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COMMUTING IN THE WARSAW SUBURBAN AREA FROM A SPATIAL PERSPECTIVE – AN EXAMPLE OF EMPIRICAL RESEARCH

1. INTRODUCTION

As a result of concentration of economic activities, an important element of the New Economic Geography (Krugman 1991: 483-499), metropolitan regions in Poland have been developed recently. One of the basic criteria for definition of metropolitan (functional) areas is connected with a range of commuting (OECD 2002).

Undoubtedly, Warsaw is a central area in the regional labour market. It can be also perceived as a central point of the entire national labour market. It has been proved by the statistics from the intercommunal data matrix concerning employees commuting to work on the basis of the taxpayers' tax deductions provided by the Central Statistical Office of Poland (Urban Statistics Centre in Poznan). The significant role of Warsaw in the spatial structure of the region in terms of the number of workers commuting to the city was also pointed out for example by Śleszyński (2013: 5-25), who concluded that this is the result of its function as the capital and of the development of labour market in the transition period.

In the literature on the matter, the criterion of commuting is a basis for the delimitation of local labour markets. Hence, many authors have studied this subject, including Golata et al. (2011: 77-85), who analysed commuting in a range of municipalities and counties across Poland. Based on the Thünen theory, the authors characterised commuting by using selected spatial statistical

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methods (Moran and Gear's statistics). The analysis of commuting to Warsaw using a gravity model was also conducted by Niedzielski (2006: 2 485-2 502).

According to the basic principle of geography, the elements located close together have more similarities than objects far from each other. In accordance to this principle, also known as Tobler's first law of geography, objects that are close to each other influence each other more strongly than objects farther apart (Miller 2004: 284-289). Consequently, phenomena studied in one spatial unit cause increase (or decrease) of their probability in adjacent units. This process is called spatial dependency or autocorrelation (Bivand 1980: 23-38). There are various causes of spatial dependency, for example:
 − the strong connections between territorial units (regional, provincial, county, municipal, village affiliations); and
 − the spatial dimension of people's socio-economic activities, which is determined to a large extent by distance and location (Janc 2006: 76-83).

The phenomenon of a spatial autocorrelation plays an important role in the analysis of spatial data. It is an integral part of the group of quantitative methods that are a part of a spatial analysis. One of the commonly used measures of a spatial autocorrelation is Moran's statistic. The value of this statistic generally falls into the interval [-1, 1] and three different situations may occur:
 − $I = 0$ – no autocorrelation;
 − $I < 0$ – negative autocorrelation (objects that are located next to each other at a specified distance have different values);
 − $I > 0$ – positive autocorrelation (objects located next to each other, at a specified distance, have similar values).

The global Moran's statistic is described by the formula (1):

$$I_i = \frac{n}{W} \frac{{}^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2} \, , \qquad (1)$$

where: w_{ij} – is weight of the connections between units i and j (1st order row standardised matrix), x_i and x_j – are value of the variables in spatial units i and j (1st order row standardised matrix), $\bar{x}$ – is an arithmetic mean value of the analysed variable for all spatial units.

The global Moran statistic was not a useful tool for a local analysis. It described only a certain pattern observed in the whole area. To investigate the changes in the individual spatial units, other measures (local ones) should be used. These indicators are determined separately for each region. This allowed accurate access to the diversity of the studied phenomenon. In other words, based on local statistics, we can judge whether the tested area is adjacent to areas

of low or high values. Such an analysis allows to detect clusters of areas of high (or low) value of the tested variable, and also identify unusual areas (values of which significantly differ from their neighbours). The most commonly used measure is the local Moran's statistic. This measure is used to examine how the value of one region is formed in comparison with neighbouring regions, as compared to a random distribution of values in the tested area. The local Moran's statistic is expressed by the formula (description as previously):

$$I_i = \frac{\left(x_i - \overline{x}\right)^2 \sum_{i=1}^{n} w_{ij}\left(x_j - \overline{x}\right)}{\frac{1}{n}\sum_{i=1}^{n}\left(x_i - \overline{x}\right)^2} \; . \qquad (2)$$

The study material comes from a project entitled "*Economic and social determinants of rural areas development of the Mazovia region in the suburban and external zone of Warsaw*", No N N114 145240, financed by the National Science Centre (Poland). Research was conducted in a form of questionnaire interviews in 800 households from 30 communes of the Warsaw suburban zone (Figure 1). In total, there were 2 215 adult participants. For the purpose of this study, data from 29 out of 30 communes was used because one of them had no neighbours.

