Poverty Risk Index as A New Methodology for Social Inequality Distribution Assessment

Małgorzata Swiader ¹, Szymon Szewrański ¹, Jan Kazak ¹
¹ Wrocław University of Environmental and Life Sciences, Department of Spatial Economy, Wrocław, Poland

malgorzata.swiader@upwr.edu.pl

Abstract. The paper presents new concept of poverty risk index measurement due to dynamics of urban development among years. The rapid urbanization could seriously surpass the capacity of the most cities, which may lead to insufficient services of their inhabitants. Consequence of this situation could be polarized, social differentiated cities with high rates of urban poverty. The measurement and analysis of urban poverty phenomenon requires the dedicated tools and techniques. The data based assessment could allow planners and public policy makers to develop more socially integrated cities. This paper presents analysis of urban poverty phenomenon in Wrocław city (Poland) during period 2010-2012. This analysis was conducted for ten Social Assistance Terrain Units (SATU) delineated at the city area. Our primary study objective concerns the proposal and calculation of poverty risk index based on diagnostic features, which represent the most common causes of social benefits granting, as: number of single households granted permanent benefits, number of people in families granted permanent benefits, number of people in families granted temporary benefits due to unemployment, number of people in families granted temporary benefits due to disability, number of people in families granted meals for children. The calculation was conducted by using the theory of development pattern - Hellwig's economic development measure. The analysis of poverty risk index showed that commonly the central and south-eastern part of the city is characterized by the highest poverty risk index. The obtained results of the inequalities spatial distribution relate to European and American patterns of poverty concentration in urban structures.

1. Introduction
Over 50% of the world population lives in the urbanized areas [1]. United Nations predicts that until 2050 this percentage will increase to 72%. Therefore, urban population will rise from 3.6 billion (2011) to 6.3 billion in 2050 [2]. This occurrence is connected with expanding urbanization process during the last years [3]. Urban growth could surpass the capacity of most cities, and in effect, not provide public services for their inhabitants [4]. The consequence of this situation could be the creation of socially differentiated and even polarized cities [5]. This rapid growth of urbanization in the nearest future is mentioned as one of the factors affecting the persistent poverty [6].

Poverty is a multidimensional phenomenon [7, 8, 9, 10] which could be defined as inability to provide basic needs i.e. food, housing as well as medical care. This basic needs approach is connected with insufficiency of material or non material resources [11] of households - monetary poverty [12]. During years, this concept was expanded from purely economic factors including additionally social
and personal conditions, which determine conducting of the good life [13]. This occurrence could be considered from several aspects, i.e. poverty as a phenomenon at the national or regional level as well as poverty of households or individuals [14]. This phenomenon could be understood also as an extreme inequality, which in turn leads to necessity of applying for social benefits [8]. Poverty, and thus social benefits receiving, are connected with socio-economic factors, e.g.: severe or long term health problems, children in households with many other children, unemployment, etc. [15]. These poverty reason lead to deterioration of the quality of life, social exclusion, structural problems and low or lack of participation in social life [15]. These socio-economic inequalities cause increase in residential segregation [16].

The analysis of poverty phenomenon is dominated by money-metric approach. However, taking into account, that poverty is multidimensional approach, the analysis requires additional tools and techniques [8]. Therefore, spatial approach to poverty measurement could be useful for designing and managing of urban areas [6, 17]. Therefore, we proposed methodology, which connects econometric analysis with spatial dimension. The aim of this study is to identify the spatial distribution of poverty phenomenon of Wrocław city with the use of the theory of development pattern - Hellwig's economic development measurement. Our analytical approach, based on data from Wrocław City Social Welfare Centres' annual reports, could give an information about spatio-temporal diversification of the poverty within borders of 10 Social Assistance Terrain Units (SATU). The proposed analytical approach could be a part of a decision support system for urban planning and development, which improves local development management [18].

