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## Labour market areas in Poland

### 1. INTRODUCTION

Administrative regions are becoming discrepant with naturally grown functional areas. The historical boundaries diverge often from the contours of territories consistent due to socioeconomic reasons.<sup>3</sup> An urgent need emerges to develop the concept of 'functional regions', often in the form of Labour Market Areas (LMAs). LMA is a functional, geographic region beyond the administrative boundaries. It is economically integrated, while residents may find jobs within a reasonable commuting distance and might change their job without changing their place of residence (compare Gołata, 2004). Therefore, LMAs allow to analyze the effects of commuting on the labour market centres and their hinterland. It should be beneficial for the design of employment, labour mobility and urban planning policies. LMAs could help to decide on the investment plans, road, train infrastructure, pre-schools, kindergartens or managing bus, train connections and other.

A close concept to the LMAs are the Larger Urban Zones (LUZ) (Carlquist, 2006). LUZ is a functional urban area which includes the central city (i.e. core) and an area of the core's main commuting flows from the neighbouring localities (i.e. commuting zone). Młodak (2012) presented a delineation of metropolises and LUZ for Poland and explained the differences between LUZ and Functional Urban Areas (FUA). In turn, FUA for Poland were delineated by taking into account a broader set of selected economic issues like: commuting, migration between the core and the commuting zone, share of the employment outside agriculture sector, number of companies per number of residents, housing market and population density (Śleszyński, 2013). Other works on the analyses of func-

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<sup>3</sup> See: Młodak (2008) for the selected methods to cluster spatial areas in the surveys of population flows and Klapka, Halás (2016) for a typology of functional regions in geographical research.

tional urban areas for Poland include, for example: Sołtys, Gołędzinowska (2017), Szafranek (2017), OECD (2016), Śleszyński (2014).

LUZ, similarly like LMAs and as opposed to FUA, are delineated by using mainly data on commuting flows, which are the main indicator of functional linkage (Rakowska, 2014). However, LMAs are sub-regional geographical areas where the majority of the labour force works and lives. As opposed to it, a commuting zones of LUZ are delineated by Eurostat if at least 15 percent of employed residents work in a city, while if 15 percent of the employed live in one city and work in another city, these cities are treated as a single city. In consequence, LUZ are larger than LMAs and LUZ should contain several LMAs to capture the impact zone of a city. Therefore, LMAs have the potential to play a key role in the evaluation and monitoring of policies at smaller, local areas.

The delineation of Polish local labour markets presumably for the first time in over several years was carried out by Gruchociak (2012, 2013). Author used variants of the taxonomic approach to obtain two LMA's delineations, which were next compared to each other. The algorithm was based on a methodology which was an early attempt of Eurostat (1992) for delineating employment zones at that time. The more recent article of Gruchociak (2015) compared the differences between local labour markets obtained by three different methods and at two points in time, namely for the years 2006 and 2011. The 2011 data came from the 2011 Polish Census of Population and Housing, whereas for the European variant author used the European Algorithm for Regionalisation (Eurostat, 1992). Similarly, Wdowicka (2016) using data from the 2011 Census delineated three different sets of local labour markets with the Eurostat (1992) methodology. Wdowicka (2016) discussed and applied also the selected criteria for evaluation of the results. In turn, Szczebiot-Knoblach, Kisiel (2014) analysed the supply side of the labor market in rural areas, although authors used the administrative boundaries and they have not delineated any new areas.

The goal of the article is to delineate LMAs in Poland, to discuss LMA methodology and its problems. The novelty is that we use a more recent version of the Mike Coombes, Office for National Statistics (2015) algorithm. The algorithm has been simplified in comparison to previous versions of the TTWA (Travel to Work Areas) algorithm in order to remove the no longer needed set of initial stages to form 'proto-TTWAs' before the main LMA definition process is applied. Moreover, the final version of the algorithm was a result of the discussions during Eurostat Task Force's meetings, seminars and workshops. We add new insights into the literature as we select typical input parameters for Poland. We also propose the output of Polish taxonomy for this purpose. The relevance of the proposal rests on the fact that in literature exists no unambiguous solution to select the optimal values of parameters in the TTWA algorithm. Polish experiences could be beneficial – especially that most empirical papers on LMAs concern highly developed countries.

The policies, decisions and investments resting on regional, functional data (instead on historical boundaries) seem to be required in modern, knowledge-based economies (KBE). The reason is that information infrastructure is a key determinant of KBE (Madrak-Grochowska, 2016). Moreover, Ręklewski, Ryczkowski (2016) evidenced that regional labour market well-being improves the quality of public's life. In turn, Balcerzak, Pietrzak (2015) found a positive impact of the efficiency of the institutions in relation to the potential of the global KBE on the quality of life. The access to the proper spatial information may accelerate economic growth and in consequence may lead to a faster progress towards Europe 2020 targets (European Commission, 2010). Šnajder, Bobek (2014) confirmed that the concept of functional regions is relevant for the effective development. Authors argue that in Slovenia LMAs or functional regions could improve the quality of services, work against state centralization and provide additional stimulus for the regional development. Moreover, Stimson et al. (2016) point that administrative regions create the modifiable area unit problem, which makes it necessary to address spatial autocorrelation issues. Finally, labour mobility associated with functional regions is getting a lot of attention nowadays because it is a mean by which knowledge circulates at the regional scale and matches labour supply and demand (Huber, 2012).

