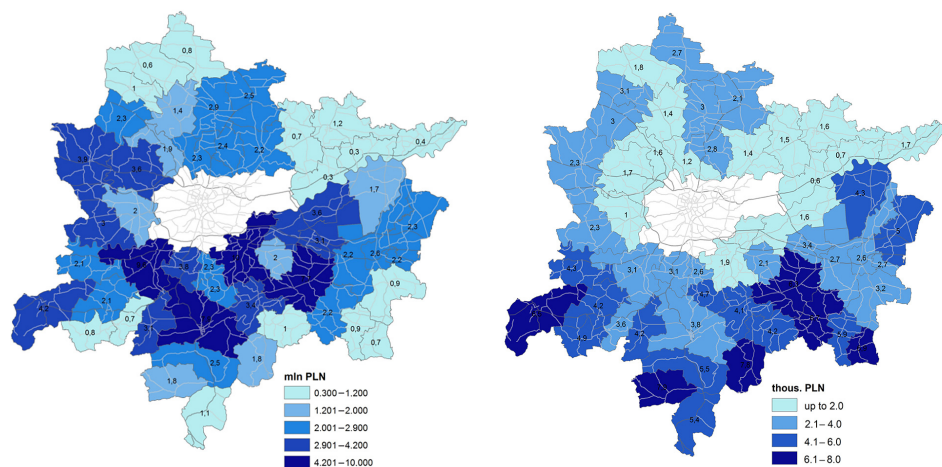


Fig. 2. Financial losses in commuting to work to Cracow from communes of CMA annually [FL]

Source: own.

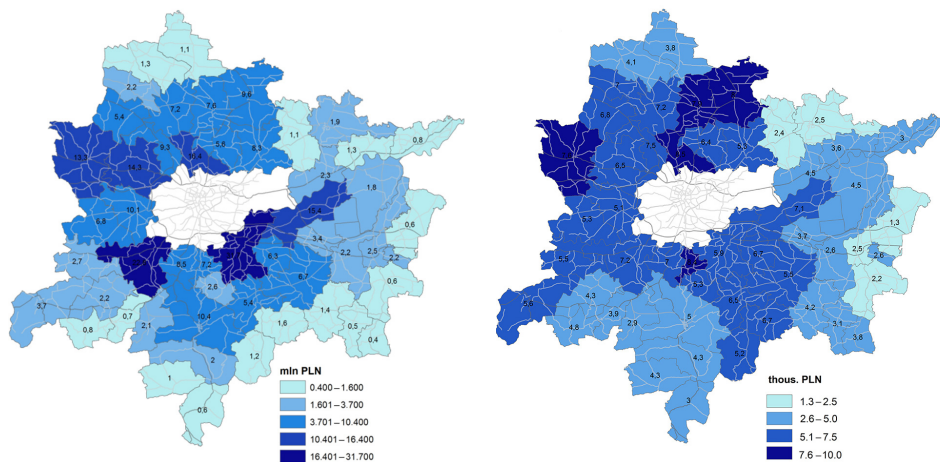


Fig. 3. The value of the time lost in commuting to work to Cracow from the communes of CMA annually [VL]

Source: own.

social interest of CMA is the most justified for carrying out communication investments – investments diversifying the current functioning road connections.

The results of the above estimates indicate that the largest losses are characteristic for the communes that are considered as sprawling areas. The noticeable effect of the disorder of the spatial structure is the non-functional structure of internal roads in CMA. This structure makes it difficult to carry out road investments. As a result, the phenomenon of a large congestion is observed, and further high direct costs and the value of the time lost can be noted. In addition,

