TRANSITIONS INTO AND OUT OF NEAR POVERTY IN URBAN AND RURAL AREAS IN POLAND

ANNA SĄCZEWSKA-PIOTROWSKA
University of Economics in Katowice, Faculty of Economics,
Department of Statistical and Mathematical Methods in Economics,
1 Maja St. 50, Katowice, Poland
e-mail: anna.saczewska-piotrowska@ue.katowice.pl

Abstract

The aim of paper is to analyse the movement into and out of near poverty in urban and rural areas in Poland using Markov transition matrices. Three poverty states are considered: poverty, near poverty (income between 100 and 125 per cent of the poverty threshold is assumed in the paper) and above near poverty. The analysis is conducted for Poland based on the balanced panel from 2009 to 2015 (four waves: 2009, 2011, 2013, 2015) in the framework of the "Social Diagnosis" project. The panel contains almost four thousand households. The near poverty rate is higher in rural areas than in urban areas. The probability that a household will remain in near poverty in two years is higher in urban households and the probability that a household will exit from near poverty to poverty is higher in rural areas. The mean duration of stay in near poverty is slightly longer in urban areas.

Key words: *Markov chain, near poverty, poverty transitions, the Shorrocks mobility index, urban and rural areas.*

1. Introduction

Poverty is a phenomenon often analysed all over the world. The actions of governments and social organizations are designed to help poor households. There is a group of households living in near poverty – their income is only slightly higher than poverty line and these households usually do not receive any help. The actions of social policy should be focused on this group and they should prevent the exit to poverty. The aim of paper is to analyse movement into and out of near poverty in urban and rural areas in Poland using Markov transition matrices. There are considered three poverty states: poverty, near poverty and above near poverty. Markov chains will allow to predict the conditional probability of stay in near poverty in urban and rural areas. Based on transition matrices there will be computed the predicted distributions of poverty state in urban and rural areas. Estimated transition matrices will allow to estimate the mean duration of stay in poverty state and to compare the mobility from one poverty state to another in urban and rural areas. The poverty is a wide category covering monetary and nonmonetary aspects. We will focus on the economic aspects of poverty considered through the prism of income.

Dynamics of poverty is often analysed using several types of methods. The simplest method counts the number of years below the poverty line over a set observation window. More difficult methods use different kinds of models to decompose the income into permanent and transitory components or to estimate the hazard of leaving a poverty spell at given durations and for different characteristics. Dynamics of poverty in Poland is analysed, inter alia, by Sączewska-Piotrowska (2014).

Some authors use Markov chains to analyse income and poverty dynamics. Transition probability matrices for three states (poverty, near poverty and above near poverty) are calculated by Hokayem and Heggeness (2014). They analyse transitions and factors influencing transitions in United States of America from 2004 to 2012. In this paper there are estimated transition probability matrices based on idea proposed by Hokayem and Heggeness.

2. Definition of the Near Poverty

Income of households or families living in near poverty are close to, but not below, poverty threshold. The term "close to" is not clearly defined. The first idea of near poverty has been proposed by Orshansky (1966). She has defined the near poor as those living from 100 to 133 percent of the poverty threshold. From 1971 U.S. Census Bureau reports has contained information about near poor persons defined as those living from 100 to 125 percent of poverty threshold. The other authors propose different solutions concerning the definition of near poverty. Ben-Shalom et al. (2011) define the near poor as those living from 100 to 150 percent of poverty threshold. Short and Smeeding (2012) define the near poor very wide – as those living between 100 and 200 percent of poverty threshold. In one of the most recent study Hokayem and Heggeness (2014) returned to the idea of 125 percent definition.

It should be noted that poverty threshold in the United States is absolute (i.e. does not depend on the standard living of the other members of society and is defined as absolute needs standard remaining constant over time). The level of poverty in European Union (EU) is measured using relative poverty threshold (i.e. depends on the standard living of the other members of society and changes over time), mainly 60% of the national median income. There are also used thresholds set at 40% and 50% of the national median income. In the Luxembourg Income Study literature and in the analyses conducted by Organization for Economic Cooperation and Development (OECD) is often used 50% threshold. In the EU the 40% threshold referred to as "severe poverty" and 60% threshold is sometimes called "near poverty" (Gornick and Jäntti, 2009).