2. Materials and methods

According to Polish law, the entitlement to individual and family social benefits is referred to the statutory poverty line, which is also called as the social intervention threshold [19]. Therefore, the social benefits could be granted by individuals or families in specific issues, i.e.: “poorness, orphanhood, homelessness, unemployment, disability, long-term or serious illness, domestic violence, and the need to protect victims of human trafficking, the need to protect maternity, helplessness in matters of care and education and household management, especially in single-parent families or families with many children, the difficulties the integration of foreigners who have obtained refugee status in the Republic of Poland, subsidiary protection or temporary residence permit (...), difficulty in adjusting to life after release from prison, alcoholism or drug addiction, fortuitous event and crisis, natural or ecological disaster”[20]. Thereby, all of these aspects refer to features causing poverty. In Poland, the statistics about causes of poverty (causes of social benefits granting) are summarized in annual reports created by Municipal Social Welfare Centers (MSWC). Until 2012, Wrocławs' MSWC prepared more detailed annual reports, which were created for ten Social Assistance Terrain Units (SATU) within Wrocław. Since 2013 annual reports are made for the whole city. Therefore, we decide to analyze 2010-2012 period of annual reports and causes of social benefits granting, which refer to poverty features. Reports before 2010 were unavailable.

Accordingly, we decided to calculate the poverty risk index based on features, which represent the most common causes of social benefits granting according to number of people in assisted families. Consequently, we have chosen following diagnostic features:

- $x_1$ - the number of single households, granted permanent benefits;
- $x_2$ - the number of persons in families, which granted permanent benefits;
- $x_3$ - number of people in families, which granted temporary benefits due to unemployment;
- $x_4$ - number of people in families, which granted temporary benefits due to disability;
- $x_5$ - number of people in families, which granted meals for children.

The poverty risk index was calculated using Multidimensional Comparative Analysis (MCA) according to the concept of development pattern [21]. The method allows the description of comprehensive phenomena, which are determined by more than one variable [22,23,24]. This method
uses Hellwig's economic development measure, which is a synthetic indicator of taxonomic distances from the theoretical pattern (object) and analyzed objects [25]. Therefore, the Pi-set of objects (in this case SATUs, where \( i = 1,2,3,..,n \)) is arranged, where each giving object is described with a set of m-diagnostic features [26]. These features are usually determined as stimulants or destimulants [25]. In the case of poverty analysis, and the characteristics taken into account in the study, all the features are destimulants.

Performing a comparative analysis, there is a need to adjust the features to comparable, commensurate values, i.e. calculated per 1000 inhabitants. Furthermore, set of attributes describing the individual objects should be unified through standardization according to the formula [27].

\[
z_{ij} = \frac{x_{ij} - x_j}{Sd_j}
\]

where:  
- \( x_{ij} \) - the initial value of the standardized jth feature for ith SATU;  
- \( x_j \) - arithmetic mean of the jth feature;  
- \( Sd_j \) - standard deviation of the jth feature.

Accordingly, previous standardization allowed to transit X matrix of features values to Z matrix of standardized features values, as following [27]:

\[
X = \begin{bmatrix}
x_{i1} & x_{i2} & \ldots & x_{im} \\
\vdots & \vdots & \ddots & \vdots \\
x_{ni} & x_{n2} & \ldots & x_{nm}
\end{bmatrix} \quad Z = \begin{bmatrix}
z_{i1} & z_{i2} & \ldots & z_{im} \\
\vdots & \vdots & \ddots & \vdots \\
z_{ni} & z_{n2} & \ldots & z_{nm}
\end{bmatrix}
\]

(2)

where:  
- \( x_{ij} \) - the jth feature value of (j = 1,2,3,..,m) for the ith SATU (i = 1,2,3,.., n);  
- \( z_{ij} \) - the jth standardized feature value of \( x_{ij} \).

Standardized values allow to determine the pattern [28], which could be defined as the best theoretical object \( P_0 \) (in this case SATU) characterized by the standardized variables. Usually, this hypothetical object represents the best values for each observed variable. Due to the fact, that standardized values of poverty features are destimulants, the theoretical object represent the minimum standardized value \( Z \). Thereby, the theoretical pattern is characterized as following [26]:

\[
P_0 = [z_{01}, z_{02}, z_{03},.., z_{0m}],
\]

(3)

where:  
- \( z_{01}, z_{02}, z_{03},.., z_{0m} \) - the minimum standardized features values of jth feature.