The article is organized as follows. Second section presents literature review and international experiences with LMAs. In the third section we describe the methodology and briefly the EU-TTWA algorithm, followed by a fourth section with data description. In the fifth section, we present the results (with LMA maps) while, in the sixth section, we discuss key problems and possible solutions.

## 2. EXPERIENCES OF COUNTRIES

Numerous and alternative approaches to the definition of local labour market areas have been developed in recent decades. Casado-Diaz, Coombes (2011) review international scientific research on the delineation of local labour market areas. Official recognition of functional regions varies considerably between countries (OECD, 2002). For instance, in the United States already since 1980s, hierarchical cluster analysis was used by the Census Bureau to group counties into Commuting Zones and LMAs. LMAs were defined similarly to Commuting Zones, except that they were restricted by a minimum population of 100,000 persons. Nevertheless, LMAs were only estimated in 1980 and in 1990 (United States Department of Agriculture). The approach to LMAs differs among countries. In this respect, it was an important and challenging task ahead of Eurostat to define a methodology for creating harmonized LMAs throughout Europe. Ultimately, the algorithm is largely based on its British counterpart.

TTWAs became the official British definition of LMAs since 1960s, although their predecessors go further back in time. Following each national census and starting from the 1971 one, functional areas have been delineated using the data

on commuting flows based on the place of residence of an employee and his/her workplace (UK Office for National Statistics, 2015). The method was revealed to work well in practice and has led Coombes (2000) to ascertain that: 'the TTWA method had been shown to be the *best practice* for defining local labour market areas across Europe'.

In December 2014, Italian National Institute of Statistics (Istat) released LMAs (Istat, 2014; Franconi et al., 2016) that were based on the commuting data with the use of the TTWA method of Coombes, Bond (2008). Istat has been working on this method together with Eurostat and with members of the designated Task Force. The leading role in the Task Force was assigned to Istat, due to its long experience in defining functional regions. Istat released LMAs already in 1989 using the commuting data from the 1981 population Census. Next, similar exercises were repeated in 1991, 2001 and 2011.

For other developed countries the concept of LMAs has also been developed. Kropp, Schwengler (2016) with the use of a novel three-step method obtained 50 German labour market regions that were quite heterogeneous in terms of size. Stimson et al. (2016) implemented the Intramax procedure to the journey-to-work (JTW) commuting flows from the 2011 census data to derive functional, economic regions for Australia. In fact, many approaches could be used to identify functional regions. For instance, Kim et al. (2015) proposed a spatial optimization model with the p-functional regions problem, to solve a regionalization dilemma. Authors considered geographic flows and grouped areal units into smaller number of clusters to classify the areal units with similar properties.

### 3. METHODOLOGY

The description of the algorithm implemented in Poland (EU-TTWA) can be found in the Eurostat Task Force's LMA Final Report (Eurostat, 2015). Therefore, we will present it only briefly. We measure self-containment for the supply and demand side. Supply side self-containment (SSC) is the number of people living and working in an area divided by the number of residents in the area. Demand side self-containment (DSC) is the number of people living and working in an area divided by the number of jobs (residents and not-residents employed) in the area. The EU (TTWA) method uses four parameters:

- a) minimum self-containment (minSC) – a level of self-containment SC, where  $SC = \min(SSC, DSC)$ , at which clusters of large sizes are acceptable,
- b) target self-containment (tarSC), a level of SC at which clusters of small sizes are acceptable,
- c) minimum number of working residents (minSZ) for a cluster to be considered a valid LMA,
- d) target number of working residents (tarSZ) – a value at which lower levels of self-containment are acceptable for an LMA.

We apply a function which assesses whether a grouping of gminas comprises a viable LMA. This function has the following properties:

- a) Cluster of LAUs-2 (Local Administrative Unit: *gmina*) with self-containment (on supply and demand side) that exceeds tarSC and has at least minSZ workers living in the area should be accepted.
- b) Cluster of LAUs-2 with self-containment (on supply and demand side) that exceeds minSC and has at least tarSZ workers living in the area should be accepted.
- c) Cluster of LAUs-2 in which fewer than minSZ workers live should be rejected.
- d) Cluster of LAUs-2 with self-containment (on either supply or demand side) that is less than minSC should be rejected.
- e) For cluster of LAUs-2 where live between minSZ and tarSZ workers, the required self-containment (on both supply and demand side) should progressively decrease from tarSC for the smallest areas to minSC for the largest ones.

Therefore, we classify a cluster of LAU-2s to be an LMA if it is consistent with the a–e points, that is the following validity condition must be met:

$$\frac{\min SC}{\text{tarSC}} \leq \left( 1 - \left( 1 - \frac{\min SC}{\text{tarSC}} \right) \text{MAX} \left( \frac{\text{tarSZ} - SZ}{\text{tarSZ} - \min SZ}, 0 \right) \right) \left( \frac{\text{MIN}(SC, \text{tarSC})}{\text{tarSC}} \right). \quad (1)$$

The right-hand side of the condition (1) represents a function that measures the trade-off between the size of a LAU2 unit (SZ) [in occupied persons] and the minimum of SSC and DSC ( $SC = \min(SSC, DSC)$ ). The validity condition (1) fulfils all the properties from 'a' to 'e'. Coombes and Bond's (2008) methodology allows for a certain degree of flexibility in defining the value of the four parameters. In line with Eurostat's guidelines each country should define its individual values depending on the specificity of the economy. Nevertheless, the typical values for tarSC are between 0.75 and 0.8, for the minSC are between 0.6 and 0.7, while the size parameters depend on the data – usually they take values from 10 thousands and more.