In the analysis the poverty threshold is set at 60% of the national income and the term "near poverty" is referred to income between 100 and 125 percent of the 60% threshold. Therefore, it is used European poverty threshold, but U.S. way of defining near poverty.

3. Discrete-Time Markov Chains

Discrete-time Markov chains (also called Markov chains) permit to model the transition probabilities between discrete states by the aid of matrices.

Markov chain with the state space $S = \{1,2,...,r\}$ is a stochastic process $\{X_n, n \geq 0\}$ with memoryless property

$$P(X_n = j \mid X_0 = i_0, X_1 = i_1, \ldots, X_{n-1} = i) = P(X_n = j \mid X_{n-1} = i) \tag{1}$$

for all $j, i, i_0, ..., i_{n-2} \in S$ (Bhat, 2000, pp. 98-99).

The probability

$$P(X_n = j \mid X_{n-1} = i) = p_{ij}(n), \tag{2}$$

is called the (one-step) transition probability at step *n*.

The Markov chain is said to be time homogeneous (or having stationary transition probabilities) if the transition probabilities from state i to state j are independent of time index *n*:

$$P(X_n = j \mid X_{n-1} = i) = P(X_{n+k} = j \mid X_{n+k-1} = i) = p_{ij,} \tag{3}$$

where p_{ij} is a probability of transitioning from state i to state j in a single step (per unit time). There will be considered only time homogeneous Markov chains.

The collection of all one-step transition probabilities forms a matrix:

$$\mathbf{P} = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1r} \\ p_{21} & p_{22} & \cdots & p_{2r} \\ \cdots & \cdots & \cdots & \cdots \\ p_{r1} & p_{r2} & \cdots & p_{rr} \end{bmatrix}. \tag{4}$$

One-step transition probability matrix satisfies the following conditions:

1. $\underset{i,j}{\forall} p_{ij} \geq 0,$
2. $\underset{i}{\forall} \sum_j p_{ij} = 1.$

The matrix $\mathbf{P}$ is therefore a stochastic matrix.

With known transition probability matrix it is possible to predict future distribution according to formula:

$$\mathbf{d}_n = \mathbf{d}_{n-1}\mathbf{P}, \tag{5}$$

hence

$$\mathbf{d}_n = \mathbf{d}_0\mathbf{P}^n, \tag{6}$$

where $\mathbf{d}_n = \begin{bmatrix} d_{n1} & d_{n2} & \cdots & d_{nr} \end{bmatrix}$ denotes distribution at time *n*, $d_{nj} = P(X_n = j)$.

A Markov chain with initial distribution $\mathbf{d}_0$ and with transition matrix $\mathbf{P}$ is ergodic if a limit (Podgórska et al., 2002, pp. 15-16)

$$\lim_{n\to\infty} \mathbf{d}_n = \lim_{n\to\infty} \mathbf{d}_0\mathbf{P}^n = \mathbf{d}_0\mathbf{E} = \mathbf{e} \tag{7}$$

exists independently from initial distribution $\mathbf{d}_0$. Matrix $\mathbf{E}$ is an ergodic stochastic matrix (has identical rows), vector $\mathbf{e}$ is a row of matrix $\mathbf{E}$.

There are used two types of data to estimate parameters of Markov chains: micro-data and macro-data. In our analysis there are available detailed micro-data for several time periods. In this case maximum likelihood estimators of the stationary transition probabilities over the entire sample period are given by (Anderson and Goodman, 1957; Podgórska et al., 2002, p. 63):

$$\hat{p}_{ij} = \frac{\sum_{t=1}^{m} v_{ij}(t)}{\sum_{t=1}^{m}\sum_{j=1}^{r} v_{ij}(t)}, \tag{8}$$

with $v_{ij}(t)$ denoting number of individuals transitioning from state *i* to state *j* in all periods $(t-1, t\rangle, t = 1,2,..., m.$

Transition probability matrices are often used to measure income mobility. Commonly used measure of mobility is the Shorrocks mobility index defined as (Shorrocks, 1978):

$$M_S = \frac{r - \text{Trace}(\mathbf{P})}{r-1}, \tag{9}$$

where r is the number of states. Prais (1955) has shown that the mean exit time from state *i* is given by:

$$\mu_i = \frac{1}{1-p_{ii}}, \tag{10}$$

where p_{ii} is the probability that an individual will remain in state *i* for one period to the next period. Shorrocks mobility index is the inverse of the harmonic mean of μ_i scaled by the ratio $r/(r-1)$.