The guidelines established above constitute the base for calculation of development model for each of SATUs' according to the Sen's index formula [29]:

\[
p_{ri} = \frac{D_{10}}{D_0}
\]

(4)

where:  
- \( p_{ri} \) - poverty risk index for ith SATU;
$D_{0i}$ - Euclidean distance for $i$th SATU from the subject $P_0$, which was calculated as:

$$D_{0i} = \sqrt{\sum_{j=1}^{m}(z_{ij} - z_{0j})^2}$$  \hspace{1cm} (5)

$D_0$ - model value of the Euclidean distance, which was calculated as:

$$D_0 = \bar{D}_0 + 2S_0$$  \hspace{1cm} (6)

where:

$$\bar{D}_0 = \frac{1}{n} \sum_{i=1}^{n} D_{0i}$$  \hspace{1cm} (7)

$$S_0 = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (D_{0i} - \bar{D}_0)^2}$$  \hspace{1cm} (8)

Therefore, calculated poverty risk indexes for each individual SATU allowed to construct a synthetic poverty risk index for Wroclaw. The indicator is the arithmetic average of the indexes calculated for each SATUs, which is given by the formula:

$$\tilde{p}_r = \frac{1}{n_i} \sum P_{ri}$$  \hspace{1cm} (9)

where:  
- $\tilde{p}_r$ - average poverty risk index of Wroclaw;  
- $\sum P_{ri}$ - total amount of poverty risk indexes of each SATU;  
- $n_i$ - number of poverty risk indexes equal to the number of SATUs.

The obtained values of the poverty risk index have been classified according to the arithmetic mean and standard deviation [30]. Therefore, the best units (similar to the model subject) reaching a value of 0.00 [29], consequently represents unit with the lower poverty risk.

Accordingly to this circumstance, the obtained results were classified as following:

- 1st unit group (very high poverty risk index) : $p_{ni} \geq \tilde{p}_r + \sigma$;  \hspace{1cm} (10)
- 2nd unit group (high poverty risk index) : $\tilde{p}_r + \sigma > p_{ni} \geq \tilde{p}_r$;  \hspace{1cm} (11)
- 3rd unit group (low poverty risk index) : $\tilde{p}_r > p_{ni} \geq \tilde{p}_r - \sigma$;  \hspace{1cm} (12)
- 4th unit group (very low poverty risk index) : $p_{ni} < \tilde{p}_r - \sigma$;  \hspace{1cm} (13)

where:  
- $p_{ni}$ - poverty risk index;  
- $\tilde{p}_r$ - average poverty risk index of the SATU;  
- $\sigma$ - standard deviation of the poverty risk indexes observed in the SATUs.

This classification was made based on 30 indexes obtained from all 10 SATUs during three years’ period (2010-2012). Therefore, it allowed to set homogenous intervals and compare data over the years.
3. Results and discussions

The calculation of the poverty risk index for Wrocław city showed some spatial patterns in social inequality distribution in the urban structure.

Preliminary analysis of the results (Table 1) showed that in 2010 and in 2011, the lowest value of the index, and thus the greatest degree of risk of poverty, was recorded in SATU 7. In 2012, the highest poverty risk was noted at SATU 6.

Table 1: Poverty risk index calculated during 2010-2012 period.

| No. | SATU | Poverty risk index during 2010-2012 period |
|-----|------|------------------------------------------|
|     |      | 2010 r. | 2011 r. | 2012 r. |
| 1   | 2    | 0.703   | 0.777   | 0.732   |
| 3   | SATU2| 0.296   | 0.267   | 0.221   |
| 4   | SATU3| 0.210   | 0.456   | 0.277   |
| 5   | SATU4| 0.269   | 0.206   | 0.128   |
| 6   | SATU5| 0.115   | 0.077   | 0.233   |
| 7   | SATU6| 0.648   | 0.754   | 0.734   |
| 8   | SATU7| 0.744   | 0.779   | 0.700   |
| 9   | SATU8| 0.442   | 0.459   | 0.458   |
| 10  | SATU9| 0.273   | 0.593   | 0.279   |
| 11  | SATU10| 0.255   | 0.216   | 0.258   |
| 12  | MIN  | 0.115   | 0.077   | 0.128   |
| 13  | MAX  | 0.744   | 0.779   | 0.734   |

Source: own study

The lowest risk of poverty, compared to other SATUs', recorded in 2010 and 2011 within SATU 5, and in 2012 within SATU 4.

