On the Regional Convergence of Income at District Level in Slovakia[1]

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Abstract

The aim of this paper is to investigate regional convergence of income at district level in Slovakia, and to answer the question of whether Slovak districts converge or diverge over time, and across different sectors of the Slovak economy. Our analyses are based on monthly income data on median wages and old-age pensions at district territorial level (LAU 1), and two types of convergence are assessed: convergence towards national median income and convergence towards regional (NUTS 3 regions) median income. Using the Markov chains on the spatially lagged bimonthly district medians we find that the highest degree of wages convergence is found in the districts of Banská Bystrica, Žilina and Nitra Regions; and the highest degree of old-age pensions convergence is found in the districts of Košice and Banská Bystrica Regions. The given trends are influenced by the wages development in different economic activity sectors in these regions.

Keywords: *regional convergence, income polarization, Markov chains, Slovakia*

JEL Classification: I31, I32, D31, R12

Introduction

The debate about convergence of incomes started to appear in Slovak literature as Slovak Republic became one of the countries to access the European Union (EU). In this regard, two different streams of literature began to appear in

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empirical literature. The first stream is focused on the position of Slovakia in the EU and the convergence patterns of the Slovak economy towards the EU average at the time of its accession (Brzica, 2002; Šikula, 2003; Šikulová, 2004). This stream of literature was later extended by studies analysing the changes in Slovakia's position over time (Vintrová, 2009; Čarnický et al., 2017; Formánek, 2018). The second stream of literature emphasizes regional convergence within a country or a group of countries (Baláž, 2004; Chocholatá and Furková, 2016; Horridge and Rokicki, 2017), regional inequalities (Kämpfer, 2008) or regional disparities (Tvrdoň and Skokan, 2011; Klamár, 2016). Only very few studies assess convergence in terms of personal income (e.g. Pauhofová and Páleník, 2005) or consumption expenditures (Liobikiene and Mandravickaite, 2013).

The majority of empirical studies are based on macroeconomic aggregates such as gross national/regional product/income or gross value added, which does not necessarily reflect the welfare of the population, see for example the report by the Commission on the Measurement of Economic Performance and Social Progress (Stiglitz, Sen and Fitoussi, 2010). Unlike most similar studies, in this paper regional convergence is assessed in terms of wages and old-age pensions. Our aim is thus to contribute to empirical literature on regional convergence of personal income, and to answer the question of whether incomes at district level in Slovakia converge over time and across different sectors of the economy. We believe that, as opposed to the macroeconomic aggregates, such a proxy of income reflects the true nature of people's welfare and to some extent allows us to assess the convergence of living conditions at regional level.

From the methodological viewpoint, convergence of regions has been investigated in economic literature since the 1950s, and in principle two fundamental approaches to the assessment of income convergence are discussed in the literature. First, the regression approach is based on the Solow (1956) and Swan (1956) models of economic growth, elaborated by Baumol (1986) and Barro and Sala-i-Martin (1992). Quah (1993a) argued that the traditional models were unable to produce a diverging distribution over time or to provide a more detailed insight into data structure, and thus he proposed a distribution dynamics approach as an alternative to the traditional models to the regional convergence assessment (Quah, 1993b; 1997). Quah (1993a) argues that developing a probability model of transitions can be used to generate a characterization of the steady state, and that discrete Markov chains can be used to approximate and estimate a 'law of motion' for the evolving distribution. Thus, Markov chains, as one of the distribution dynamics methods, allow us to study an evolution in time of an entire cross-section distribution (Bulli, 2001). Due to the spatial nature of data, the original income distribution dynamics approaches had to be adjusted in order to account for space (Fischer and Stumpner, 2008; Rey, 2014).

Our analyses are based on monthly income data on median wages and old-age pensions at district territorial level (LAU 1). Due to a high level of income polarization in Slovakia (see e.g. Pauhofová and Želinský, 2015; Pauhofová et al., 2016) two assessments of regional convergence are performed: convergence of district income toward national median income and towards regional (NUTS 3) median income.[2] Thus, two different types of results are presented – results relativized to the national median, and results relativized to regional medians. From the perspective of economic policy, results relativized to the national median are of higher importance, as income distribution policy is applied at the national level.

We assume that the results obtained in this study will allow us either to explain certain patterns of a polarization tendency, or to disconfirm the hypothesis of income polarization. In particular, we study whether the convergence/divergence process in terms of wages and old-age pensions are of a similar nature in the whole spectrum of Slovak districts, or whether certain districts differ in some sense. However, we have to differentiate between regional convergence towards regions with a low wage level, and convergence towards regions with a higher wage level. Taking into account the results on the convergence/divergence of wages across the sectors of the Slovak economy allows us to identify the regions that contribute significantly to the overall convergence/divergence of wages and old-age pensions.

