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Spatial wage inequality in Belarus

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Abstract

This paper studies the wage inequality in Belarus' districts from 2000 till 2015 following the multi-step and multi-mechanism framework. The empirical results show: first, that wage disparities across the districts decreased in the 2000-2012 period and then increased from 2013 to 2015; second, there is the spatial dependency in district wages and increasing separation between districts, and between rural and urban population in Belarus; third, the main economic factors that contribute to decrease in district wage inequality are industrial development, retail trade and agricultural development. Finally, from theoretical point of view this research rejects the inverted U-shaped relationship between spatial inequality and economic development for Belarus and supports the hypothesis made by French economist Thomas Piketty that slow growth rates lead to rising inequality.

Keywords: economic growth, quantile regression, spatial dependence, stochastic kernel, wage inequality, Belarus

JEL Classification: C30, C46, I30, J31, O18, Q53, R12

Belarusian Economic Research and Outreach Center (BEROC) started its work as joint project of Stockholm Institute of Transition Economics (SITE) and Economics Education and Research Consortium (EERC) in 2008 with financial support from SIDA and USAID. The mission of BEROC is to spread the international academic standards and values through academic and policy research, modern economic education and strengthening of communication and networking with the world academic community.

1. Introduction

Despite the general decline of wage inequality among Belarus's districts over the last fifteen years, the regional dimension of inequality and the growth level needed for reductions in disparities remains to be one of the central questions of economic policy in Belarus. Wages generate a significant portion of personal and household income in Belarus and accounts approximately for 46% of GDP. Therefore, whether wage is equally distributed affects the nature of the Belarus' labor market, and therefore the scale and degree of socio-economical disconnect.

Policy makers in Belarus attempt to address the regional inequalities through the administrative, fiscal and political decision-making changes to the 118 districts in the country. However, these concerns translate into the unavoidable tradeoffs between the promotion of regional equality and overall economic efficiency.

Among different programs that target regional inequality in Belarus some mainly address poor and affected by Chernobyl disaster districts, while others address directly poor people. Such dual structure reveals a general lack of agreement on how to struggle with disparities between leading and lagging districts and within districts, that is, urban against rural areas within a given district or region.

The above concerns were reinforced in recent years, that is, there is a growing understanding that regional disparities serve as a potentially significant connection to overall economic development and growth of a country. According to the World Bank's 2009 World Development Report titled Reshaping Economic Geography (World Bank, 2009) regional inequality increases in the early stages of development and decreases after the subsequent periods. Using the development data of upper-middle income countries, it showed that different levels of inequality converge at different speeds. As a result, if richer districts grow at a faster rate than the poorer ones, this supposedly could increase inequalities between them.

From this point of view, in order to decrease spatial inequality and increase overall economic efficiency in Belarus' districts specific policies should be attributed more to the facilitation of the drivers of growth in the districts and less on initial spatial inequality.

Therefore, this paper addresses the next questions:

(i) How serious is an inequality concern for Belarus and how does wage inequality vary among its districts and regions?
(ii) Has Belarus's high economic growth been partly at the expense of widening regional inequality or vice versa?
(iii) What is the correlation between neighboring districts in the wage inequality?
(iv) To what extent wage inequality differences in Belarus' districts are mainly driven by differences in their economic performance?

This paper contributes to the current research in the next way:

(1) The paper studies for the first time spatial wage inequality at district level on the example of such developing country as Belarus. Particular attention is given to estimating district

wage inequality, to determining the spatial interdependencies in wages among Belarus' districts, to exploring intra-distributional dynamics of district wages and to finding the factors that influence district wage inequality.

(2) In the economic literature there have been many studies of earnings and inequality. However, most analysis of wages has used conventional regression analysis, concentrating mainly on wage differentials at the mean (or at the median in case of log wage as a dependent variable). Such approach revealed low level of accuracy, because wage inequality is influenced by the entire distribution of wages, but not just conditioned by the middle of the distribution. As an alternative, this paper applies a distribution dynamics approach (Quah, 1993, 1996) and quantile regression to see differentials across the entire distribution of wages in Belarus' districts.

(3) The main results from the research show:

- The average district wages in Belarus are approximately 20% lower than average republican wages and this difference increased in recent years indicating the increase in rural-urban divide in Belarus (the relatively poor district population became poorer in comparison with urban population of large cities). Also, the distribution dynamics of wages in Belarus indicates the existence of increasing separation between districts, that is, middle wage districts move into either high or low wage parts of the distribution.
- There are strong and positive spatial interdependences in district wages in Belarus indicating that districts with similar high or low levels of wages tend to concentrate geographically. Further, substantial increase in positive spatial interdependencies in wages between districts coincides with the significant decrease in economic growth in Belarus due to economic recession.
- The empirical results also indicate that the regional outcomes in Belarus are conditioned by their neighbors' outcomes as it was established for many countries (especially developed), but the lack of a neighbors' effect (as it was found for Belarus also) is mostly concern to the developing countries.
- During studied 2000-2015 period accelerating levels of economic growth first led to decrease in wage inequality among Belarus' districts; next, the persistent levels of wage inequality coincided with the high and stable economic growth; and, finally, negative economic growth corresponded to increase in district wage inequality in Belarus. Thus, from theoretical point of view these results rejects the hypothesis of inverted-U-shaped relationship between spatial inequality and economic development (during the process of development inequality in the initial years increases, then reaches its peak, and then decreases) stated by Kuznets (1955), and confirms the hypothesis stated by French economist Thomas Piketty (Piketty, 2014) that declining growth rates increase inequality.
- Finally, results from quantile regressions indicate, first, that the main economic factors that contribute to decrease in district wage inequality (between poor and rich districts)

among Belarus' districts are industrial development, retail trade and agricultural development; second, the main economic factors that influence wage growth in richest districts in Belarus are growth of population and capital investments; and, third, the high positive influence of spatial dependence may indicate that in many cases the economic factors are not the main causes that determine wage growth in Belarus districts, but most likely that the administrative redistribution (equalization) of wages is a core driver of wage growth in Belarus indicating that labor market in Belarus is highly regulated.