4. Empirical Results

The analysis of the near poverty is conducted for Poland based on the balanced panel 2009 – 2015 (four waves: 2009, 2011, 2013, 2015) in the framework of "Social Diagnosis" project (Council for Social Monitoring, 2015). The panel contains 3653 households: 2060 in urban areas and 1593 in rural areas.

Generally, the Social Diagnosis is based on panel research. The first sample being taken in 2000. The next sample took place three years later and since then measurement has been repeated every two years (eight waves in 2000 – 2015). The project takes into account both economic and noneconomic aspects of life of households and their members.

Poverty analysis adopts economic definition of poverty. We assume that the indicator for poverty measurement is net income of households in Poland in March/June 2009, 2011, 2013 and 2015. In order to take account of the differences in a household's size and its composition there is calculated equivalised income by dividing the household's income by its equivalent size. There was used the modified OECD equivalence scale. This scale assigns 1 to the first adult of the household, 0.5 to each subsequent adult aged 14 or more and 0.3 to children (each person under 14). Poverty threshold is set at 60% of the median equivalised income.

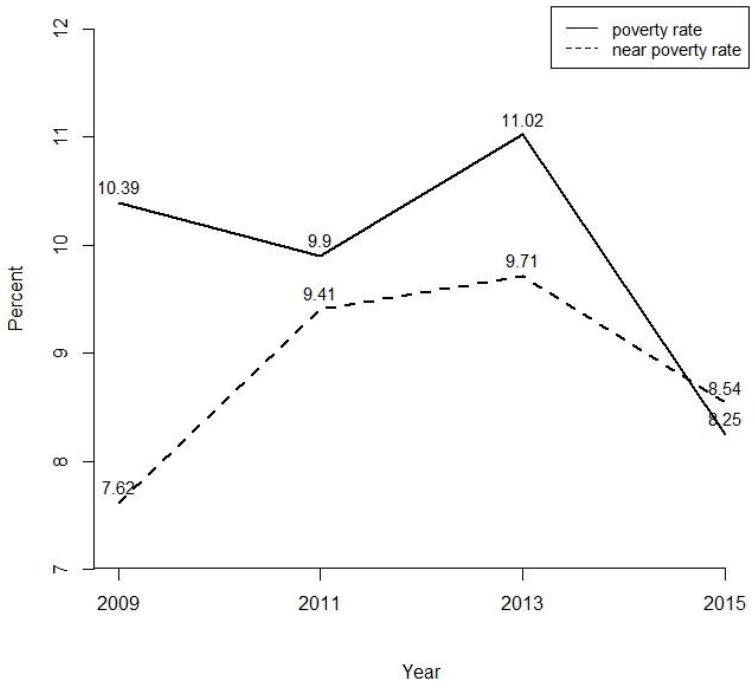
It is considered a Markov chain with state space $S = \{1,2,3\}$ representing poor, near poor and above near poor. The term "near poverty" is referred to households living between 100 and 125 percent of the 60% of the median equivalised income. The Markov chain is defined in terms of poverty state of a household assuming that the poverty state of household in a given year depends on the poverty state of household in the previous period, i.e. two years earlier (in our case single step lasts two years).

All calculations related to the Markov chains are performed in R program (R Core Team, 2016) using `msm` (Jackson, 2016) and `markovchain` (Spedicato et al., 2016) packages.