Figure 1. Investigated area

Source: Drejerska, Chrzanowska, Pomianek (2014).

Taking into account that use of information about localisation allows one to set more research questions connected with relationships resulting from a spatial perspective (Suchecka, Łaszkiewicz 2014: 198), the study objectives concerning the group of respondents were as follows:
  − to determine a range of the capital labour market; and
  − to examine the influence of some spatial patterns on the intensity of commuting to Warsaw in the investigated communes.

The structure of respondents (employed and entrepreneurs) was characterised according to workplace localisation and had the following descriptions:

– Warsaw,
– another town,
– another village,
– work at one's residence.

The analysis was based on binary matrix **B** and weight matrix **W** standardised according to rows. A criterion of a common border was assumed as a neighbouring criterion. The weight matrix was built in the first step, then the global Moran's statistic was calculated for each workplace location. Then, the local Moran's statistics were calculated. This approach can also be found in works of other authors, for example, Klimanek, Szymanek (2013: 228-235).

2. DIFFERENT DESTINATIONS OF COMMUTING – RESULTS OF GLOBAL MORAN STATISTICS

Communes with only one or two neighbours were identified. These were border communes, where an edge effect takes place (Table 1); this may cause differences in the estimation of spatial effects. Celestynów, Prażmów and Puszcza Mariańska have the fewest connections, whereas Leszno and Nadarzyn have the greatest number of connections.

Table 1. Number of communes and their neighbours

Number of communes	3	9	9	5	2
Number of neighbours	1	2	3	4	5

Source: own elaboration.

Calculations of the global Moran's statistic proved that the investigated communes are similar regarding commuting to another village (Table 2).

Table 2. Results of the global Moran's statistic

Proportion of workers	Another village	Another town	The same place for work and living	Warsaw
Global Moran's statistic	**0.34**	0.19	-0.03	0.10

Source: own elaboration.

Clusters of communes of similar values were identified as well. Respondents who lived in other villages than the location of the local self-government (local capitals) commuted to work in public services (Figure 2). For example, the inhabitants of villages in the Tarczyn commune commuted to other villages for working in public services such as schools or service and retail trade companies.

Figure 2. Similar proportion of commuters to other villages – example of Puszcza Mariańska, Radziejowice, Żabia Wola and Tarczyn

Source: own elaboration.

The low value of the statistic for the variants: another town compared to Warsaw can be explained by diverse transportation infrastructure. People who live in the areas with good communication with the capital (or the local centre) decide to commute longer distances, whereas people residing in the areas poorly communicated with larger urban centres more often resign from work that involves commuting for long distances.

3. DIFFERENT DESTINATIONS OF COMMUTING – RESULTS OF LOCAL MORAN STATISTICS

This study also assumed the calculation of the local Moran's statistic, which indicates a spatial relationship of a particular variable with neighbouring objects in a particular location. Four variants of the correlation results for all commuting options are illustrated in Figures 3–6. Figure 3 presents variants of the local Moran's statistic for commuting to another village. The darkest colour indicates positive local correlation coefficients, such as in Puszcza Mariańska and Radziejowice. A relatively high proportion of respondents commuted to

another village (23%) in Puszcza Mariańska and in neighbouring Radziejowice (42%). On the other hand, the medium colour illustrate negative local correlation coefficients. For example, in Raszyn about 14% respondents commuted to another village, whereas no one did in Michałowice, and only 2% did in Lesznowola and Nadarzyn.

Figure 3. Local Moran's statistic – another village

Source: own elaboration.

Figure 4 presents variants of the local Moran's statistic illustrating commuting to another town.
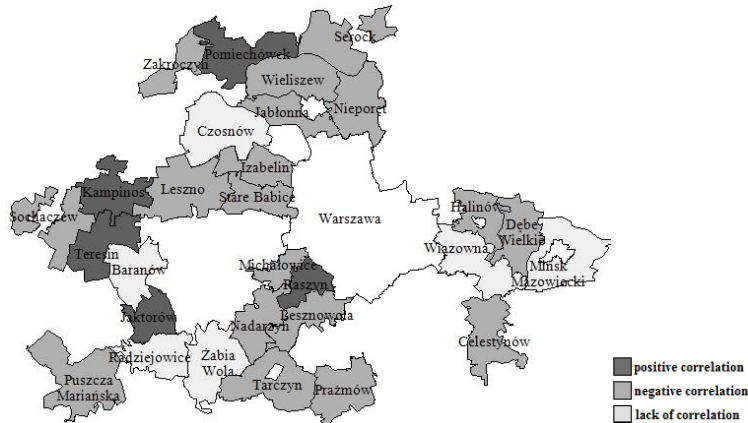

Figure 4. Local Moran's statistic – another village

Source: own elaboration.