The paper is structured as follows. Section 2 presents the literature review. Section 3 describes the methodology used in the research and guides the empirical analysis at the district level. Section 4 discusses the data used. Section 5 presents and interprets the results of the analysis. Finally, Section 6 concludes and develops some implications for policy.

2. Literature Review

2.1 Theory

Regional inequality is one of the main research topics in the economic geography since the 1950s. The study of issues related to spatial disparities and its causal relationships with economic growth led to the formation of three main theories: convergence (Barro & Sala-i-Martin, 1992), divergence (Smith, 1984) and evolutionary (Kuznets, 1955).

The convergence hypothesis states that gap between rich and poor economies tend to narrow leading to decline in inequality in the long run. This statement is based on the prediction of convergence generated by the neoclassical growth model (Solow, 1956), that is, the level of per capita income of poor economies or regions tends to catch up with the rich ones converging to the same long-run steady state. As a result, neoclassical economists came to conclusion that regional inequality is a temporary phenomenon. However, regions represent not closed small economies, but significantly integrated economic entities by trade flows and production factors. Respectively, in a regional framework the neoclassical growth model for a closed economy seemed to be not the best basis for the study of spatial inequality.

In the early 1990s, Barro and Sala-i-Martin (1991) have added to the neoclassical growth model condition of the partial mobility of production factors and demonstrated that basic assumptions of the theory of convergence did not change. They used two important concepts (β-convergence and σ-convergence) in order to determine the differences in the regional development in the U.S. and Europe. The presence of the β-convergence means that at the initial stage poorer regions will grow faster than richer regions. The σ-convergence supposes that because of the β-convergence the overall level of deviation tends to decrease in the long run. The authors found that the main factors that contribute to national convergence are homogeneity in technology, preferences, and institutions (see Martin & Sunley, 1998; Petrakos, Rodríguez-Pose, & Rovolis, 2005).

Taking into account the neoclassical thought of convergence the evolutionary school generated the inverted-U theory adding up the dependence of the level of inequality upon economic cycles. It states that in an early stage of development regional inequality is expected to rise, because very few people obtain profit from the increasing capital investment. However, at a later stage labor moves from the agricultural sector to the industrial sector leading to income redistribution and decline in inequality (Kuznets, 1955).

Williamson (1965) added to this idea case of spatial inequality. He reasoned that natural resources as a driver for the industrialization often not equally allocated within countries (for example, Ruhr area in Germany). Consequently, economic wealth in the industrialization process is also unequally distributed among country's regions which raise regional inequality. However, appearance of the more attractive job vacancies in the growing regions attract employees from the depressed regions, which in turn decreases wages in the host regions, but increases wages in departure regions. All these start convergence process, which coupled with enhancing government policies, decreases regional inequality and creates similar inverted-U-shaped relationship.

Additionally, the New Economic Geography theory has also considered importance of spatial factor for regional economic development. It suggests that possibility of real convergence among regions increases in case of similarity of their economic structures, because regions supposed to be more specialized than national economic systems (Krugman, 1991). The other outcome is a spatial-periphery structure, i.e. a spatial polarization of regions – development or underdevelopment caused by agglomeration. It leads to growth of the size of the market in the destination region due to labor migration caused by initial wage differential. Consequently, through the effect of scale the real wage in the target region increases rather than decreases (Kanbur and Rapoport, 2005).

Additionally, Venables (1996a) discovered the importance of forward and backward linkages in regional inequalities showing that vertical linkages between upstream and downstream industries can play a role in determining the size of the market in different regions. Complementary, putting forward the assumption that activities with increasing returns to scale are concentrated in certain territorial areas. Respectively, this forms situation of continuous economic growth for such core (industrialized) regions at the cost of regions with less favorable initial conditions (peripheral), typically rural regions where the share of employment in agriculture (or contribution to GDP) higher (lower) than the average level in the country. Moreover, in recent years other questions in regional disparities were studied including the role of regional structure and spatial interactions in explaining uneven regional development (Ramajo et al., 2008).

However, Post-Keynesian economists questioned the convergence at the regional level. Using the work of Myrdal (1957) (who reasoned that the occurrence of disparities in the regional incomes leads to a strong tendency for inequality increase) they claimed that influence of cumulative causation processes will lead to unbalanced regional growth or divergence. These happen due to demand–supply interaction on the markets for goods and labour in core regions, that is, investment in core regions leads to further expansion, which increases migration and local demand and subsequently enhances new investment and further development. By the whole, using empirical studies performed in the 1960s and 1970s the divergence theory claimed that inequality is persistent and gap between rich and poor economies or regions keep widening (Smith, 1984).

In turn, unlike neoclassical growth theory (which assumes that technologies are distributed between the regions through knowledge spillovers leading to regional convergence), endogenous growth theory also added a hypothesis that if the creation of knowledge and technology intensive activities are concentrated in rich regions, then the most likely outcome is regional divergence (Glaeser et al. 1992). Finally, in the recent years the divergence theory was also supported by French economist Thomas Piketty (Piketty, 2014) who claimed that declining growth rates increase inequality.

2.2 Empirical research

The studies on inequality can be subdivided into two groups: first concerns examination of inequality at a global level, and second focuses on individual countries or group of countries. According to the empirical results of first research group during 1990-2010 inequality has increased by 9% in developed countries and by 11% in developing ones (UNDP, 2013). Nevertheless, several studies has showed that since the early 2000s (the beginning of globalization) the increasing trend in global inequality between nations started to decline and mainly due to a faster than world average economic growth in such countries as China and India (Firebaugh and Goesling, 2004). However, most part of empirical results from resent years is controversial: some demonstrate that global income inequality has decreased, while others have increased. Differences in methodological issues (in the concepts of global inequality) and data sources lead to dissimilar pattern in global inequality (Dowrick and Akmal, 2005).