Using the Markov chains on the spatially lagged bimonthly district medians we find that the highest degree of wages convergence is found in the districts of Banská Bystrica, Žilina and Nitra Regions; and the highest degree of old-age pensions convergence is found in the districts of Kosice and Banská Bystrica Regions. In the case of Banská Bystrica and Nitra Regions we observe a type of convergence, in which districts converge to districts with an overall low level of wages, while the districts of Žilina Region converge to districts with a high level of wages. A higher level of convergence in terms of old-age pensions is observed in the districts of Kosice Region, in which the districts converge to a higher level of old-age pensions. The results further suggest an increase in wage inequalities across regions and within regions, and also among economic branches.

1. Description of Data and Methods

The analyses performed in this study are based on monthly data obtained from the Slovak Social Insurance Agency. We focus on median gross wages and old-age pensions at district level in the period of 2005 – 2015. Data on median

[2] See Appendix for the administrative division of Slovakia. For the distribution of incomes at district level of Slovakia see e.g. Pauhofová and Želinský (2015).

gross wages are further broken down by three sectors of economic activity grouped into three standard groups: *primary sector* – section A of NACE[3] Rev. 2 or sections A and B of NACE Rev. 1.1; *secondary sector* – sections B to F of NACE Rev. 2 or sections C to F of NACE Rev. 1.1; and *tertiary sector* – sections G to U of NACE Rev. 2 or (sections A to P of NACE Rev. 1.1).

The relative value of an income indicator is defined as a fraction of the indicator's absolute value for region r ($r = 1, 2, \ldots, R$) and time t ($t = 1, 2, \ldots, T$) and the median value of income indicators across all R regions in time t, i.e.:

$$y_{rt} = \frac{Y_{rt}}{med(Y_t)} \tag{1}$$

The continuous relative income values are discretised by dividing the whole sample into $N = 5$ mutually exclusive and exhaustive income classes (states) with equal frequencies (i.e. quintiles) and fixed bounds across the entire time span.

In Quah's (1993a; 1993b) tradition, the empirical investigation of median relative income level at the regional (district) level in Slovakia is based on a finite first-order Markov chain. A Markov chain is a stochastic process with the Markov property, i.e. a future state depends only on the present state. Put differently, a transition probability p_{ij}, i.e. the probability of moving from state i in period t to state j in period $t + 1$, depends only on the state i occupied in period t. Transition probabilities p_{ij} are thus determined entirely by the current state and remain fixed over time (Grinstead and Snell, 1997).

A time-stationary Markov chain process is thus summarized by a transition matrix $\mathbf{\Pi}$ (Grinstead and Snell, 1997; Bickenbach and Bode, 2003):

$$\mathbf{\Pi} = \begin{pmatrix} p_{11} & p_{12} & \cdots & p_{1N} \\ p_{21} & p_{22} & \cdots & p_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ p_{N1} & p_{N2} & \cdots & p_{NN} \end{pmatrix}$$

where p_{ij} is a transition probability of moving from state i in period t to state j in period $t + 1$; $p_{ij} \geq 0$ for all $i, j \in N$; $N = \{1, 2, \ldots, N\}$ – a finite state space; and $\sum_{j=1}^{N} p_{ij} = 1$.

As pointed out by Ray (2001) and Bickenbach and Bode (2003), the estimated transition probability matrices usually do not bear important information regarding the evolution of the income distribution, and thus are not reported in this study

[3] Statistical classification of economic activities in the European Community.

(however, they can be obtained from the authors upon request). Our results are, however, based on estimating a limiting distribution, which as suggested by Rey (2001) can be used to characterize the direction of the evolution.

For a given transition matrix $\mathbf{\Pi}$ and an initial distribution $\mathbf{h}(0)$, the distribution after the first transition period is defined as as $\mathbf{h}(1) = \mathbf{h}(0)\mathbf{\Pi}$, and after the τ^{th} transition periods as $\mathbf{h}(\tau) = \mathbf{h}(0)\mathbf{\Pi}^{\tau}$. The limiting distribution $\mathbf{h}^{*}$ is then the probability distribution $\mathbf{h}(\tau)$ as $\tau \to \infty$:

$$\mathbf{h}^{*} = \lim_{\tau \to \infty} \mathbf{h}(0)\mathbf{\Pi}^{\tau} \tag{2}$$

Grinstead and Snell (1997) show that if the transition matrix is primitive (i.e. if there exists some $\tau \geq 1$ such that every element of $\mathbf{\Pi}^{\tau}$ is positive), the probability distribution $\mathbf{h}(\tau)$ converges to the limiting distribution $\mathbf{h}^{*}$ as τ becomes large; and that $\mathbf{h}^{*}$ does not depend on the initial distribution $\mathbf{h}(0)$. The estimation of limiting distribution in this paper is based on an identification starting from finding which eigenvectors correspond to identity eigenvalues, and then normalizing them to sum up to unity.