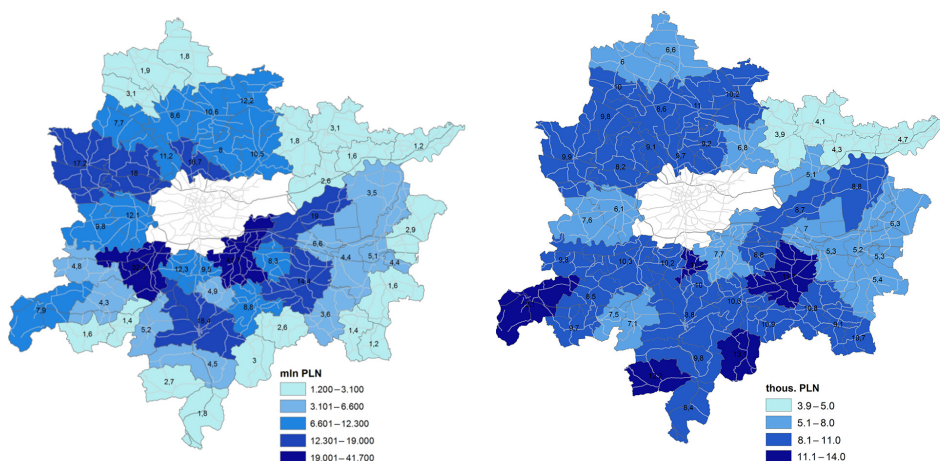


Fig. 4. Total financial losses and value of time lost annually [FL + VL]

Source: own.

communes with the highest losses do not always suffer from a deficit of basic roads and highways. However, an archaic road system hinders functional use. It should be added that both Skawina and Wieliczka are characterized by the availability of the A4 road, which has the parameters of the highway (Cracow-Silesia) and the expressway (southern bypass of Cracow). In relation to the A4 road mentioned, it should be noted that due to the limited number of entries to the road and crossings to the other side of the road, it constitutes a significant spatial barrier. Indeed, historically the number of entries and crossings was sufficient, but nowadays this road is a significant barrier of transport accessibility, which makes communication in the metropolitan area remarkably difficult. The indicated financial losses may be the basis for reflection of public authorities on the construction of additional entries for the road and crossroad passing (bridges, tunnels).

Conclusions

The subject matter situates an article in the field of research of the uncontrolled suburbanisation in Poland and the costs which are its result. The purpose of the article was to attempt to estimate the losses from commuting residents of the metropolis to work in the core city. It was pointed out that social losses due to commuting to work are high and in the case of CMA exceed PLN 400 million. These losses are a consequence of a non-functional road system being a derivative of the chaotic spatial structure caused by urban sprawl. As a result, it causes a large congestion, and the dispersion of buildings makes it difficult to carry out road investments. High values of losses of selected communes of CMA can be at the same time an informative instrument indicating a specific area that requires carrying out road investments. In addition, the calculated values can be considered losses due to the urban sprawl in the metropolis.

In the presented estimates, attention was paid to two categories: directly incurred losses and the value of time lost. Both categories have significant meaning not only to households but also to the economy as a whole. Direct losses are the amount of expenditures that could be invested by dynamising the development of the metropolitan area (PLN 126 million a year in CMA). However, the value of time lost for travel to work reflects the loss of the labour market, which in the face of limited labour resources in large cities is starting to gain importance (PLN 275 million a year in CMA).

The proposed research methodology can contribute to the development of Polish study through conceptualization and operationalization of loss valuation taking into account not only fuel consumption, but also: car amortization or real distance and travel time. The added value of research is also data that is widely available and does not require specialized knowledge and software.

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Urban sprawl a mobilność w metropolii: pomiar strat finansowych dojazdów do miasta rdzeniowego

Zarys treści: Podjęta problematyka sytuuje artykuł w nurcie badań nad kosztami niekontrolowanej suburbanizacji w Polsce. Celem artykułu jest próba oszacowania strat z tytułu dojazdów mieszkańców do pracy do miasta rdzeniowego. Obliczenia przeprowadzono dla Krakowskiego Obszaru Metropolitalnego. Wskazano, że straty społeczne z tytułu dojazdów do pracy są wysokie i przekraczają 400 mln zł rocznie. Straty te są konsekwencją niefunkcjonalnego układu drogowego będącego pochodną chaotycznej struktury przestrzennej wywołanej urban sprawl.

Słowa kluczowe: przestrzeń, mobilność, obszar metropolitalny, koszty, dojazdy do pracy, sieć drogowa