The algorithm to delineate LMAs checks every LAU against the condition (1). If not all LAUs fulfil the condition, the LAU<sub>A</sub> that gives the lowest value for the right-hand side of the condition (1) is selected. This LAU<sub>A</sub> is then assessed against all other LAUs to find the LAU<sub>B</sub> which has the most important commuting flows in line with the formula:

$$\text{MAX} \left( \frac{CF(LAU_A \rightarrow LAU_B)^2}{ER_{LAU_A} \times E_{LAU_B}} + \frac{CF(LAU_B \rightarrow LAU_A)^2}{ER_{LAU_B} \times E_{LAU_A}} \right). \quad (2)$$

Where, CF – commuting flows, ER – employed residents, E – employed residents and non-residents. LAU<sub>A</sub> and LAU<sub>B</sub> are grouped. The grouping of LAU<sub>A</sub> and LAU<sub>B</sub> (LAU<sub>AB</sub>) is now considered as one entity and the joined commuting

flows to the other LAUs are recalculated. Cases when LAUs need to be re-grouped or put on a reserve list (a list of LAUs that fail the validity condition during merging) are described in Eurostat (2015). The process stops when all LAUs or groupings of LAUs fulfil the condition (1).

The problem with the EU-TTWA algorithm is a lack of unambiguous method to select the final values for the minSC, tarSC, minSZ and tarSZ. Therefore, we compared basic data between Poland and countries, which had already used the TTWA algorithm (Italy and Great Britain). As a result of the comparisons and the discussions at the Eurostat LMA's seminars and workshops, we have chosen the following parameter values for further analyses:

- minSZ = {1,000; 2,000; 3,000; 3,500; 4,000; 5,000}
- tarSZ = {7,500; 10,000; 15,000; 16,000; 17,000; 18,000; 19,000; 20,000; 25,000; 30,000; 35,000}
- minSC = {0.5, 0.55, 0.6, 0.667, 0.7}
- tarSC = {0.667, 0.7, 0.75, 0.8, 0.85, 0.9}

We have taken into account the combinations of the above values. In consequence, we estimated several hundred LMAs and evaluated their properties using functions implemented in 'LabourMarketAreas' R-package available on CRAN<sup>4</sup>. In particular, we calculated the characteristics for the alleged LMAs: number of clusters consisting of only one *gmina* (undesirable), number of clusters which fulfill the validity condition (desirable), number of clusters with no central *gmina* (namely, no *gmina* with more people commuting into the *gmina* than commuting out of the *gmina* – undesirable), arithmetical means of the supply side and demand side self containment (the lower is the worse, as both values indicate then that LMA is too 'loose', namely the commuting flows interact strongly with other areas) and the Q-modularity index<sup>5</sup> of Newman, Girvan (2004). We resigned from the sets of input parameters if at least one measure had undesirable properties and we accepted the input parameters, which delivered expected and desirable properties for all the measures. Finally, LMAs with too many non-contiguous areas or with high number of *gminas* on a reserve list were treated as inappropriate. We refer to this part: a 'sensitivity analysis'.<sup>6</sup>

Next, to rank the sets of input parameters with desirable properties (and after abandonment of the sets with undesirable properties), we used the Hellwig's Method of a taxonomic measure of development (Hellwig, 1968; Nowak, 1990;

<sup>4</sup> The most recent version is: Ichim et al. (2017), <https://cran.r-project.org/web/packages/LabourMarketAreas/index.html>.

<sup>5</sup> Q-modularity index stands for a quality measure for each split of a network into communities. It verifies the correlation between the probability of having an edge joining two sites and the fact that the sites belong to the same community. It is verified for every split while moving down a dendrogram in order to detect local peaks. It equals unity in case of strong community structures – in reality strong community structures are represented by smaller values, typically from 0.3 to 0.7.

<sup>6</sup> The desired and undesired values for the measures were selected by comparisons with the average outcome for all the potential LMAs.

Sucheckii, 2010). The method was recently applied, for instance, in Balcerzak (2016). The level of a complex phenomenon (quality of LMAs) is evaluated by a synthetic variable calculated for every LMA as a distance from the abstract, ideal solution (defined by multiple-criteria: stimulants and destimulants). The variables, for which an increase in their value lead to the improvement of the LMA's properties (stimulants) were: mean of the demand side self-containment of LMAs, mean of the supply side self-containment of LMAs, median of the percentage of internal flows (excluding flows having the same *gmina* as origin and destination) within LMAs to the total internal flows (Cohesion 1), median of the ratio of the number of links between communities inside LMA (excluding itself) to the maximum number of possible links (Cohesion 2), Q-modularity index. The variables, for which an increase in the value lead to the deterioration of LMA's properties (destimulants) were: number of LAUs in a reserve-list, percentage of LMAs with only one LAU, percentage of clusters with the right-hand side of the validity condition (1) smaller than unity, percentage of clusters with no LAU having a centrality measure<sup>7</sup> greater than unity. All these statistics were computed cross all LMAs constructed using a given set of input parameters.