All calculations in this paper are performed in R environment (R Core Team, 2017) with packages ‘markovchain’ (Spedicato, 2017), ‘msm’ (Jackson, 2011), ‘rgdal’ (Bivand, Keitt and Rowlingson, 2017), ‘spdep’ (Bivand and Piras, 2015; Bivand, Hauke and Kossowski, 2013), ‘maptools’ (Bivand and Lewin-Koh, 2017) and ‘classInt’ (Bivand, 2017).

In our interpretations we will focus on estimated limiting distributions $\hat{\mathbf{h}}^{*}$, which are under the assumption of a finite first-order Markov chain process independent of the initial distributions. Comparing the estimated limiting distribution $\hat{\mathbf{h}}^{*}$ with the initial income distribution $\mathbf{h}(0)$ indicates the level of convergence or divergence across regions. An increase in the probabilities of the median-income class of the limiting distribution indicates convergence, while an increase in probabilities in the lowest and highest classes (at the same time) indicates divergence.

The properties described in this section are valid for a first-order Markov chain, and thus it is necessary to test homogeneity and independence in order to verify the assumptions. Due to the spatial nature of data, we test both time and spatial homogeneity, and time and spatial independence in order to decide whether the transition probabilities can be assumed constant over time and space (homogeneity) and of order 1 (independence), as proposed by Bickenbach and Bode (2003).

The assumption of time (spatial) homogeneity assumes that the transition probabilities of the first-order Markov chain are constant over time (space). If specific time periods (or alternatively groups of regions) follow different processes, estimations based on an entire sample may lead to incorrect conclusions. If these assumptions are violated, the sample should be divided into more homogeneous time sub-periods (or alternatively subgroups of regions), and estimate a limiting distribution for each sub-period (or alternatively subgroup). Time independence is the main property of Markov chains (so-called 'Markov property'), assuming that transition probabilities do not depend on states at previous points in time. Analogously, spatial independence assumes that the income level of a region does not depend on the income of the neighbouring regions. In the presence of time dependence it is suggested to assume that transition periods are longer than one period, and to use averages of several consecutive periods. Similarly, in a case of spatial dependence it is suggested to modify the Markov process such that it captures transitions of regions and their neighbours simultaneously (Besag, 1974), e.g. replacing an actual value of income by an average income of neighbouring regions.

All tests in this part of the section are adapted from Bickenbach and Bode (2003) and adjusted to our data.

The test of time homogeneity is performed by dividing the sample into M mutually exclusive sub-periods (m = 1, 2, …, M; $M \leq T$). We test $H_0 : \forall m : p_{ij|m} = p_{ij}$ against $H_a : \exists m : p_{ij|m} \neq p_{ij}$; $(m = 1, \ldots, M)$ implementing the following Pearson chi-squared statistic:

$$Q^M = \sum_{m=1}^{M} \sum_{i=1}^{N} \sum_{j \in A_i} n_{i|m} \frac{\left(\hat{p}_{ij|m} - \hat{p}_{ij} \right)^2}{\hat{p}_{ij}} \sim \chi^2 \left(\sum_{i=1}^{N} (a_i - 1)(b_{i|m} - 1) \right) \qquad (3)$$

where $\hat{p}_{ij|m} = \frac{\sum_{t \in m} n_{ij|m}(t)}{\sum_{t \in m} n_{i|m}(t-1)}$ – the estimated transition probability for sub-period m, $\hat{p}_{ij} = \frac{n_{ij}}{n_i}$ – the transition probability estimated for the whole sample. In our case the sample is divided into three sub-periods (annual transitions between 2005 and 2008, 2008 and 2012, and 2012 and 2016). The degrees of freedom are determined as the number of additional independent restrictions imposed by H_0 as compared to H_a, with a_i being the number of elements in the set $A_i = \left\{ j : \hat{p}_{ij} > 0 \right\}$, i.e. a set of positive transition probabilities in the i^{th} row of the original transition matrix, and $b_{i|m}$ the number of sub-periods with a positive number of observations in the i^{th} row in the subset $B_{i|m} = \left\{ m : n_{i|m} > 0 \right\}$. H_0 is rejected if Q^M exceeds the critical value.