The second group examined regional inequality. Martin (2006) studied 15 EU countries and found that inequalities among nations have decreased since 1995, although internal differences have increased indicating presence of national convergence coupled with regional divergence. Additionally, several authors have showed that during the recent years inequality rises in European and Asian transition countries, reduces in the Caribbean, Latin America (Birdsall et al, 2012) and Sub-Saharan Africa (Bigsten, 2014) and remains mostly unchanged in the Arab states (Bibi and Nabli, 2009). However, the decrease in regional income inequality cannot fully contribute to the decline in inequality in particular countries within studied regions. For example, in the region of Sub-Saharan Africa inequality has increased in such countries as: Uganda, Zambia and Ghana (Kai and Hamori, 2009).

In the empirical literature there are different explanations for the persistence of inequality or its increase. The persistence of interregional disparities several authors tried to investigate taking into account such economic variables as unemployment rate or employment growth rates (see Boldrin and Canova, 2001). Considering evolutionary theory at the regional level it was founded that an increase in correlation of cycles at national level was supplemented by decreasing co-movement across European regions (Fatas, 1997). Some authors explain positive link due to sharp economic growth (Knowles, 2005). Others claim that there is no direct relation between growth and inequality, but rather a non-inclusive growth structure, and try to explain this pattern due to increased trade and financial globalization (Das and Mohapatra, 2003).

However, the most reliable explanation concerns wrong national policy that fostered negative effects on distribution of welfare. The main issues are linked to limited institutional capacity and subjective allocation of public services and infrastructure investments toward particular geographic areas (core regions) at the cost of the rural and peripheral regions (Adam and Bevan, 2006).

For example, Basile (2010) determined that over the period 1980–2003 high (low) labour productivity regions tend to other high (low) productivity regions in Western Europe confirming presence of a core-periphery spatial pattern in the regional development. Moreover, it was found that core regions with good market access display higher per capita income than peripheral regions (Lin, 2005). Additionally, Redding and Venables (2004) found that wages at core regions are higher. Other empirical studies confirm above results for US counties (Hanson, 2005), for Italy (Mion, 2004), for Belgium (De Bruyne, 2003), for 114 German districts (Brakman et al., 2004) and for European Union (Head and Mayer, 2006).

Finally, several authors studied convergence/divergence theories for European transition countries. Marelli (2007) confirmed convergence hypothesis for the transition countries. Complementary, Tondl and Vuksic (2008) using data on 36 NUTS2 regions of five Eastern European transition countries found that the most important factors in regional convergence processes are direct foreign investment, human capital, and accessibility to markets. Additionally, Demidova and Signorelli (2012) presented robust indication of spatial dependence between regions, that is, regions with better economic performance (level or dynamics) tend to be closer to regions in a similar state.

However, presented above empirical studies have generally disregarded aspects of regional development in transition countries focusing mostly on whether regional inequality in these countries had decreased or expanded since economic reforms presenting little evidence of the dynamics of regional inequality within countries (for example, Wood 1997). Regional inequality is an essential problem for these countries, thus, its elimination is a major target for implemented economic reforms. However, it was found that in many cases reforms have led to intensification of regional inequality in these countries (Wei and Ma, 1996), with substantial disconnect about driving forces that cause uneven regional development within each country (Lyons, 1991; Tsui, 1991).

One of the explanation is related to established presence of the core-periphery structure of regional development in these countries, which has strong geographical basis and hardly changeable. On of such examples constitute eastern and western regions in Russia strengthened through new spatial distribution of labor, political tensions, and the integration of the core regions into the global economy (Bradshaw & Vartapetov, 2003; Carluer, 2005). More precisely Demidova (2014) determined that eastern and western regions in Russia form clubs with different growth patterns, specifically: for the western regions – positive spatial correlation of the main macroeconomic indicators, for the eastern regions – both positive and negative externalities, for the eastern and western regions – the asymmetric influence on each other.

However, while there are studies analyzing regional convergence in other transition countries, empirical evidence concerning Belarus is limited mostly to a descriptive analysis. Little is known about how inequality compares across the Belarusian districts and how it has evolved the recent years. Even though the country has succeeded to keep national and regional inequality indicators at a moderately low level, these may hide large disparities at a district level and severe urban-rural gap. A better understanding of the dynamics, the pattern and economic factors that influence inequality at a district level in Belarus is crucial for improving social cohesion and sustainable growth in the country.

3. Methodology

3.1. Exploratory spatial data analysis

In the first step the overall description of 118 Belarusian districts and their wage characteristics will be accomplished. Next, the spatial analysis will be used to check the spatial dependence, spatial association patterns and clusters, and to identify spatial autocorrelation (Anselin, 1996) and similarity among 118 Belarusian districts. For last purposes the Global and Local Moran's I statistics and Moran scatter plots and maps are constructed.

The Moran's I statistic represents a cross-product correlation measure that integrates space feature of the data through means of a spatial weights matrix W (Moran, 1950). Its value ranges from -1 to 1. The value of Moran's I statistic beyond zero and greater a certain significance level indicates spatial positive correlation and evident spatial clusters of objects under study with higher attribute values or lower attribute values. Moran's I near +1.0 implies a small global or local spatial difference. From the other hand, the value substantially below zero indicates spatial negative correlation and an apparent spatial difference in the attribute values between the certain objects and their neighboring objects. Finally, Moran's I near -1.0 implies a large spatial difference and value near $-1/(N-1)$ shows that the data is spatially random without spatial autocorrelation (Cliff and Ord, 1981).

The Moran's statistic presented as the slope in a scatter plot (Moran scatter plot) of a spatially lagged variable on the original variable enables to classify the identified spatial autocorrelations into four categories: observations in the Quadrant 1 (high-high) and Quadrant 3 (low-low) determine potential spatial clusters (objects surrounded by similar neighbors), and observations in the Quadrant 2 (high-low) and Quadrant 4 (low-high) mean potential spatial outliers (objects surrounded by dissimilar neighbors) (Anselin, 1996).