A more detailed analysis of poverty risk was made based on the classification of obtained index values. This allowed for a consistent assessment of poverty over time. Therefore, we created a classification based on all obtained values of indicator within three years. The calculations of arithmetic mean \( \bar{p}_i = 0.419 \) and standard deviation \( \sigma = 0.230 \) allowed to classify values of indexes as following:

- 1st unit group (very high poverty risk index): \( p_i < 0.649; 1.00 \)
- 2nd unit group (high poverty risk index): \( p_i < 0.419; 0.649 \);
- 3rd unit group (low poverty risk index): \( p_i < 0.188; 0.419 \)
- 4th unit group (very low poverty risk index): \( p_i (0.00; 0.188) \).

where:

\( p_i \) - value of poverty risk index.

The analysis showed changes in the level of poverty risk during 2010-2012 period. The particular change is visible in 2011 (Fig. 1). The situation of residents in most units has deteriorated, what is especially seen for SATU 3, SATU 9 and SATU 6, which are now classified in a 2nd class with very high poverty risk index. This change was associated with the rapid growth of number of people in families, which granted temporary benefits due to unemployment. After this abrupt change in 2011 in the following year - 2012, the poverty risk decreased in most of SATUs. The exception is SATU 5, which during 2010 and 2011 was classified in group with the lowest poverty risk, but in 2012 was classified in 2nd group of units.
Figure 1. Poverty risk index during 2010-2012 period

In 2010, the 1st group of areas with the highest poverty risk index was characterized by SATU 1 and SATU 7. In 2011 and 2012, this group was classified again SATU 1 and SATU 7, but also SATU 6. Therefore, the 2nd group, which classified areas with a high poverty risk index, included SATU 6 and SATU 8 in 2010. In 2011, this group once again included SATU 8, but also SATU 3 and SATU 9, which was connected with the deterioration of the situation in these areas, and thus an increase in the poverty level. In 2012 was classified SATU 8 in this group.

Areas with a low risk of poverty (3rd group) set the largest-area units as: SATU 10 (northern and north-eastern part of the city), SATU 2 and SATU 3 (north-west and south-west part of the city), SATU 4 (south-central part of the city) and SATU 9 (east-central part of the city). In 2011 and 2012, this group included again SATU 2, SATU 4 and SATU 10. In 2012, this group also included SATU 9. It is also noticeable deterioration within SATU 5, which was classified from 4th group (areas with the lowest level of poverty risk) in 2011 into 3rd group of poverty. The 4th group (areas with very low risk of poverty) was ranked only SATU 5 (south part of the city) in 2010 and (as it was mentioned) in 2011. In 2012, SATU 4 is an area that in comparison to others, is characterized by the lowest degree of poverty risk.

Spatial distribution of poverty risk index shows that the greatest concentration of SATU's areas with the highest risk of poverty is located in the central and south-western part of the city. It is worth emphasizing that these areas are characterized by the highest level of urbanization, the highest rate of economic development as well as dense housing and services development. The development of these units is a result of city's development strategy implementation, which envisages supplement of urban structure. Thus, having on one hand far progressive economic development and the poverty risk on the other hand, the further development goals of the city should be disused and declared. Lack of sufficient information on current state may result in a growing number of social problems (such as gentrification, social segregation) in the further structure of the city.
4. Conclusions

Due to the alarming increase of poverty risk and the number of people in need, an essential element of the modernization policy should be development of the systematic studies and monitoring of the level of social inequalities and their economic and non-economic causes. These analyzes could be an element of decision support system for development and management of the city. In Wroclaw, the Municipal Social Welfare Centre is the unit, which provides social assistance in the city. Despite the fact, that in the period 2010-2012 the number of people, who were financially supported by the city decreased, some inhabitants are still struggling with the problem of poverty.

During the 2010-2012 period, there is a noticeable decrease of poverty risk in Wroclaw. Areas characterized by the highest level of risk, measured on the basis of five statistical characteristics (i.e. single households, families, unemployment, disability, children) are localized in the city centre. The lowest level of poverty risk was recorded in the south-central part of the city.