Due to the spatial nature of data it is necessary to test whether groups of regions follow the same process. With respect to this test the sample is divided into V mutually exclusive and exhaustive subsamples (v = 1, 2, …, V; $V \leq R$). We test $H_0 : \forall m : p_{ij|v} = p_{ij}$ against $H_a : \exists v : p_{ij|v} \neq p_{ij}$; $(v = 1,\ldots,V)$ implementing the following Pearson chi-squared statistic:

$$Q^V = \sum_{v=1}^{V}\sum_{i=1}^{N}\sum_{j\in A_i} n_{i|v}\frac{\left(\widehat{p}_{ij|v} - \widehat{p}_{ij}\right)^2}{\widehat{p}_{ij}} \sim \chi^2\left(\sum_{i=1}^{N}(a_i - 1)(b_{i|v} - 1)\right) \qquad (4)$$

where $\widehat{p}_{ij|v} = \frac{\sum_{t\in v} n_{ij|v}(t)}{\sum_{t\in v} n_{i|v}(t-1)}$ is the estimated transition probability for subsample v, and $\widehat{p}_{ij} = \frac{n_{ij}}{n_i}$. In our case the sample is divided into three subsamples: Western Slovakia, Central Slovakia and Eastern Slovakia. Similarly to the case of time homogeneity, a_i is the number of elements in the set $A_i = \left\{ j : \widehat{p}_{ij} > 0 \right\}$, i.e. a set of positive transition probabilities in the i^{th} row of the original transition matrix, and $b_{i|v}$ the number of subsamples with a positive number of observations in the i^{th} row in the subset $B_{i|v} = \left\{ v : n_{i|v} > 0 \right\}$.

Time independence (or the so-called 'Markov property') assumes that the probability of a random variable being in the state j at time t independently of the states in the previous periods, i.e.:

$$P\{X(t) = j \mid X(t-1) = i, X(t-2) = i_{t-2}, \ldots, X(0) = i_0\} = P\{X(t) = j \mid X(t-1) = i\} \quad (5)$$

As proposed by Tan and Yilmaz (2002) and further elaborated by Bickenbach and Bode (2003), we first test order 0 versus order 1 (equation (6)): $H_0 : \forall i : p_{ij} = p_j$ against $H_a : \exists i : p_{ij} \neq p_j$; $(i = 1,\ldots,N)$, and then order 1 versus order 2 (equation (7)): $H_0 : \forall h : p_{hij} = p_{ij}$ against $H_a : \exists h : p_{hij} \neq p_{ij}$; $(h = 1,\ldots,N)$:

$$Q^{O(0)} = \sum_{i=1}^{N}\sum_{j=1}^{N} n_i(t-1)\frac{\left(\widehat{p}_{ij} - \widehat{p}_j\right)^2}{\widehat{p}_j} \sim \chi^2\left((N-1)^2\right) \qquad (6)$$

$$Q^{O(1)} = \sum_{h=1}^{N}\sum_{i=1}^{N}\sum_{j\in C_i} n_{hi}\frac{\left(\widehat{p}_{hij} - \widehat{p}_{ij}\right)^2}{\widehat{p}_{ij}} \sim \chi^2\left(\sum_{i=1}^{N}(c_i - 1)(d_i - 1)\right) \qquad (7)$$

where $\hat{p}_j = \frac{n_j}{n}$, $\hat{p}_{hij} = \frac{\sum_{t=2}^{T} n_{hij}(t)}{\sum_{t=2}^{T} n_{hi}(t-1)}$ is the transition probability given observations were in h^{th} income class in period $t - 2$, c_i and d_i are the numbers of elements in the sets $C_i = \left\{ j : \hat{p}_{ij} > 0 \right\}$ and $D_i = \left\{ h : n_{hi} > 0 \right\}$ respectively; and the sample is divided into N subsamples representing the regions' income at time $t - 2$. If order 0 is rejected, while the test of order 1 against order 2 is not, the process is assumed to be of order 1. However, if the latter test is also rejected, the process can be of higher order, which becomes difficult to test and the results might be unreliable (Bickenbach and Bode, 2003).