In consequence, we have obtained 144 efficient sets of parameters. To unify the variables (stimulants and destimulants), we standardized them to obtain variables  $z_{ij}$  with a zero mean and a unitary variance for  $i=1,2,\dots,n$   $j=1,2,\dots,m$ , where:

$n$  – number of sets of expected input parameters, where  $n=144$ ,

$m$  – number of variables (stimulants and destimulants), where  $m=9$ .

Next, we changed all the variables into stimulants by multiplying the values of the standardized destimulants by minus one. The optimal object would be then:

$$z_j^W = \max_i z_{ij},$$

The distance of each LMA from the abstract, optimal benchmark was measured by the Euclidean formulae:

$$d_{i0} = \sqrt{\sum_{j=1}^m (z_{ij} - z_j^W)^2 w_j} \quad \text{for } i = 1, 2, \dots, n. \quad (3)$$

We assumed all the weights  $w_j$  to be equal (in the basic scenario), where:

$$\sum_{j=1}^m w_j = 1 \text{ and } w_j \geq 0 \text{ for } j = 1, 2, \dots, m.$$

<sup>7</sup> The centrality measure  $C_k = \frac{f_{*k} - f_{kk}}{f_{k*} - f_{kk}}$ , where  $f_{*k}$  denotes commuting flows from all gminas to gmina  $k$ ,  $f_{k*}$  are the commuting flows from gmina  $k$  to all gminas and  $f_{kk}$  denotes commuting flows within gmina  $k$ .

The development measure (synthetic variable) is given by (the higher the values of  $m_i$ , the better LMAs' properties):

$$m_i = 1 - \frac{d_{i0}}{d_0}, \quad (4)$$

where  $d_0$  is the Euclidean distance between  $z_j^W$  and  $z_j^A$ ,  $m_i \in [0,1]$  and:

$$d_0 = \sqrt{\sum_{j=1}^m (z_j^W - z_j^A)^2 w_j}. \quad (5)$$

Table 1. ALTERNATIVE WEIGHTS USED TO CONSTRUCT THE TAXONOMIC MEASURE OF DEVELOPMENT

Variables	Weights 1	Weights 2	Weights 3
<b>Destimulants</b>			
Number of LAUs in a reserve-list .....	0	0.1	0
LMAs with only one LAU .....	0.125	0.15	0.16
LMAs with expression (1) smaller than unity .....	0.125	0.17	0.18
LMAs with centrality measure greater than unity .....	0.125	0.13	0.14
<b>Stimulants</b>			
Mean SC demand side .....	0.125	0.07	0.1
Mean SC supply side .....	0.125	0.07	0.1
Cohesion 1 .....	0.125	0.06	0.06
Cohesion 2 .....	0.125	0.06	0.06
Q modularity index .....	0.125	0.19	0.2
Sum of weights .....	1	1	1

Source: own elaboration.

We experimented also with different structures of weights (table 1). Eventually, the final, chosen by us set of input parameters was evaluated on the basis of the knowledge of experts from the statistical offices. The acceptance of the delineated LMAs was based on comparisons of the LMAs with the official labour market data and spatial distribution of companies that could attract employment.

#### 4. DATA

Data come from the Polish National Census of Population and Housing 2011. The Census was based on direct interviews and twenty-eight administrative sources. Data for creating LMAs are aggregated at the LAU-2 level. We used administrative part of the Census to create a matrix of commuting flows. Persons at the age of fifteen years old or more and having in the National Insurance System an insurance code of the employed were taken into account. Persons, who were not employed, working abroad or those for whom it was impossible to define a place of work from the registers, were excluded from the matrix. Next, for

each person, two LAU-2 codes: *living\_code* (place of residence of an employee) and *working\_code* (place of work of an employee) were specified. Each farmer was considered as living and working in the same *gmina*. Persons who have not declared travelling to work in a tax registry, had their *working\_code* and *living\_code* set equal. The final matrix of commuting flows between *living\_code* and *working\_code* contained 277,686 links (the number stands for existing combinations of *gminas*, not for people commuting to work between *gminas*).

## 5. RESULTS

Since density of population in Poland is lower than the density of population in Great Britain and in Italy, it was decided to check the target self-containment between 0.667 and 0.85. Lower (higher) values of the target self-containment resulted in too many (too few) LMAs. Simple and proportional relationship between the density of population and the number of LMAs in Italy and Great Britain, suggests that the number of LMAs in Poland should fall between 110 and 378. According to Eurostat guidelines in each LMA the majority of persons is supposed to both live and work. Therefore, the values for minimal self containment below 0.5 were not considered. To maintain the international comparability of LMAs' definitions, the value of the minimal self-containment was decided to be analyzed between 0.6 and 0.7. The upper bounds for the minimal size of LMA and for the target size of LMA were chosen close to the values in Great Britain. Their lower bound was chosen equal to the values in Italy. The most important characteristics of labour market in Italy, Great Britain (UK) and Poland are summarized in table 2.