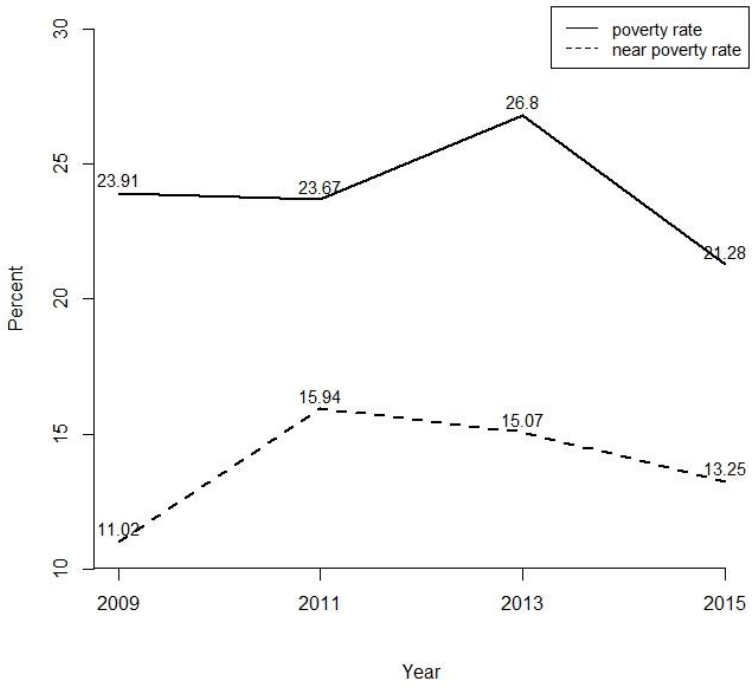
To the best of author's knowledge, the near poverty rate in Poland has never calculated. For this reason in the first step there will be calculated near poverty rates in each wave of panel in urban and rural areas. Figure 1 presents poverty rates and near poverty rates over the time period 2009 – 2015 in urban and rural areas.

Figure 1: Poverty and near poverty rates in urban and rural areas

a) urban areas



b) rural areas



Source: the author based on Council of Social Monitoring (2015).

In all years poverty rate is more than two times higher in rural areas than in urban areas. It can be seen that changes in poverty rates are similar in both urban and rural areas – slight decrease in 2011, large increase in 2013 and significant decrease in 2015. In urban areas the values of near poverty rate are similar to poverty rate values. In rural areas there is a significant difference between poverty and near poverty rates – the poverty rate is higher by 10 percentage points. From 2009 to 2015 the changes in near poverty rates in urban and rural areas are different. In urban areas the rate has been increasing from 2009 to 2013 and in 2015 the rate has significantly decreased. The near poverty rate in rural areas has been increasing from 2009 to 2011 and in the subsequent years the rate has been gradually decreasing.

Table 1 shows the near poverty entry rates from poverty and from above near poverty.

Table 1: Near poverty entry rates (%)

Areas	2009 – 2011	2011 – 2013	2013 – 2015
a) near poverty entry from poverty			
Urban	15.42	11.76	21.15
Rural	16.27	13.26	17.10
b) near poverty entry from above near poverty			
Urban	5.68	5.78	3.37
Rural	10.76	10.19	5.40

Source: the author.

In urban and rural areas the lowest percentage of households enter into near poverty from poverty between 2011 and 2013, the highest percentage – between 2013 and 2015. In the last period the lowest percentage of households enter into near poverty from above near poverty, in the other two periods the percentages were at a higher similar level. We can conclude that in both urban and rural areas the most positive changes in economic situation were taking place between 2013 and 2015.

In Table 2 there are shown near poverty exit rates to poverty and to above near poverty.

Table 2: Near poverty exit rates (%)

Areas	2009 – 2011	2011 – 2013	2013 – 2015
a) near poverty exit to poverty			
Urban	20.38	19.07	14.50
Rural	24.23	28.74	17.50
b) near poverty exit to above near poverty			
Urban	38.22	39.69	49.00
Rural	37.89	35.04	45.83

Source: the author.

It can be seen that between 2013 and 2015 the lowest percentage of households exit near poverty to poverty and the highest percentage of households exit near poverty to above near poverty. It means that between 2013 and 2015 has taken place the largest improvement of the economic situation. These changes have been occurred in both urban and rural areas. The least favorable changes in the economic situation have taken place between 2009 and 2011 in the case of urban areas, between 2011 and 2013 in the case of rural areas.