There are noticeable analogies between the results obtained by us using the poverty risk index and poverty measurement by the so-called headcount ratio (which is the relationship between the number of people in families granted benefits and the total number of inhabitants, is reflected in the performance values of the indicator of poverty risk) [19]. It is noticeable that SATU, where incidence of poverty rate was estimated as very high (eg. SATU 6, which recorded the highest value in this analysis), received high value of the indicator of poverty risk. The analogy is possible, which could be conditioned by the data used in the analyzes. The poverty rate was calculated based on the total number of people in families granted social benefits. In turn, the poverty risk index was based on the details of the most reasons, which provide to the deterioration of the living conditions of people (e.g. unemployment, disability), and thus in consequence to the necessity of applying for social benefits. Therefore, proposed method allows monitoring the poverty phenomenon at the first context of poverty features, and at the second - spatial context.

Thus, in this study we noted a high increase of poverty risk in 2011, which resulted from a growth of registered unemployment in MSWC. The analysis showed, that the core centre of the city has the highest level of poverty risk (despite of the high level of economic development of these areas and permanent increase of investments or new developments). Our results refer to the European [31] and American [32,33] trends of poverty concentration in urban centers, which is a result of rapid development of cities. These experiences emphasized the need for monitoring and responding to such a state of affairs [6, 8, 10]. Failure to take appropriate steps can lead to the polarization of the city [17], spatial segregation [35], social exclusion [36] and even gentrification of urban structure [37].

References

[1] V. Watson, “The planned city sweeps the poor away…,” Urban planning and 21st century urbanisation, Progress in Planning, vol. 72 (3), pp. 151–193, 2009.
[2] M. Cao, D. Xu,; F. Xie, E. Liu, S. Liu, “The influence factors analysis of households' poverty vulnerability in southwest ethnic areas of China based on the hierarchical linear model. A case study of Liangshan Yi autonomous prefecture”, Applied Geography, 66, pp. 144–152, 2016.
[3] L. Cui, J. Shi, “Urbanization and its environmental effects in Shanghai, China,” Urban Climate, 2, pp. 1–15, 2012.
[4] B. Cohen, “Urbanization in developing countries. Current trends, future projections, and key challenges for sustainability”, Technology in Society, vol. 28 (1-2), pp. 63–80, 2006.
[5] E. Coiacetto, “Urban social structure: a focus on the development industry”, City Structure, 26, pp. 1-13.
[6] P. B. Cobbinah, M. O. Erdiaw-Kwasie, P. Amoateng, “Rethinking sustainable development within the framework of poverty and urbanisation in developing countries”, Environmental Development, 13, pp. 18–32, 2015.
[7] S. K. Annim, S. Mariwah, J. Sebu, “Spatial inequality and household poverty in Ghana”, Economic Systems, 36 (4), pp. 487–505, 2012.
[8] N. H. Chamhuri, H. A. Karim, H. Hamdan, “Conceptual Framework of Urban Poverty
Reduction. A Review of Literature”, Procedia - Social and Behavioral Sciences, 68, pp. 804–814, 2012.

[9] A. Chatterjee, S. Mukherjee, S. Kar, “Poverty Level of Households. A Multidimensional Approach Based on Fuzzy Mathematics”, Fuzzy Information and Engineering, 6 (4), pp. 463–487, 2014.

[10] J. C. Duque, J. E. Patino, L. A. Ruiz, J. E. Pardo-Pascual, “Measuring intra-urban poverty using land cover and texture metrics derived from remote sensing data”, Landscape and Urban Planning, 135, pp. 11–21, 2015.

[11] J. M. Henriques, “On becoming healthier communities: Poverty, territorial development and planning”, Revista Portuguesa de Saúde Pública, 31, pp. 58-73, 2013.

[12] I. Sy, “The monetary poverty in Senegal between 2002-2006: Regional disparities and effects of poverty decomposition”, Procedia Economics and Finance, 5, pp. 326-335, 2013.

[13] B. Nolan, C. T. Whelan, “Using non-monetary deprivation indicators to analyze poverty and social exclusion: Lessons”, Journal of Policy Analysis and Management, 29, pp. 305-325, 2010.

[14] X. W. Chen, Z. Y. Pei, A. L. Chen, F. Wang, K. J. Shen, Q. F. Zhou, L. Sun, “Spatial Distribution Patterns and Influencing Factors of Poverty - A Case Study on Key Country From National Contiguous Special Poverty-stricken Areas in China”, Procedia Environmental Sciences, 26, 82-90, 2015.