Table 2. BASIC DATA ON ITALY, GREAT BRITAIN AND POLAND IN 2011

Variable	Italy	Great Britain	Poland
Population (persons) .....	59,433,744	63,182,180	38,044,565
Population of 15 years & more (persons)	51,107,701	52,082,285	32,262,995
Economically active (persons) .....	25,985,295	32,442,335	17,576,246
Employed (persons) .....	23,017,840	30,008,635	15,443,421
Unemployed (persons) .....	2,967,455	2,433,705	2,132,825
Area (thousands km <sup>2</sup> ) .....	302,073	248,528	312,679
Density of population (persons/km <sup>2</sup> ) .....	197	254	122
Number of building blocks <sup>1</sup> .....	8,092	10,399	3,081
Minimal size of LMA (working residents)	1,000	3,500	4,000
Target size of LMA (working residents)	10,000	25,000	30,000
Minimal self-containment of LMA .....	0.6	0.667	0.667
Target self-containment of LMA .....	0.75	0.75	0.8

Table 2. BASIC DATA ON ITALY, GREAT BRITAIN AND POLAND IN 2011 (dok.)

Variable	Italy	Great Britain	Poland
Number of LMAs .....	611	228	339
Average population in a LMA (persons)	97,273	277,114	112,226
Average area of a LMA(thousands km <sup>2</sup> )	494	1,090	922
Average number of building blocks in a LMA .....	13	46	9.1

<sup>1</sup>In Poland building blocks consist of gminas (LAU-2); in Italy LAU-2; in Great Britain: a) in England and Wales layer super output areas (LSOA); b) in Scotland data zones (DZ); c) in Northern Ireland super output areas (SOA)

Source: own elaboration on the basis of Eurostat, Europa.eu portal, Istat, INSEE, CSO Poland and the Population Census 2011 data.

Using different combinations of the selected values of the four parameters (p. 7), we estimated several hundred LMAs in line with the EU-TTWA method. Next, after the 'sensitivity analysis' (i.e. the procedure of acceptance of the results or their rejection due to LMAs' properties), we performed the rank analysis for the  $n=144$  most reliable sets of parameter values (table 3).

Table 3. RANKING OF THE TOP TEN VALUES OF THE PARAMETERS ACCORDING TO THE TAXONOMIC MEASURE OF DEVELOPMENT FOR POLAND

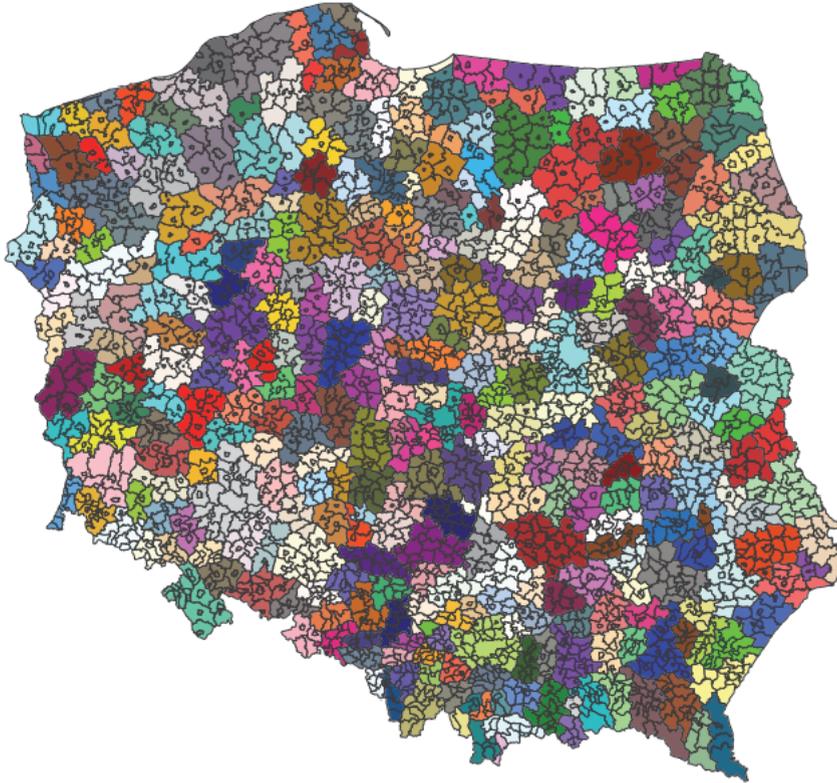
Development measure	Rank	MinSZ	MinSC	TarSZ	TarSC	NbClusters
0.653	1	4000	0.667	30000	0.8	339
0.649	2	3000	0.667	20000	0.8	391
0.646	3	4000	0.667	25000	0.8	346
0.644	4	4000	0.667	20000	0.8	366
0.643	5	5000	0.667	25000	0.75	386
0.643	6	5000	0.667	20000	0.75	390
0.642	7	5000	0.667	15000	0.8	368
0.637	8	3000	0.667	25000	0.8	371
0.637	9	4000	0.667	15000	0.8	387
0.633	10	5000	0.667	25000	0.8	337

Source: own elaboration.

The chosen, final set of parameter values (table 2; table 3, row 1) allowed us to delineate 339 areas (Map 1) within which people commute. Different weights for the stimulants and destimulants in the ranking method have not affected the choice.

The smallest population density in Poland corresponds to the highest minimal size of LMA and to the highest target size of LMA. In consequence, both the average population and average area of an LMA is between values obtained for Italy and Great Britain. Moreover, Poland having the biggest average area of building blocks, has the smallest number of building blocks per LMA. Two LMAs consist of one *gmina* as they fulfill the condition of being a valid LMA (see table 4 for other characteristics).