Again, due to the spatial nature of data, it is further necessary to test spatial independence, i.e. whether income level in a region depends on income level in its neighbours. As suggested by Rey (2001) and further elaborated by Bickenbach and Bode (2003) the sample is divided into N subsamples, while subsample s (s = 1, …, N) is used to estimate the transition probabilities for regions neighbouring with regions whose average relative income falls into class s. Now, we test $H_0 : \forall s : p_{ij|s} = p_{ij}$ against $H_a : \exists s : p_{ij|s} \neq p_{ij}$; $(s = 1, \ldots, N)$ employing the following Pearson chi-squared statistic:

$$Q^V = \sum_{s=1}^{N} \sum_{i=1}^{N} \sum_{j \in A_i} n_{i|s} \frac{\left(\hat{p}_{ij|s} - \hat{p}_{ij} \right)^2}{\hat{p}_{ij}} \sim \chi^2 \left(\sum_{i=1}^{N} (a_i - 1)(b_{i|s} - 1) \right) \quad (8)$$

where $\hat{p}_{ij|s} = \frac{\sum_{t \in s} n_{ij|s}(t)}{\sum_{t \in s} n_{i|s}(t-1)}$ is the transition probability given observations were surrounded by regions whose relative income falls into class s and $\hat{p}_{ij} = \frac{n_{ij}}{n_i}$.

The results of the performed tests (see Table 1) indicate that the transition probabilities of the first-order Markov chain can be assumed constant over time (we fail to reject the null hypothesis of time homogeneity). Although that assumption does not hold for the results broken down by sectors, omitting highly influential observations leads to the assumption of constant probabilities over time, and thus we do not break down the results by periods.[4]

Moreover, we do not fail to reject the null for testing the time independence. The test results suggest that the Markov chain is of an order higher than 2. Following the recommendations by Bickenbach and Bode (2003), we use biannual income levels defined as averages of median incomes across two successive

[4] Results broken down by sectors and periods can be obtained from the authors upon request.

years. Although even the biannual transitions indicate a process of an order higher than 2 (with the exception of old-age pensions), the test statistics are inflated by a small number of highly influential observations. If contribution of those rows to the test statistics values are not taken into account, the overall test statistics decrease, and we fail to reject the null, assuming a Markov chain process of order 1.

Table 1

Tests of Homogeneity and Independence Results

Test	**Gross wages broken down by economic activity sectors:**				**Pensions**
	all sectors	primary	secondary	tertiary	
(1) Time homogeneity	38.59 (30) [0.1352]	93.28 (40) [0.0000]	51.32 (30) [0.0090]	98.11 (32) [0.0000]	89.39 (16) [0.0000]
(2) Spatial homogeneity	1 354.73 (93) [0.0000]	825.82 (132) [0.0000]	1 315.11 (96) [0.0000]	678.57 (98) [0.0000]	525.51 (48) [0.0000]
(3) Time independence: monthly	6 479.59 (47) [0.0000]	3 111.45 (80) [0.0000]	4 969.21 (47) [0.0000]	5 221.89 (54) [0.0000]	2 421.20 (14) [0.0000]
(4) bimonthly	685.85 (14) [0.0000]	373.06 (41) [0.0000]	660.53 (17) [0.0000]	660.53 (17) [0.0000]	714.39 (14) [0.0000]
(5) Spatial independence	1 087.91 (60) [0.0000]	738.61 (80) [0.0000]	655.01 (60) [0.0000]	283.83 (64) [0.0000]	365.16 (28) [0.0000]

Notes: The table reports results of tests of Markov chain assumptions. Gross wages are assessed at all NACE levels and at primary, secondary and tertiary sectors. For type of income and performed test the following characteristics are reported: value of test statistics, number of degrees of freedom (in parentheses) and p-value [in square brackets].

Source: Own table based on Slovak Social Insurance Company data.

The results also indicate spatial heterogeneity, which is why we also present separate results broken down by regions. The presence of spatial dependence in the Markov chain process is addressed by employing spatial lags of income variables (i.e. the original value is replaced by a spatial average of neighbouring regions (definition of neighbours is based on contiguity) and the value itself), and similarly, the presence of time dependence is addressed by using bimonthly averages.[5]

2. Results and Discussion

In this section we present the main results for gross wages and old-age pensions separately. We present the limiting distributions of income (transition matrices can be obtained from the authors upon request), while two different approaches

[5] Although even using the bimonthly averages leads to the rejection of the null hypothesis of time independence, the test statistics values decrease considerably (compare values in rows (3) and (4) in Table 1), and the values are inflated by a small number of large values. Complete test results including the contribution of time periods/regions to the test statistics values can be provided by the authors upon request.

were used to determine the class intervals: country-wide classes and region-specific classes. While country-wide classes indicate convergence/divergence of district incomes relative to a median Slovak district income, region-specific classes capture the level of convergence/divergence of district incomes relative to median income in a specific region (NUTS 3 level).