3.2. Evaluation of inequality measures

In the second step the overall description of wage inequality will be accomplished at different wage percentiles of 118 Belarusian districts and, subsequently, by studying district inequality measures. However, due to large number of inequality indicators used in the empirical studies the assessment of wage inequality across the Belarusian districts will be performed using four most commonly applied inequality indicators (see Haughton, 2009):

- The Gini coefficient (*Gini*) – calculated as the arithmetic average of the absolute value of differences between all pairs of incomes, divided by the average income (takes values between 0 and 1, where zero value corresponds to perfect equality).
- The coefficient of variation (*CV*) – calculated as a standard deviation divided by the mean and represents a dimensionless statistic that allows comparing the dispersion in the distribution of particular value.
- Theil indices, $T(\alpha)$, represent entropy measures that show the deviations from perfect equality. Parameter α (0 or 1) assigns a weight to distances between incomes in different parts of the income distribution. For lower value of α, the measure is more sensitive to changes in the lower tail of the distribution and, for higher value, it is more sensitive to changes that influence the upper tail. When $\alpha=0$, $T(0)$, the index is called "Theil's L" or the "mean log deviation" measure. When $\alpha=1$, $T(1)$, the index is called "Theil's T" index. Their values vary between zero (perfect equality) and infinity (or one, if normalized).

These measures satisfy the Pigou–Dalton transfer principle (Cowell, 1995) and also are independent of population size and scale.

3.3. Distributional dynamics of regional wage disparities

In third step a distribution dynamics approach (Quah, 1993, 1996) will be employed. It is used in order to identify the dynamics of wage inequality among districts in Belarus and involves the estimation of stochastic kernel.

The stochastic kernel estimator represents a smoothed version of the histogram that is used to evaluate a probability density function f of a random walk variable X. In comparison with the traditional histogram estimation of kernel density can smooth the data but hold the overall structure. But the shape of the empirical density is seriously conditioned by the choice of the smoothing parameter (bandwidth). There are different approaches to evaluate the bandwidth, but in this paper the Silverman's "rule-of-thumb" method is adopted using Gaussian kernel function (Silverman, 1986).

The stochastic kernel will show mobility and presence of persistence in the districts' wage inequality, and also will help to examine the polarization (through the shape of the distribution (see Duro, 2005) and convergence of wages across Belarus' districts, and, finally, the transitions of districts between higher and lower wage states over time.

3.4. Factors influencing district wage inequality: quantile regression

In the final step of the research a quantile regression developed by Koenker and Basset (1978) as an extension to classical linear regression (OLS) will be applied. The methodology under quantile regression used in this research is following.

Let (y_i, x_i), $i=1, 2, \ldots, n$ be the population of n sample districts in period t (t=1, 2, …, T), where x_i is the vector of the wage income determinants (regressors), and y_i the wage level in district i. Supposing that the θth quantile of the conditional distribution of y_i is linear in x_i the conditional quantile in the regression model can be written as follows:

$$y_i = x_i^{'}\beta_\theta + u_{i\theta},$$
$$Quant_{y_i}(\theta \mid x_i) \equiv \inf\,[y : F(y_i \mid x) \geq \theta] = x_i^{'}\beta_\theta, \qquad (1)$$
$$Quant_{u_i}(\theta \mid x_i) = 0.$$

where $Quant_{y_i}(\theta \mid x_i)$ represents the θth conditional quantile of y_I, conditional on the regressor x_i; β_θ defines the vector of unknown parameters that should be evaluated for different values of θ in (0, 1); $u_{i\theta}$ denotes the error term; and $F(y_i \mid x)$ represents the cumulative distribution function conditional on x.

By changing the value of θ between (0, 1) the full distribution of y conditional on x can be obtained.

The estimator, β_θ, is calculated by solving the next optimization problem:

$$\min_{\beta_\theta} \sum_{i=1}^{n} \rho_\theta (y_i - x_i^{'}\beta_\theta), \qquad (2)$$

where ρ_θ represents the loss function that denoted as:

$$\begin{cases} \theta u, & if \quad u \geq 0 \\ (\theta - 1)u, & if \quad u < 0 \end{cases}. \qquad (3)$$

The function (2) estimates the residual term and multiplies the values in (3). This estimator is obtained applying linear programming (Koenker and Basset , 1978).

In comparison with the OLS, where estimator is focused only on a measure of central tendency, the quantile regression investigates the level of influence by quantile, thus, defines data better. Quantile regression combines all available information and evaluates each quantile using the entire sample of data by ascribing weights to the observations. It properly accounts for heteroscedasticity by allowing for different coefficients at different quantiles. Thus, in case of skewed distributions in error terms, this methodology allows to retain efficiency (Buchinsky, 1998).

The main specification for the quantile regression analysis in this research is next:

$$\begin{aligned} Real\ wage = f\,(&Population, Exports\ of\ goods, Exports\ of\ services, \\ &Industrial\ production, Capital\ investments, Trend, Retail\ trade, \\ &Paid\ services, Development\ of\ agriculture, \\ &Contamination\ of\ agricultural\ land, Spatial\ dependence). \end{aligned} \qquad (4)$$

The variable *Spatial dependence* represents district's real average monthly wages relative to average real monthly wages at the national level. It was included in the model in order to take into account for direct interactions between neighboring districts (Huang and Chand, 2015), because regions that adjacent to rich ones grow faster than regions adjacent to poor ones (Rey, 2001).

Contamination of agricultural land is the variable that accounts for the level of contamination of agricultural land in districts with radionuclides. This factor is considered because it was found that the quality of the regional environment may have a direct influence on their economic development (Courtney et al., 2006).

According to previous studies economic factors influence local wages (Krugman, 1991). Thus, to control for the levels of development of districts in Belarus next economic variables were included in the model: *Industrial production* is a district's industrial production (in millions of Belarusian rubles); *Capital investments* denotes district's capital investments (in billions of Belarusian rubles); *Exports of goods* is a district's exports of goods (in thousands of US dollars); *Exports of services* represents a district's exports of services (in thousands of US dollars); *Population* is a district's population (in number of people); R*etail trade* denotes a district's retail trade (in billions of Belarusian rubles); *Paid services* is a district's paid services (in billions of Belarusian rubles); *Development of agriculture* denotes the level of district’s agricultural development (index). All the economic variables (except of *Development of agriculture*) in Formula (4) were transformed into logarithms in order to show the growth pattern.