Map 1. Labour Market Areas in Poland in 2011



Grey contours mark gminas (LAU2), while LMAs are reflected by different colors.

Source: own elaboration using R software and EU-TTWA algorithm on the Population Census 2011 data.

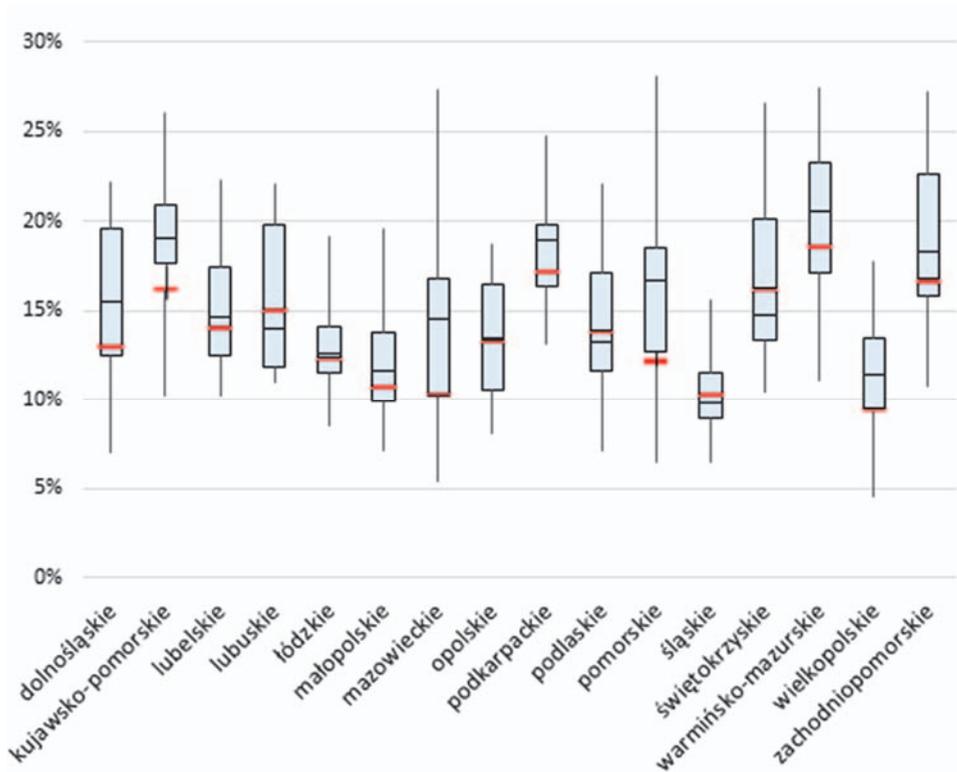
Table 4. POLISH LABOUR MARKET AREAS – SUMMARY

Characteristic	Value
Number of LMAs .....	339
Mean self-containment .....	0.816
Mean size (persons) .....	41,818
Mean number of gminas forming the LMA .....	9.1
Mean validity .....	1.12
Number of LMAs with validity < 1 .....	1
Number of links between LMAs .....	46,167
Number of LMAs with no gminas having a centrality measure > 1 .....	41
Mean SC (demand side) .....	0.902
Standard deviation of the DSC .....	0.050
Mean SC (supply side) .....	0.822
Standard deviation of the SSC .....	0.055

Source: own elaboration on the Population Census 2011 data.

LMAs should constitute economically integrated regions. Indeed, for the ratio of the unemployed to the population in the working age: an average of the ratio's absolute deviation between LMAs is 2.5%, whereas an average of the ratio's absolute deviation inside LMAs is 1.3%. This indicates that the differences are greater between LMAs than within LMAs.

Figure 1. Selected statistics on the LMA unemployment rate for voivodships, March 2011



Any LMA<sub>x</sub> is assigned to the voivodship, where gmina with the highest number of working residents among all gminas belonging to this LMA<sub>x</sub> is located. For every voivodship, the minimum, first quartile, median, third quartile and the maximum values of the unemployment rate were visualized. The red lines present the unemployment rate in the voivodship.

Source: own elaboration.

We find that Mazowieckie voivodship has the largest difference between its minimum and maximum values of unemployment rates between LMAs (figure 1). The registered unemployed to the working age population ratio was lower in LMA 1550 (containing Warsaw)<sup>8</sup> (4.08%) than in the neighbouring LMAs (4.96%-

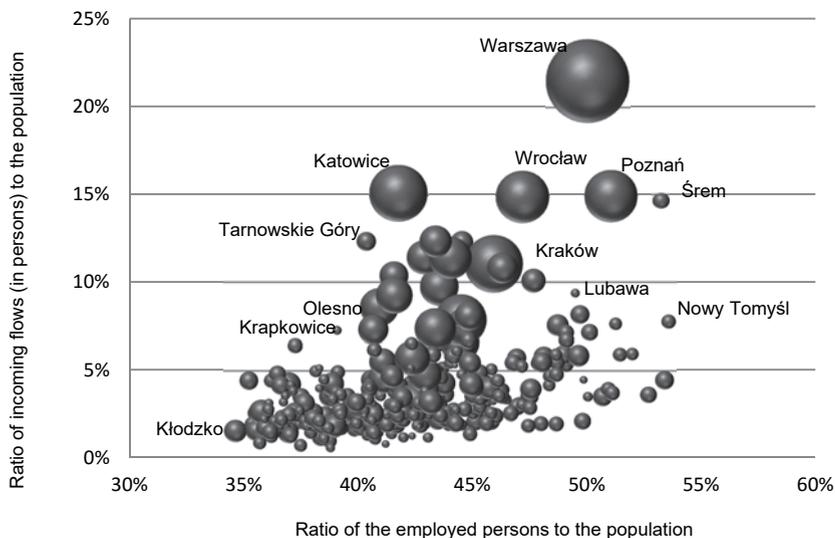
<sup>8</sup> The numbers next to LMA are numbers assigned by an algorithm to an LMA and thus they have no interpretation.