In the next step there has been estimated transition probability matrices for households in urban areas:

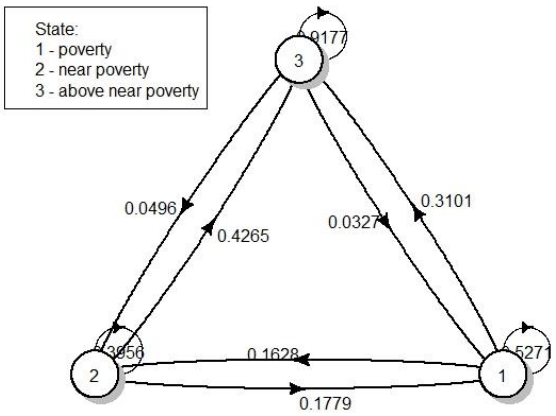
$$\hat{\mathbf{P}}_U = \begin{bmatrix} 0.5271 & 0.1628 & 0.3101 \\ 0.1779 & 0.3956 & 0.4265 \\ 0.0327 & 0.0496 & 0.9177 \end{bmatrix}$$

and for households in rural areas:

$$\hat{\mathbf{P}}_R = \begin{bmatrix} 0.6371 & 0.1561 & 0.2068 \\ 0.2358 & 0.3689 & 0.3953 \\ 0.0759 & 0.0884 & 0.8357 \end{bmatrix}$$

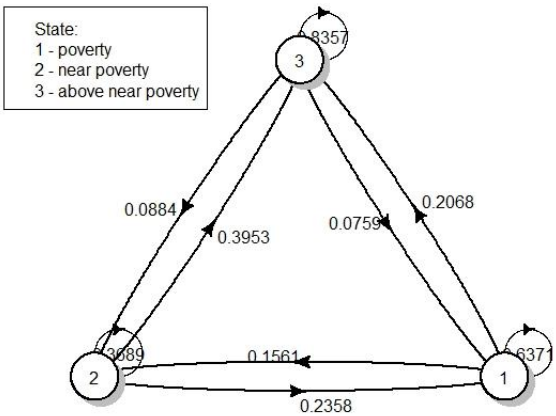
The elements of estimated matrices represent transition probabilities from one poverty state to another. The main diagonal elements of matrices indicate the probability that the household will remain in the same poverty state in the next period (in two years). Transition probability matrices are illustrated in Figure 2 (for urban households) and in Figure 3 (for rural households).

Figure 2: Markov chain plot for urban households 2009 – 2015



Source: the author.

Figure 3: Markov chain plot for rural households 2009 – 2015



Source: the author.

It can be seen that the probability of remaining above near poverty is very high in urban and rural areas (0.9177 and 0.8357 respectively). The probability of remaining in near poverty is higher in urban areas than in rural areas (0.3956 and 0.3689 respectively). In both areas exit from near poverty to above near poverty is more likely than exit from near poverty to poverty, but the probability of improvement of economic situation is higher in urban areas than in rural areas (0.4265 and 0.3953 respectively). Given that a household is near poor in one year, after two years the probability of that household will be poor is 0.1779 in urban areas and 0.2358 in rural areas.

From the transition matrices there have been computed the values of Shorrocks mobility indices. The values of this index in urban and rural areas are very similar (0.5797 and 0.5791) and indicate that the degree of mobility is quite high. It means that a lot of households have chances to change their economic situation. It should be remembered that the index is general measure and does not show the direction of mobility. Shorrocks mobility index is related to the mean duration of stay in poverty state (Table 3).

Table 3: Mean duration of stay in poverty state in urban and rural areas (two-year unit)

State	Urban areas	Rural areas
Poverty	2.1148	2.7558
Near poverty	1.6547	1.5846
Above near poverty	12.1561	6.0869

Source: the author.

Mean exit time from poverty is longer in rural areas and mean exit time from above near poverty is clearly longer in urban areas. It means that the good economic situation lasts longer in urban areas than in rural areas. Mean duration of stay in near poverty is slightly longer in urban areas. Generally, mean exit time from near poverty is much shorter in comparison with other mean exit times.

Based on actual distribution of households by poverty state and based on transition probabilities there have been calculated the predicted distributions in urban (Table 4) and rural areas (Table 5).

Table 4: Actual and predicted distributions of poverty state in urban areas

State	Distribution			
	2015 (actual)	2017	2019	Ergodic
Poverty	0.0825	0.0859	0.0880	0.0910
Near poverty	0.0855	0.0885	0.0899	0.0915
Above near poverty	0.8320	0.8256	0.8221	0.8175

Source: the author.

Table 5: Actual and predicted distributions of poverty state in rural areas

State	Distribution			
	2015 (actual)	2017	2019	Ergodic
Poverty	0.2128	0.2165	0.2198	0.2255
Near poverty	0.1325	0.1340	0.1423	0.1441
Above near poverty	0.6547	0.6435	0.6379	0.6304

Source: the author.