The variable *Development of agriculture* represented by the index of agricultural development, *Iagr*, is constructed in next way. Let X_{ij} be the value data of agricultural variables of *i*-th district and the *j*-th indicator, i=1,2,…,N and j=1,2,…,k. Due to availability of statistical data the following agricultural indicators were considered: X_{i1} – grain yield in the *i*-th district (center/ha); X_{i2} – potato yield in the *i*-th district (center/ha); X_{i3} – the yield of vegetables in the *i*-th district (center/ha); X_{i4} – meat production per capita in the *i*-th district (thousands of tons); X_{i5} – milk production per capita in the *i*-th district (thousands of tons).

However, the units of measurement of the above variables are not uniform; therefore, these indicators were transformed to standardized form as follows:

$$Z_{ij} = \frac{X_{ij} - \overline{X}_j}{\sigma_j},$$

$$\text{where} \quad \overline{X}_j = \frac{\sum_{i=1}^{N} X_{ij}}{N} \text{ and } \sigma_j = \left(\sum_{i=1}^{N} \left(X_{ij} - \overline{X}_j \right)^2 \right)^{1/2}. \tag{5}$$

Then the pattern of development, C_i, of *i*-th district is calculated as follows:

$$C_i = \left[\frac{\sum_{j=1}^{k} \left(Z_{ij} - Z_j^o \right)^2}{cv_j} \right]^{1/2}, \tag{6}$$

where cv_j – coefficient of variation of the *j*-th agricultural indicator in X_{ij}; Z^o_j – optimal value of the *j*-th agricultural indicator.

Finally, the (composite) index of agricultural development, *Iagr*, is given by:

$$Iagr_i = 1 - \frac{C_i}{\frac{\sum_{i=1}^{N} C_i}{N} + 3\sigma_{C_i}},$$
$$where \quad \sigma_{C_i} = \left(\sum_{i=1}^{N} \left(C_i - \overline{C} \right)^2 \right)^{1/2}. \tag{7}$$

The closer $Iagr_i$ is to 0 the less developed agriculture is in the *i*-th district, and the closer to 1, the more developed is the district. The next inequality holds for the *Iagr*: $0 < Iagr_i < 1$.

In the empirical part a vector of coefficients, β_θ, for each of five quantiles (θ = 10th, 25th, 50th, 75th, 90th) will be estimated for the specification presented in Equation (4).

4. Data

The annual Belstat[1] data on nominal average monthly wages of Belarus' districts from 2000 to 2015 is used to create measures of wage inequality including such variables as *Real wages*, *Relative real wages*, *Spatial dependence*. The data on nominal average monthly wages was corrected by the country's CPI index (using 2000 as the base year) in order to obtain wages in real terms. Additionally, from the sample of districts the large cities were excluded in order to perform inequality analysis for the rural areas mostly.

The annual data for 2000-2015 period on such variables as *Industrial production* and *Capital investments* was obtained from Belstat, corrected by the country's PPI index using 2000 as the base year, and then divided by districts' population (represented by variable *Population*[2]) in order to obtain the per capita values. The annual data from Belstat on *Exports of goods* and *Exports of services* from 2000 to 2015 was also divided by districts' population.

The annual data for 2000-2015 period on such variables as *Retail trade* and *Paid services* was obtained from Belstat, corrected by the country's CPI index (using 2000 as the base year) and divided by districts' population in order to obtain values in real terms per capita.

The data that compose the variable *Development of agriculture* including grain yield, potato yield, the yield of vegetables, meat production, and milk production for 2000-2015 was obtained from Belstat. Additionally, the data on meat and milk production, and milk production was divided by districts' population in order to obtain the per capita values. Finally, the data on *Contamination of agricultural land* was obtained from Israel and Bogdevich (2009).

The explanation of each variable used in the paper is summarized in Table 1 and corresponding descriptive statistics of the data is provided in Table 2.

[1] **Belstat –** The National Statistical Committee of Belarus.
[2] Data on variable Population was obtained from Belstat.

Table 1. Definition of variables

Variable	Notation	Description
Population	Population	Population (by the end of the year), number of people
Real wages	Realwages	District's real average monthly wages (in constant prices), thousands of Belarusian rubles
Relative real wages	Relative wages	District’s real average monthly wages relative to average real monthly wages at the national level
Spatial dependence	Wrealwages	District's real average monthly wages relative to weighted average of the real average monthly wages of the neighboring districts
Exports of goods	Expgoods	District's exports of goods, thousands of US dollars
Exports of services	Expservices	District's exports of services, thousands of US dollars
Industrial production	Industr	District's industrial production, millions of Belarusian rubles
Capital investments	Invest	District's capital investments, billions of Belarusian rubles
Retail trade	Retail	District's retail trade, billions of Belarusian rubles
Paid services	Services	District's paid services, billions of Belarusian rubles
Development of agriculture	Iagr	Composite index of district’s agricultural development (includes next agricultural indicators: grain yield, potato yield, the yield of vegetables, meat production, milk production)
Contamination of agricultural land	Rdpol	Categorical variable: contamination of agricultural lands by Cesium-137 in Belarus' districts (2007) (the proportion of agricultural lands with contamination density of 37-1480 kBq/m^2): 0-no contamination, 1 – 1%-25%, 2 – 25%-50%, 3 – 50%-75%, 4 – 75%-100%