13.79%). LMA 1550 has also more sizeable ratio of the employed to the working age population in 2011 than the neighbouring LMAs (85.66% in comparison to 31.70%-47.46% in the neighbouring LMAs). This indicates relatively considerable differences between LMAs in voivodships.

LMA 1550 has the largest size of all LMAs in Mazowieckie voivodship with 979,478 inhabitants. Nevertheless, one could expect it to be even larger because of frequent commuting flows to Warsaw (including flows from distant gminas). The reason it does not happen is that commuting in both directions is crucial while defining LMAs. Thus when the neighbouring LMAs were analyzed, all of them turned out to have stronger<sup>9</sup> commuting links inside themselves than with the LMA 1550. The neighbouring LMAs fulfil the conditions to be valid LMAs on their own.

In turn, the ratio of incoming flows was highest in big cities. Nevertheless, in some LMAs in spite of low ratio of incoming flows to population aged over 14 years old and in spite of small population, the percentage of the employed persons exceeded 50% (figure 2).

Figure 2. Flows and employment ratios in 2011 – population aged 15 years or more



Source: own elaboration.

For example, below Nowy Tomyśl, there are two LMAs with high ratio of the employed persons to the population and low ratio of incoming flows to the population (figure 2). Both Grojec LMA and Grodzisk Wielkopolski LMA are neigh-

<sup>9</sup> Namely, more commuters travel to work inside particular LMAs (other than LMA 1550) than they travel to work between a neighbouring LMA and LMA 1550.

bouring to LMAs containing big cities (Warsaw and Poznan respectively). This fact causes a small number of incoming flows, relatively big number of outgoing flows (mainly to the neighbouring big cities) and high value of the ratio of the employed persons to the population. In general, LMAs are not homogeneous. For good policy making, one should consider not only their borders but also the specificity of the regions where employees commute.

## 6. PROBLEMS

Poland-specific problems appeared, which were not solved by the EU-TTWA algorithm. The knowledge about them may help to delineate LMAs in countries without specified commuting areas.

We found commuters between very distant *gminas*. The reason was that under certain conditions the algorithm assigned people to work in the headquarters instead of in the actual place of work due to the specificity of Polish registers. Even though in tax registers information on the fact of travelling to work is available (and it was used), it has not fully solved the problem, at least for those who travel to work<sup>10</sup>. The solution could be to analyze distance between *gminas* and to neglect insignificant links between *gminas* located unreasonably far from each other and with no fast transportation connections to commute. It is intended to be tested on the next Census data.

After running the algorithm, 26 non-contiguous LMAs appeared. According to Eurostat's requirements non-contiguous LMAs can be accepted only if they contain an administrative island (a non-contiguous part of a LAU-2). A contiguity for all the other LMAs in each country must be provided during the fine tuning process. *Gminas* which caused non-contiguity were ordered by size and each of them was assigned to the neighbouring LMA where it had the maximum value of expression (2). Moreover, we found 352 towns surrounded by a rural part of the *gmina*. In consequence, the town and the rural *gmina* may have been initially assigned to different LMAs. It resulted in 'holes' in LMAs. During the fine tuning process both parts were attached to the same LMA.

An example of non-contiguity was the LMA 1613 that consisted of two separate parts - part one with four *gminas* and 9,636 residents and part two with three *gminas* and 7,795 residents (Map 2). To provide contiguity we could split the LMA into two independent LMAs. However, self-containment of the 'part two' was lower than the required threshold. As for 'part one', the condition of being a valid LMA was not met. Both arguments were against creating two LMAs out of one. Therefore we calculated the number of 'attracting *gminas*' using the centrality index  $C_k$  (if  $C_k > 1$  then '*gmina* is attracting').

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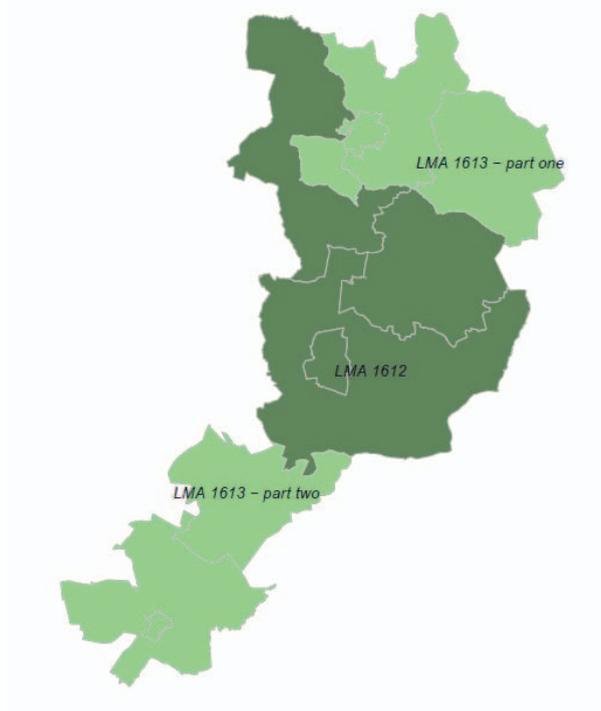
<sup>10</sup> The reason is that for all the enterprises in the Census at most three last registered places of business activity were available. Moreover, for some companies in the Census data only the headquarters' address was available.