For example, a relatively high proportion of commuters to another town (not Warsaw) were identified in Zakroczym. They lived in some nearby villages and commuted to Zakroczym, a rather significant town from the perspective of

public services localisation.[1] Neighbouring communes cannot be characterised by a similar pattern. To the contrary, Jaktorów was characterised by a low proportion of commuters to another town and was surrounded by similar communes.

Figure 5 presents variants of the local Moran's statistic illustrating proportions of respondents living and working in the same place. In this case, many communes had insignificant values of the local Moran statistic. Going into details, Serock had a high proportion of respondents living and working in the same place and neighboured communes of similar pattern. To the contrary, in Wiązowna, a relatively high proportion of respondents living and working in the same place was identified, whereas this commune's neighbours of Halinów, Dębe Wielkie and Mińsk Mazowiecki had considerably lower proportions. This situation is caused by the presence of the railway, which gives the inhabitants of these communes more opportunities to commute.
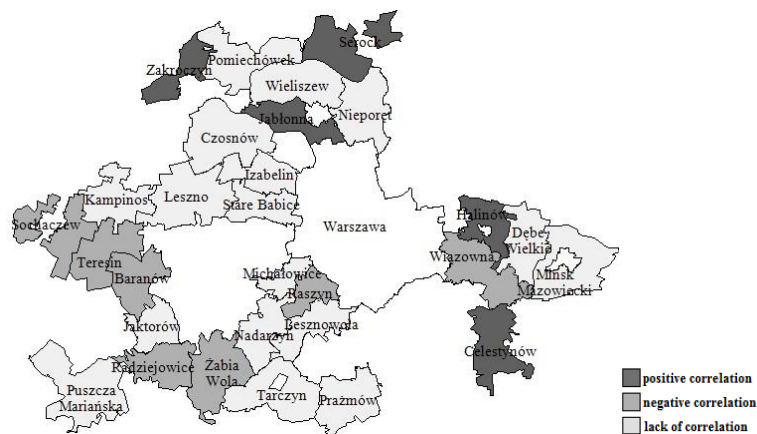

Figure 5. Local Moran's statistic – the same place of work and living

Source: own elaboration.

Figure 6 presents variants of the local Moran's statistic presenting proportions of commuters to Warsaw. In this approach, Raszyn is an interesting area with a relatively low proportion of commuters to Warsaw and is neighboured by communes with a similar situation. This is partly due to the location of big shopping centres there, which provide job opportunities not only for local inhabitants, but even for inhabitants of bordering communes as well as Warsaw. On the other hand, Celestynów is characterised by a low proportion of respondents commuting to Warsaw in comparison to Wiązowna, where the proportion of commuters to Warsaw is relatively higher.

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[1] Zakroczym is a center of this commune; local self-government is located there.
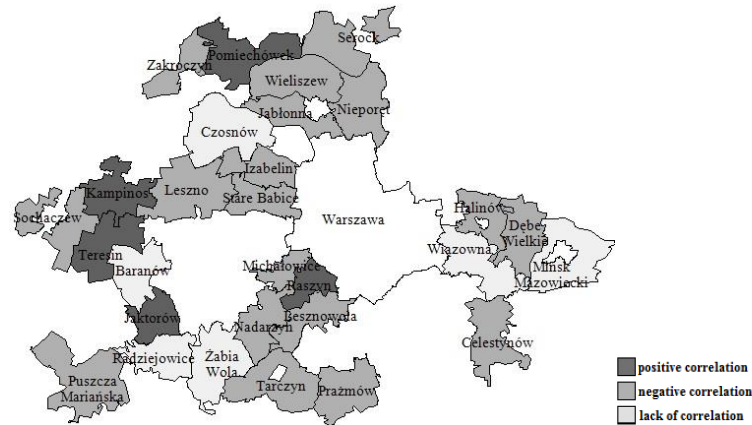
Figure 6. Local Moran's statistic – Warsaw

Source: own elaboration.