Table 2. Descriptive statistics of districts' data for 2000-2015

Variable	Observations	Mean	Std. dev.	Min	Max
Population (number of people)	1888	44551.57	34809.07	2727.00	200115.00
Real wages (thousands of Belarusian rubles in constant 2000 prices)	1888	132.537	64.83	34.20	419.31
Relative real wages	1888	0.80	0.13	0.55	1.69
Weighted on neighbors real wage	1888	0.99	0.16	0.73	2.30
Exports of goods (thousands of US dollars)	1298	79684.28	300543.20	0.00	3444100.00
Exports of services (thousands of US dollars)	1298	5645.13	33162.60	0.00	510300.00
Industrial production (millions of Belarusian rubles)	1770	938097.70	3607306.00	0.90	65200000.00
Capital investments (billions of Belarusian rubles)	1652	392.01	959.88	0.00	13732.14
Retail trade (billions of Belarusian rubles)	1652	328.42	744.91	2.70	11837.83
Paid services (billions of Belarusian rubles)	1180	44.87	76.29	0.00	907.30
Grain yield (center/ha)	1652	28.98	9.38	9.00	69.20
Potato yield (center/ha)	1652	173.30	66.30	0.00	452.00
The yield of vegetables (center/ha)	1652	159.25	102.15	0.00	740.00
Meat production per capita (thousands of tons)	1652	0.24	0.28	0.02	2.67
Milk production per capita (thousands of tons)	1652	1.20	0.67	0.00	5.32
The index of agricultural development	1652	0.34	0.12	0.07	0.85
The level of contamination of agricultural land with radionuclides	1888	0.89	1.29	0.00	4.00

5.Empirical analysis

5.1 Regional characteristics of district wages

According to Belarusian statistical definitions, Belarus has six regions: the Brest region with 16 districts, Gomel region with 21 districts, Grodno region with 17 districts, Mogilev region with 21 districts, Minsk region with 22 districts and Vitebsk region with 21 districts (see Figure 1). The overall number of population of the studied districts is equal to 4.9 million of people or approximately 50% of total population in Belarus by the end of 2015.

Figure 1. Administrative regions of Belarus

Table 3 and Figure 2 report the basic statistics of district real wages in Belarus at regional level for 2000-2015. As can be seen the development of wages is characterized by four major features. First, the list of the three regions with the highest average district wages did not change significantly since the 2000. The three regions with the highest average district wages before 2008 were Minsk, Gomel and Grodno, while in 2009 Brest replaced Grodno region as the region with the third largest average district wages in Belarus. The second is that the list of the two regions ranked on the basis of having the lowest average district wages during the same period was even more stable than that of districts with the highest. The two lowest regions were Mogilev and Vitebsk; however, in 2012 Vitebsk replaced Mogilev as the region with lowest average district wages.

The third highlight of Belarus's regional wage development in 2000-2015 is that the average district wages in Minsk region (central part of Belarus) are higher by approximately 15% than those in the interior areas. The fourth feature is that average district wages in Belarus relative to republican mean increased from 2000 up to 2005 (from 74% up to 82%) indicating catching-up process in wage income between districts (represented by mostly rural population) and large cities (represented by urban population) in Belarus (see Figure 2). However, from 2012 the convergence process ended and even reverted to divergence process in the 2013-2015 years (the average district wages in districts relative to republican mean has reached only 79% in 2015). Overly, these findings can actually suggest that the relatively poor district population became poorer in recent years in comparison with urban population of large cities in Belarus.

Table 3. Basic statistics of district real wages at regional level in Belarus

Region	Number of districts	Population, thousands of people	Share of population in overall population, %	Mean, thousands of Belarusian rubles	Mean relative to republican mean, %	Std. dev.	Min	Max
2000								
Brest region	16	889.39	8.93	43.2	73.30	4.70	35.40	50.70
Gomel region	21	1044.95	10.49	45.2	76.70	12.30	34.50	80.80
Grodno region	17	840.21	8.44	44.4	75.40	6.50	35.80	55.80
Mogilev region	21	619.57	6.22	40.0	67.90	4.40	34.20	53.10
Minsk region	22	1475.55	14.82	51.4	87.30	12.80	40.00	97.80
Vitebsk region	21	900.27	9.04	42.5	72.20	4.40	37.20	56.20
Total districts	118	5769.94	57.95	44.5	75.60	9.20	34.20	97.80
2007								
Brest region	16	812.29	8.51	122.34	78.60	11.012	105.64	147.19
Gomel region	21	966.38	10.13	124.63	80.00	24.32	101.19	197.84
Grodno region	17	772.83	8.10	123.11	79.10	11.85	107.90	145.67
Mogilev region	21	542.90	5.69	121.02	77.70	11.91	104.58	151.68
Minsk region	22	1379.58	14.46	136.53	87.70	22.54	116.36	217.20
Vitebsk region	21	792.64	8.31	120.95	77.70	7.86	109.74	145.47
Total districts	118	5266.62	55.19	125.02	80.30	17.15	101.19	217.20
2015								
Brest region	16	729.30	7.68	220.48	79.10	16.32	193.69	244.11
Gomel region	21	891.59	9.39	222.23	79.70	29.99	188.38	293.39
Grodno region	17	684.52	7.21	219.21	78.60	20.55	192.91	263.15
Mogilev region	21	471.59	4.96	214.61	77.00	17.34	187.94	250.83
Minsk region	22	1353.42	14.25	250.11	89.70	49.97	208.35	419.31
Vitebsk region	21	709.07	7.47	205.49	73.70	19.82	175.12	246.32
Total districts	118	4839.49	50.95	222.42	79.80	31.95	175.12	419.31

Finally, the fifth feature is that the overall district population in Belarus decreased by approximately 930 thousand people (or by 16% of district population at the start of 2000) in the last 15 years (see Table 3).