2.1. Gross Wages

Table 2 presents the limiting distribution of wages (only country-wide class intervals are reported, as using the region-specific intervals resulted in uniform distribution).

While the limiting distributions at country level across all NACE subdivisions are rather uniform,[6] our interpretations are focused on convergence/divergence processes across Slovak regions.[7]

An increase in the probabilities of the median-income class (i.e. class 3) of the limiting distribution indicates convergence, whereas an increase in the probabilities in the lowest and highest classes indicates divergence.

The results in Table 2 suggest that while the Western Slovakia districts (in Bratislava, Trnava and Trenčín Regions) are more likely to belong to higher income districts, Eastern Slovakia districts (in Prešov and Košice Regions) are more likely to belong to low-income districts. A relatively higher degree of convergence towards the national median income is observed in Nitra (Western Slovakia) and Central Slovakia Regions districts (Žilina and Banská Bystrica Regions).

However, the positions of Banská Bystrica Region districts are ambiguous – under certain conditions it converges to the national median income class (economy as a whole, agricultural and manufacturing sectors), while under different conditions (services sectors) it converges towards low-income class districts.

Limiting distributions by NACE suggest a high level of convergence towards higher wages in the primary sector in the districts of Bratislava, Trnava, Trenčín, and to some extent also in Nitra Regions. In contrast, districts of Prešov, Košice and Banská Bystrica converge to lower wages in the same sector. With respect to the manufacturing sector, the highest level of convergence is reported in Bratislava and Trnava Regions, and followed by Žilina Region. As opposed to that, the districts of Prešov, Banská Bystrica and Košice Regions converge to the districts with low wage levels in manufacturing. Trenčín and Nitra Regions are situated in the centre of the convergence spectrum. Regional convergence under

[6] Moreover, spatial homogeneity assumption does not hold (see Table 1).

[7] Limiting distributions based on region-specific class intervals can be obtained from the authors upon request.

the influence of wage development in the services sector approaches regions with a higher wage level, while Bratislava and Trnava regions are the most similar, followed by Trenčín, partly Žilina and to some extent also Košice Region. Convergence towards districts with lower wages in the services sector is also characteristic of the districts of Prešov and Banská Bystrica Regions.

Table 2

Limiting Distributions of Wages at Regional Level, Broken Down by Economy Activity

Economic activity sector		Income class				
		1	2	3	4	5
The whole economy	**BA**	0	0	0	0	1.000
	TT	0	0	0.001	0.200	0.799
	TN	0	0.002	0.325	0.397	0.276
	NR	0	0.445	0.313	0.242	0
	ZA	0.014	0.179	0.230	0.431	0.147
	BB	0.213	0.342	0.257	0.175	0.013
	PO	0.753	0.225	0.022	0.001	0
	KE	0.323	0.213	0.307	0.072	0.085
	SK	0.209	0.197	0.193	0.197	0.205
Primary sector	**BA**	0	0	0	0.123	0.877
	TT	0.001	0.030	0.115	0.379	0.475
	TN	0.033	0.071	0.086	0.317	0.493
	NR	0.009	0.129	0.296	0.360	0.205
	ZA	0.101	0.256	0.364	0.208	0.071
	BB	0.119	0.300	0.249	0.230	0.102
	PO	0.709	0.196	0.087	0.007	0
	KE	0.304	0.410	0.243	0.043	0
	SK	0.205	0.199	0.196	0.196	0.204
Secondary sector	**BA**	0	0	0	0	1.000
	TT	0	0	0.016	0.265	0.718
	TN	0	0.063	0.361	0.340	0.236
	NR	0.002	0.353	0.391	0.253	0.001
	ZA	0.013	0.183	0.195	0.478	0.131
	BB	0.123	0.396	0.285	0.125	0.071
	PO	0.830	0.152	0.015	0.002	0
	KE	0.331	0.249	0.202	0.095	0.122
	SK	0.211	0.196	0.194	0.197	0.203
Tertiary sector	**BA**	0	0	0	0	1.000
	TT	0	0.001	0.004	0.093	0.902
	TN	0.041	0.142	0.228	0.439	0.150
	NR	0.137	0.445	0.286	0.129	0.003
	ZA	0.061	0.137	0.312	0.274	0.215
	BB	0.382	0.217	0.195	0.200	0.006
	PO	0.433	0.281	0.186	0.098	0.001
	KE	0.241	0.249	0.209	0.253	0.048
	SK	0.202	0.198	0.196	0.199	0.204

Note: The table reports limiting distributions of wages at national level (rows denoted as "SK" – abbr. for Slovakia) and at regional level (all other rows, for abbreviations explanation see Table A1 in Appendix) – in both cases representing convergence of districts towards ***national median wage*** in the respective sector (at regional level convergence of districts is evaluated for each region separately). Higher probabilities around income class "3" indicate a higher level of regional (district) convergence towards median; higher probabilities in the lowest and highest income classes indicate regional (district) divergence.