Among the other municipalities, one can observe units that stand out against their neighbours. For example, Raszyn and Pomiechówek are surrounded by municipalities with low values of the calculated local statistic. In turn, Jaktorów had a high autocorrelation, while there was no autocorrelation in its neighbourhood.

4. CONCLUSIONS

The global Moran's statistic was significant only for respondents commuting to another village. There were clusters of communes with a similar proportion of respondents commuting to another village, usually inhabitants of smaller villages commuting to the commune centre for work in public services or retail.

A spatial structure of commuting does not facilitate analysis. As a result, the relationships form radial patterns with Warsaw as the centre, rather than clusters. Different patterns of commuting have been formed according not only to distance, but also infrastructural lines such as railways. The results of the study required much qualitative knowledge for interpretation. Moreover, the investigated area was not continuous; its borders and edges make it complicated for interpretation and can influence the results. That is why the results of the study should be treated also as inspirations for further research.

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ABSTRACT

Commuting plays a significant role in forming metropolitan areas. It is one of the basic criteria for delineation of functional areas, including metropolitan regions. The objectives of this study included determining the Warsaw labour market and examining the influence of some spatial patterns on the intensity of commuting to Warsaw in the investigated communes. The research was conducted in a form of questionnaire interviews in 800 households from 30 communes of the Warsaw suburban zone, involving 2 215 adult participants. The analysis was based on a binary matrix **B** and weight matrix **W** standardised according to rows. A criterion of a common border was assumed as a neighbouring criterion. The weight matrix was built in the first step, and then the global Moran's statistic was calculated for each workplace localisation. Then local Moran's statistics were calculated.

The global Moran's statistic was significant only for respondents commuting to another village. There were clusters of communes with a similar proportion of respondents commuting to another village, usually inhabitants of smaller villages commuting to the communal centre for work in public services or retail. As far as local Moran's statistics are concerned, they allowed the pointing out of some examples of communes surrounded by similar or different commuting patterns. A spatial structure of commuting does not facilitate analysis. As a result, the relationships form radial patterns with Warsaw as the centre, rather than clusters.

DOJAZDY DO PRACY W OBSZARZE PODMIEJSKIM WARSZAWY NA PODSTAWIE BADAŃ EMPIRYCZNYCH

ABSTRAKT

Dojazdy do pracy odgrywają dużą rolę w kształtowaniu obszarów metropolitalnych. Są jednym z podstawowych kryteriów delimitacji obszarów funkcjonalnych, w tym regionów metropolitalnych. W związku z tym, badaniem objęto mieszkańców gmin wiejskich i miejsko-wiejskich, największego obszaru metropolitalnego w Polsce – strefy podmiejskiej Warszawy. Badania przeprowadzono w 800 gospodarstwach domowych z 30 gmin strefy podmiejskiej Warszawy uzyskując informacje o sytuacji na rynku pracy dla 2 215 badanych osób dorosłych. Analiza została oparta na macierzy binarnej **B** oraz macierzy wag **W** standaryzowanej wierszami. Za kryterium sąsiedztwa przyjęto kryterium wspólnej granicy. W pierwszym kroku wyznaczono macierz wag, następnie biorąc pod uwagę strukturę osób dojeżdżających do pracy w różnych lokalizacjach policzono statystyki Morana: globalną i lokalną.

Wartość globalnej statystki Morana była istotna dla dojazdów badanych respondentów z miejsca zamieszkania do innej wsi. Oznacza to, że na badanym obszarze istniały klastry badanych gmin o podobnym odsetku dojeżdżających do pracy w innej wsi. Zwykle mieszkańcy mniejszych wsi dojeżdżali do wsi gminnej do pracy w usługach publicznych bądź handlu. Na podstawie wartości lokalnych statystyk Morana wskazano przykłady gmin otoczonych podobnymi lub rożnymi gminami w zakresie lokalizacji miejsc pracy respondentów. Przestrzenna struktura dojazdów do pracy w regionie metropolitalnym nie ułatwiała analizy i interpretacji otrzymanych wyników – tworzy ona zwykle układ promienisty a nie skupienia.