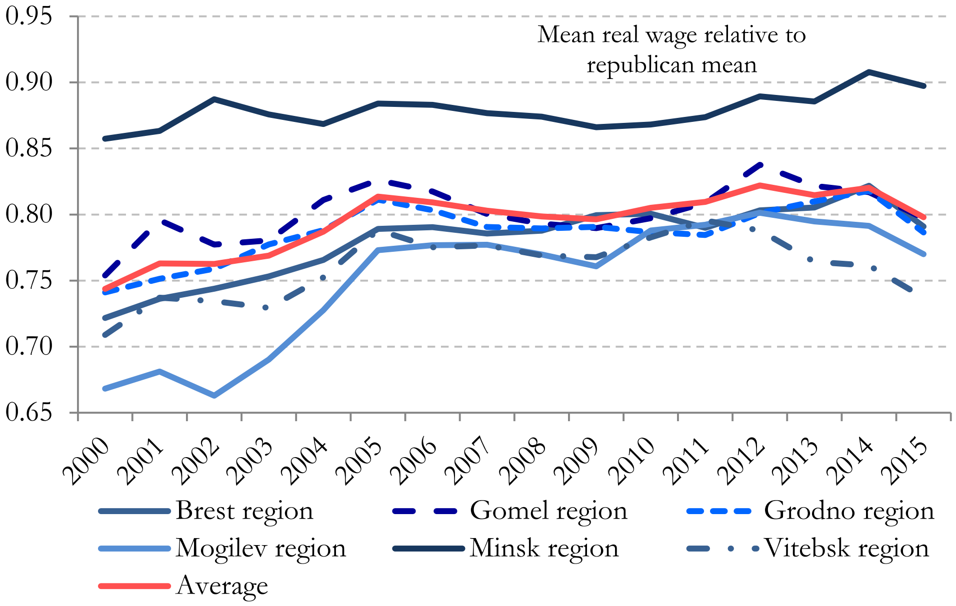


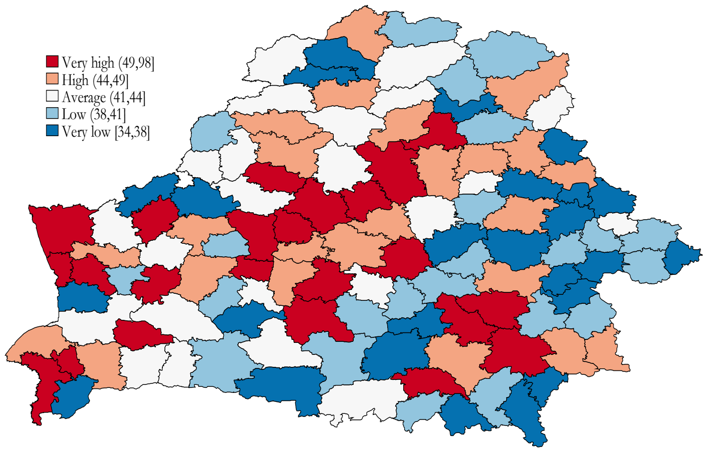
Figure 2. Decomposition of district real wages at regional level in Belarus, 2000-2015

Next, the district real wages in Belarus were subdivided by five categories (very high, high, average, low, and very low) for 2000, 2007 and 2015 (see Figure 3).

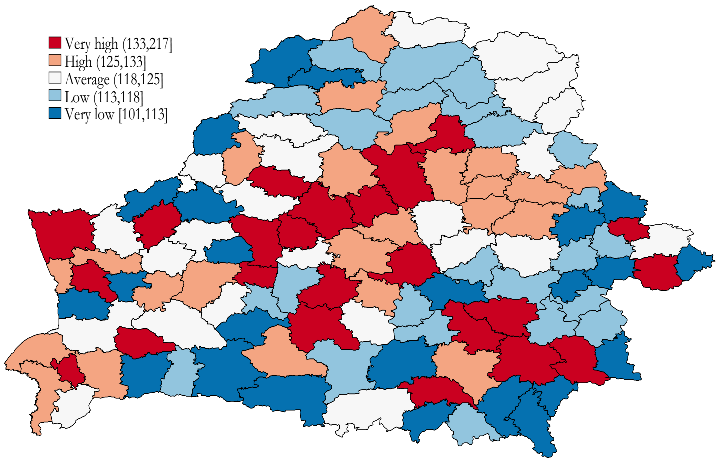
As can be seen wage differences across districts vary by a factor of 2.8 to 2.4 in 2000 and 2015, correspondingly. The highest class includes 23 districts both in 2000 and 2015. The lowest class comprises of 25 districts in 2000 and 24 districts in 2015.

Over time the largest increase in number districts with lowest wages demonstrate the northern part of Belarus represented by Vitebsk region – the number of lowest wage districts increased from 4 districts in 2000 to 9 in 2015; and taking into account the low wage districts the overall number of depressing ones in Vitebsk region account for 62% in 2015.

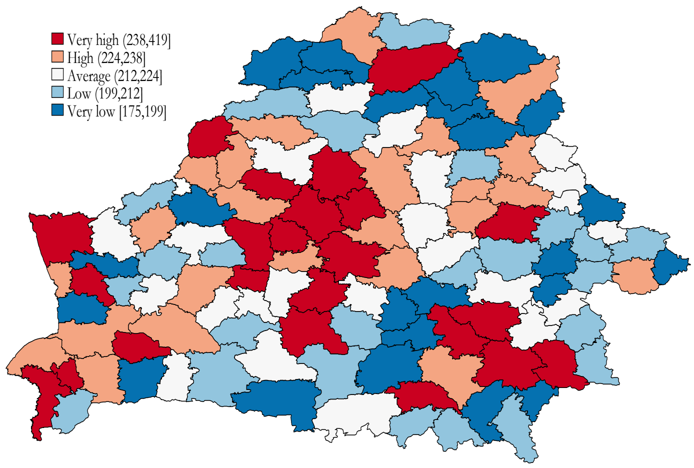
On the other hand, the number of high and highest class districts in other regions of Belarus does not change considerably in the studied period (indicating the persistence in their economic positions). However, there are four characteristic features. First, the largest number of highest class districts falls on Minsk and Gomel region. Second, these districts coincide with both central and most industrialized parts of Belarus (Minsk, Zhlobin, Mozyr and Soligorsk). Third, during the studied period the number of new districts in Mogilev, Brest and Grodno regions with highest wages did not grow, but decreased.



(a) 2000



(b) 2007



(c) 2015

Figure 3. Classification of Belarus' districts by levels of real wages, 2000, 2007, 2015

Finally, the overall feature in allocation of different levels of wages at the district level in Belarus is that the higher/lower wage districts tend to concentrate with the similar districts indicating presence of spatial dependence in wage distribution in Belarus.