Source: Own table based on Slovak Social Insurance Company data.

2.2. Old-age Pensions

Old-age pensions are the second most important primary source of income (wages being the first) in the Slovak economy, accounting for almost 20 per cent of Slovak inhabitants, which clearly represents a significant proportion of the Slovak population. In this section we present the main findings on the regional convergence of old-age pensions at district level in Slovakia.

T a b l e 3

Limiting Distributions of Old-age Pensions, Broken Down by Periods and Regions

		Income class				
		1	**2**	**3**	**4**	**5**
Whole-period classes	**2005 – 2008**	0.201	0.180	0.207	0.191	0.221
	2009 – 2012	0.176	0.170	0.219	0.207	0.227
	2013 – 2016	0.235	0.269	0.097	0.146	0.253
Period-specific classes	**2005 – 2008**	0.193	0.193	0.193	0.186	0.236
	2009 – 2012	0.188	0.189	0.201	0.211	0.211
	2013 – 2016	0.206	0.195	0.145	0.204	0.249
Country-wide classes	**BA**	0	0	0	0	1.000
	TT	0	1.000	0	0	0
		0	0	0.149	0.277	0.574
	TN	0	0	0.115	0.512	0.373
	NR	0.499	0.501	0	0	0
		0	0	0	1.000	0
	ZA	NA				
	BB	0.119	0.248	0.243	0.194	0.196
	PO	0.662	0.303	0.029	0.005	0
	KE	0.249	0.144	0.339	0.246	0.022
	SK	0.205	0.204	0.177	0.185	0.229
Region-specific classes	**BA**	0.200	0.160	0.159	0.160	0.320
	TT	0.196	0.194	0.186	0.186	0.238
	TN	0.202	0.201	0.203	0.201	0.192
	NR	0.266	0.201	0.133	0.200	0.201
	ZA	0.211	0.201	0.190	0.190	0.209
	BB	0.208	0.196	0.177	0.197	0.222
	PO	0.182	0.203	0.203	0.197	0.215
	KE	0.209	0.240	0.201	0.176	0.174

Notes: The table reports limiting distributions of old-age pensions at national and regional levels. In the case of whole-period classes, regional convergence towards a long-term national median is assessed. In the case of period-specific classes, convergence of districts towards a national median income for each specific period is assessed distinctly. Country-wide classes represent convergence of districts towards national median old-age pensions; region-specific classes represent convergence of districts towards median incomes estimated for each region separately. Higher probabilities around income class "3" indicate a higher level of regional (district) convergence towards the median; higher probabilities in the lowest and highest income classes indicate regional (district) divergence.

In the case of Trnava Region (TT), the algorithm found two limiting distributions; in the case of Žilina Region (ZA), the algorithm did not converge to a solution.

Source: Own table based on Slovak Social Insurance Company data.

Due to time inhomogeneity, results are broken down by three time periods, as reported in Table 3, while two different types of classes are used: 'whole-period classes' represent a relativization of old-age pensions to the medians across the whole time period, and 'period-specific classes' represent old-age pensions relativized to medians for a particular time period.

The limiting distributions of old-age pension in the periods 2005 – 2008 and 2009 – 2012 are rather uniform, whereas the period 2013 – 2016 suggests divergence from the median income class (lowest value in the middle class, and higher values when departing from the middle class in both directions – indicating a U-shape), and a similar finding is supported by the assessment of the limiting distribution based on all Slovak districts.

Convergence/divergence patterns of old-age pensions are ambiguous. While the region-specific income classes suggest a low degree of divergence for most regions, the country-wide income classes indicate convergence towards high-income classes (Bratislava and Trenčín districts), convergence towards low-income classes (Prešov districts), convergence towards 'the median-income class' (Košice, Banská Bystrica districts) and ambiguous conclusions (Trnava, Nitra and Žilina districts). The algorithm found two different limiting distributions for the districts of Trnava and Nitra Regions – one suggesting convergence towards higher wages, and one towards lower. One of the potential causes of this ambiguity could be the changes in the profile of economic structure in those two regions. The significance of manufacturing (in particular: car production) and services in Trnava Region has increased over time, which leads to higher wages, thus implying higher old-age pensions. The low level of old-age pensions in Nitra Region is a result of ongoing low wages in the agricultural sector, which is crucial for the respective region due to its natural resources character.