[15] S. Jencova, E. Litavcova, R. Kotulic, R. Vavrek, I. Kravcakova-Vozarova, T. Litavec, “Phenomenon of Poverty and Economic Inequality in the Slovak Republic”, Procedia Economics and Finance, 26, pp. 737–741, 2015.

[16] S. Marciničzak, “The evolution of spatial patterns of residential segregation in Central European Cities. The Łódź Functional Urban Region from mature socialism to mature post-socialism”, Cities, 29, pp. 300-309, 2012.

[17] C. Eddo, “Urban social structure: a focus on the development industry”, City Structure, 26, pp. 1-13, 2005.

[18] J. Kazak, J. van Hoof, S. Szewrański, “Challenges in the wind turbines location process in Central Europe - The use of spatial decision support systems”, Renewable and Sustainable Energy Reviews, 2017, (in press).

[19] M. Świąder, S. Szewrański, J. Kazak, “Spatial-temporal diversification of poverty in Wroclaw”, Procedia Engineering, 161, pp. 1596-1600, 2016.

[20] USTAWA z dnia 12 marca 2004 r. o pomocy społecznej (The Social Assistance Act of 12th March 2004)

[21] D. Wawrzyniak, “Standard Of Living In The European Union”, Comparative Economic Research, Vol. 19, No. 1, pp. 141-155, 2016.

[22] K. Kompa, D. Witkowska, “Comparison of European stock exchanges one-and multi-dimensional analysis”, Indian Journal of Fundamental and Applied Life Sciences, 4(S1), pp. 2111-2126, 2014.

[23] K. Kompa, D. Witkowska, “Synthetic measures of the European capital markets development”, Ekonometria. Econometrics, 4(50), pp. 216-227, 2015.

[24] I. Pomianek, “Socio-economic development of agricultural problem areas in Poland”, Economics & Sociology, Vol. 7, No 2, pp. 218-235, 2014.

[25] A. Jain, S. Ganti, “A taxonomy for evaluation and comparison of financial performance of Indian IT companies”, Adarsh Journal of Management Research, 8(2), pp. 1-13, 2015.

[26] B. Jurowska, “The Federal States of Germany – Analysis and Measurement of Development Using Taxonomic Methods”, Oeconomia Copernicana, Volume 5, Issue 3, pp. 49-73, 2014.

[27] A. Distaso, “Local sustainable development and well-being/well-being/quality of life. An application of the
capability approach at regional level”, Quaderno, 25, pp. 23-26, 2005.
[30] A. Nowak, P. Janulewicz, A. Krukowski, B. Bujanowicz-Haraś, “Diversification of the level of agricultural development in the member states of the European Union”, Cahiers Agricultures, 25: 55004, 2016.
[31] C. Martinez-Fernandez, I. Audirac, S. Fol, E. Cunningham-Sabot, “Shrinking Cities: Urban Challenges of Globalization”, International Journal of Urban and Regional Research, 36.2, pp. 213–25, 2012.
[32] A. M. Séguin, P. Apparicio, M. Riva, “Identifying, mapping and modelling trajectories of poverty at the neighbourhood level: The case of Montréal, 1986-2006”, Applied Geography, 35, pp. 265-274, 2012.
[33] H. A. O’Connell, J. Howell, Disparat City: Understanding Rising Levels of Concentrated Poverty and Affluence in Greater Houston, Rise Kinder, Kinder Institute for Urban Research (Houston), 2016. Available online at: http://kinder.rice.edu/reports/ [16.03.2017]
[34] E. C. M. Hui, J. Zhong, K. Yu, “Land use, housing preferences and income poverty. In the context of a fast rising market”, Land Use Policy, 58, pp. 289–301, 2016.
[35] M. Adato , M. R. Carter, J. May, “Exploring poverty traps and social exclusion in South Africa using qualitative and quantitative data”, The Journal of Development Studies, 42 (2), pp. 226-247, 2015.
[36] C. Keyder, “Globalization and Social Exclusion in Istanbul”, International Journal of Urban and Regional Research, 29.1, pp. 124-134, 2015.