Table 5. Centrality index values for gminas in LMA 1613

Territorial code of a gmina	Gmina	Part	Centrality index value
1608024 .....	Gorzów Śląski	one	<b>1.39</b>
1608044 .....	Praszka	one	<b>1.02</b>
1608045 .....	Praszka	one	0.20
1608062 .....	Rudniki	one	0.15
1608072 .....	Zębowice	two	0.17
1609084 .....	Ōzimek	two	0.95
1609085 .....	Ozimek	two	2.35

Source: own elaboration on the Population Census 2011 data.

Map 2. Non-contiguous LMA 1613 (Praszka) and LMA 1612 (Olesno)



Source: own elaboration using the *LabourMarketAreas* R-package.

Part one contained two attracting *gminas* and part two had only one (table 5). Therefore, we let part one to stay as an autonomous LMA<sup>11</sup> and we split the 'part two' into *gminas*. Each of them was assigned to one of the neighbouring LMAs with the largest commuting flows with it. After the new assignment of *gminas* to the neighbouring LMAs, the validity condition was still met.

<sup>11</sup> Eurostat allows for a small number of LMAs which do not fulfil the validity condition if there are required changes during the fine-tuning process. In consequence, the part one was accepted as an LMA.

## 7. SUMMARY

EU-TTWA algorithm allowed us to delineate 339 Labour Market Areas in Poland. The novelty is that we use a more recent version of the Mike Coombes, Office for National Statistics (2015) algorithm. Moreover, the final version of the algorithm was a result of the discussions during Eurostat Task Force's meetings, seminars and workshops. Therefore, we maintained international comparability with the results of European countries by following the recent EU guidelines. We add new insights into the literature as we select typical input parameters for Poland. We also propose the usage of Polish taxonomy as a way to select values of the input parameters. Labour Market Areas may be used for compiling and evaluating data related to the road, train, plane, or bus infrastructure, the spatial distribution of pre-schools or kindergartens, the timetables of public transportation, the premises for investments and many more. After all, right policies, decisions and investments resting on exact regional data (instead on historical boundaries) are required in modern knowledge-based economies. Labour Market Areas by delivering new spatial information may accelerate the growth of an economy. Nevertheless, for good policy making, one should consider not only their borders but also the specificity of the region where employees commute as we found large dissimilarities between LMAs. A future task would be to differentiate LMAs by occupational categories, employment by gender, mode of travel to work and other. The revised LMAs should be delineated after the Population Census 2021 to assess the changes in the Polish commuting patterns within recent decade. Finally, delimitation of industrial districts seems also to be a promising concept. Assessing the functional polycentricity may be applied to relatively small regions (Hanssens et al., 2014). Detailed analysis of functional regions covering, for instance, an urban area of Silesian Metropolis could be an interesting case study as well (see Sojka, 2013).

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## OBSZARY RYNKU PRACY W POLSCE

### Streszczenie

*Celem artykułu jest wyznaczenie obszarów rynku pracy w Polsce przy wykorzystaniu metody EU-TTWA opracowanej pod auspicjami Eurostatu. Wykorzystując wspomnianą metodę otrzymano ponad 300 obszarów rynku pracy składających się z gmin. W artykule opisano charakterystyczne dla Polski problemy i rozwiązania, które przyjęto. Przeprowadzono także porównanie liczby obszarów rynku pracy w państwach, w których wyznaczono za pomocą tego algorytmu wspomniane obszary uwzględniając gęstość zaludnienia, liczbę ludności oraz wielkość danego państwa. W pracy zaproponowaliśmy wykorzystanie metody taksonomicznej celem wyboru parametrów wejściowych w algorytmie EU-TTWA. Obszary rynku pracy mogą dostarczać wartościowej informacji przestrzennej. Niemniej jednak okazały się one niejednorodne pod kątem wybranych statystyk. Dlatego właściwa polityka gospodarcza nie powinna ograniczać się wyłącznie do interpretowania ich granic.*

**Słowa kluczowe:** obszary funkcjonalne, obszary rynku pracy, dojazdy do pracy

## LABOUR MARKET AREAS IN POLAND

### Abstract

*The aim of the article is to delineate Labour Market Areas (LMAs) in Poland with the use of the European version of the Travel to Work Areas (EU-TTWA) methodology that was developed under Eurostat auspices. We received over 300 areas that consist of LAU-2 units (gminas) – the smallest administrative regions in Poland. We discuss Poland-specific results and problems. We compare numbers of LMAs in countries with EU-TTWA-delineated LMAs in relation to population density, total population and area. We propose the taxonomic rank method to select the parameter values for the EU-TTWA algorithm. LMAs may deliver useful spatial information, although one needs to account for their heterogeneity.*

**Keywords:** functional regions, labour market areas, travel to work, commuting