Conclusions

Regional convergence has long been explored in economic literature. While most empirical studies assess the level of regional convergence in terms standard macroeconomic indicators (such as gross domestic product or gross value added), our approach is based on personal income (aggregated at regional level). Moreover, unlike similar studies, our analyses are performed at LAU 1 (district level), which offers a significantly more detailed perspective on the phenomenon.

Results obtained in this study are based on Slovak Social Insurance Agency microdata on citizens' incomes at district level using the Markov chains, taking into account the spatial nature of the data. Interpretations of the results are based on limiting distributions (which can be interpreted as long-term steady-states). Our findings suggest that Bratislava and Trnava Regions have the highest, and somewhat similar, levels of convergence patterns towards high-wage districts, followed by the districts of Žilina and also partly Trenčín Regions. A high level of convergence, however, of an opposite direction, towards districts with low wage levels is found in Prešov, Nitra, Banská Bystrica and Košice Regions. The given trends are influenced by the wages development in different economic branches in these regions.

In a similar fashion to the particularities of regional convergence in terms of wages, particularities also exist in terms of regional convergence with respect to old-age pensions. With regard to the country-wide median, the districts of Bratislava and Trenčín Regions converge to higher wages, while the districts of Nitra and Prešov converge to the lower wages. Old-age pensions in the Košice Region indicate convergence towards median values. However, region-specific classes indicate rather a uniform distribution of districts within each region.

As this study is based on an administrative source of data, it contains information on the official income of all inhabitants, and thus allows us to study convergence of income at territorial level as low as LAU 2. The knowledge of deeper patterns of spatial distribution of income and its regional convergence is crucial in adopting appropriate social and economic policies aimed at alleviating inter- and intra-regional disparities. Moreover, an understanding of convergence/divergence processes in different sectors of an economy provides necessary information to policymakers for targeting different tools to different economic sectors.

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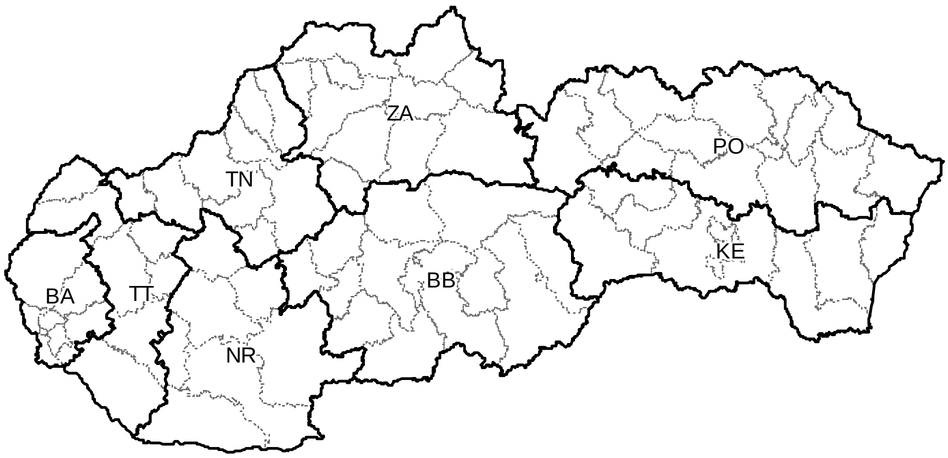
Appendix

Figure A1

Administrative Division of Slovakia



Notes: Bold borders represent NUTS 3 administrative boundaries (eight self-governing regions), light dotted borders represent LAU 1 administrative boundaries (79 districts). For abbreviations for regions' names see Table A1 below.

Source: Own construction in R environment (R Core Team, 2017) based on Geoportal.sk shape file layers.

Table A1

Administrative Division of Slovakia

Level		
NUTS 2 (Areas)	**NUTS 3 (Self-governing regions)**	**LAU 1 (Districts)**
Region of Bratislava	Region of Bratislava (BA)	8
West Slovakia	Region of Trnava (TT) Region of Trenčín (TN) Region of Nitra (NR)	7 9 7
Central Slovakia	Region of Žilina (ZA) Region of Banská Bystrica (ZA)	11 13
East Slovakia	Region of Prešov (PO) Region of Košice (KE)	13 11

Source: Eurostat.