Predicted distributions in 2017 and in 2019 are very similar to actual distribution. Markov chains for urban and rural are ergodic and reach their limit distributions. It means that in both areas in the long run the poverty state will not depend on the current poverty state. The difference between actual and ergodic distribution is not high and indicates small modification among the poverty states.

5. Conclusion

The purpose of this paper is to analyse movement into and out of near poverty in urban and rural areas in Poland. It can be stated that in 2009 – 2015 the range of near poverty is higher in rural areas than in rural areas. The most positive changes in economic situation have taken place between 2013 and 2015. On the one hand, in 2015 in both urban and rural areas the highest percentages of households enter near poverty from poverty and the highest percentages exit near poverty to above near poverty. On the other hand, in 2015 the lowest percentages enter near poverty from above near poverty and exit near poverty to poverty. The probability that a household living in near poverty improves its economic situation is higher than probability of worsening its situation. Mean exit time from near poverty is slightly longer in urban areas than in rural areas.

Natural direction for further research is estimating models to answer the question which factors (besides place of residence) cause that some households stay in the near poverty and some households move into and out of the near poverty. There should be included in models factors related to the age, gender and education of the household's head, household size, labor force status etc. Taking into account these factors will give more information about near poverty than initial analysis presented in this paper.

References

[1] ANDERSON, T. W., GOODMAN, L. A. 1957. Statistical-interference about Markov chains. In Annals of Mathematical Statistics, 1957, vol. 28, no. 1, pp. 89-110.

[2] BEN-SHALOM, Y., MOFFITT, R. A., SCHOLZ, J. K. 2011. An Assessment of the effectiveness of anti-poverty programs in the United States. In National Bureau of Economic Research Working Paper No. w17042.

[3] BHAT, B. R. 2000. Stochastic models. Analysis and applications. New Delhi : New Age International, 2000, ISBN: 81-224-1228-9.

[4] COUNCIL FOR SOCIAL MONITORING. 2015. Integrated database, http://www.diagnoza.com.

[5] GORNICK, J. C., JÄNTTI, M. 2009. Child poverty in upper-income countries: lessons from the Luxembourg Income Study, Luxembourg Income Study Working Paper Series, Working Paper No. 509.

[6] HOKAYEM, C., HEGGENESS, M. L. 2014. Factors influencing transitions into and out near poverty: 2004-2012. In SEHSD Working Paper 2014-05. Washington : U.S. Census Bureau, 2014.

[7] JACKSON, C. 2016. Msm: multi-state Markov and hidden Markov models in continuous time, https://cran.r-project.org/web/packages/msm/index.html.

[8] ORSHANSKY, M. 1966. Recounting the poor – a five-year review. In Social Security Bulletin, vol. 29, iss. 4, pp. 20-37.

[9] PODGÓRSKA, M. et al. 2002. Łańcuchy Markowa w teorii i w zastosowaniach. Warszawa : Szkoła Główna Handlowa, 2002. ISBN 83-7225-196-7.

[10] PRAIS, S. J. 1955. Measuring social mobility. In Journal of the Royal Statistical Society, Series A, Part I, 118, pp. 56-66.

[11] R CORE TEAM 2016: R : a language and environment for statistical computing. Vienna : R Foundation for Statistical Computing, 2016, http://www.r-project.org.

[12] SĄCZEWSKA-PIOTROWSKA, A. 2014. Analysis of poverty transitions in Poland using multilevel discrete-time event history models. In Proceedings of 17th AMSE, Poland, Jerzmanowice 2014, pp. 219-228, http://amse.ue.wroc.pl/proceedings.html.

[13] SHORROCKS, A. F. 1978. The measurement of mobility. In Econometrica, vol. 46, iss. 5, pp. 1013-1024.

[14] SHORT, K. SMEEDING, T. Understanding income-to-threshold ratios using the supplemental poverty measure, U.S. Census Bureau Social, Economic, and Housing Statistics Division Working Paper No. 2012-18.

[15] SPEDICATO, G. A. et al. 2016. Markovchain: easy handling discrete time Markov chains, https://cran.r-project.org/web/packages/markovchain/index.html.