5.2 Test for spatial interdependencies of district wages

In order to test the spatial interdependencies of district wages in Belarus the Global Moran's *I* (Moran, 1950) statistic is used. In the literature on spatial studies this measure is considered as a valuable tool to examine the degree of similarity between activities in one location compared to those in the neighboring places (Bai et al., 2012; Guillain et al., 2006). Specifically, the Global Moran's *I* statistic for a country consisting of *n* districts is calculated in the next way:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}, \tag{8}$$

where n – number of districts (118 in current study); W_{ij} – spatial weights matrix (a n x n matrix that denotes the degree of spatial proximity among Belarus' districts), where each element (i, j) expresses the degree of spatial proximity between the pair of districts i and j, W_{ii}=0; x_i – considered variable of interest (the annual real wage for district i in current study); $\bar{x}$ – the mean value of district values ($\bar{x} = \frac{i}{n}\sum_{i=1}^{n} x_i$).

The null hypothesis (H_0) of the above test is the absence of spatial autocorrelation among Belarus' districts and the expected value *I* is:

$$E(I) = -\frac{1}{n-1}, \tag{9}$$

where if I > E(I), than there is positive spatial autocorrelation – neighboring districts tend to show similar values of X (wages); if I < E(I), than there is negative spatial autocorrelation – neighboring districts tend to show dissimilar values of X (wages).

In overall, the statistical concept of (positive) spatial autocorrelation means that two or more objects that are spatially close tend to be more similar to each other – with respect to a given attribute X – than are spatially distant objects (Tobler, 1970). As a result, spatial autocorrelation denotes spatial clustering, i.e. the existence of sub-areas of the examined area where the considered characteristic X takes higher than average values (*hot spots*) or lower than average values (*cold spots*).

Thus, a positive coefficient of the Global Moran's *I* statistic means that neighboring districts have similar wages and a higher value indicates an increase in relationship. On the other hand, a negative coefficient shows heterogeneity between neighboring districts and a lower value suggests a stronger negative correlation. Finally, when the Global Moran's *I* statistic moves toward zero this indicates presence of a balanced co-existence of both types of correlations, i.e., a random distribution of wages across observations.

Table 4 and Figure 4 displays the results derived from the calculation of the Global Moran's *I* statistic for district real wages in Belarus. It can be seen that the values of the Global Moran's *I* statistic are positive and significant at 5 per cent level for the periods 2000-2008 and 2014-2105. This suggests presence of strong and positive spatial interdependences in district wages in Belarus for these years. Thus, districts with similar high or low levels of wages tend to be concentrated geographically. However, the tendency for spatial integration of district wages is decreasing over time as the Global Moran's *I* statistic declined from 0.152 to 0.095 between 2000 and 2008 (indicating random distribution of wages across districts) and only recovered in 2014 with the value equal to 0.138 as presented in column (5) of Table 4. However, the trend of spatial integration of district wages is substantially intensified since 2010 as the Global Moran's *I* statistic increased from 0.007 up to 0.139.

Table 4. Global Moran's I statistic for district real wages in Belarus, 2000-2015

Year	Moran's *I* value	p-value	Year	Moran's *I* value	p-value
2000	0.127	0.016	2008	0.095	0.050
2001	0.118	0.023	2009	0.073	0.100
2002	0.152	0.063	2010	0.007	0.399
2003	0.094	0.051	2011	0.025	0.290
2004	0.091	0.057	2012	0.042	0.209
2005	0.079	0.079	2013	0.069	0.112
2006	0.100	0.043	2014	0.138	0.011
2007	0.093	0.055	2015	0.139	0.009

Additionally, from Figure 4 it can be seen that starting from 2012 substantial increase in positive spatial interdependencies in wages between districts coincide with significant decrease in economic growth in Belarus (economic recession). This can mean that districts in Belarus tend to cluster with each other more closely in deteriorating economic conditions meaning more profound formation of rich and poor clusters of districts in Belarus. Such trend can be caused by the lack of public financial resources due to economic recession that restricts administrative redistribution of financial support in favor of poor districts in Belarus. As a result, poor districts tend to become even more poor (this evidence is also seen on Figure 4 especially for districts in Vitebsk region).

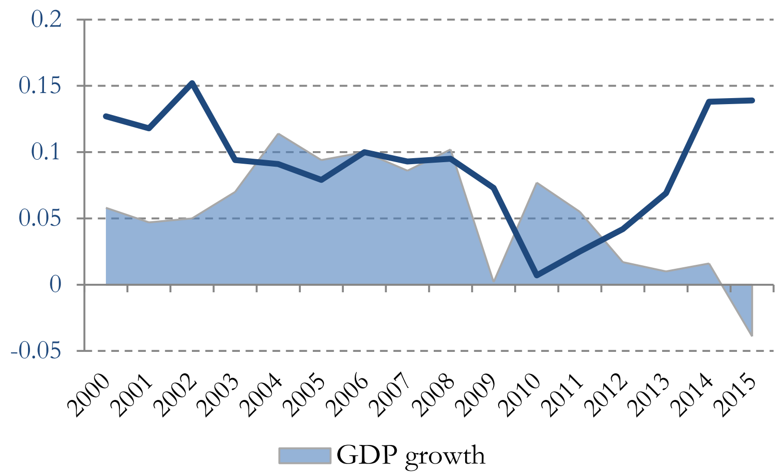


Figure 4. Global Moran's I statistic and labor productivity growth in Belarus, 2000-2015

However, since Global Moran's *I* statistic summarize the phenomenon of spatial autocorrelation in a single value showing only the overall trend (Pfeiffer et al, 2008), it is not so much appropriate for determining specific spatial clusters needed to identify the presence of a general tendency to wage clustering among Belarus' districts.

Therefore, to consider this question the local index of spatial autocorrelation (Local Moran's *I* statistic) is employed in this study. Concerning Belarus it will define for each district r_i of a given study area A (Belarus) the degree of similarity between that district and its neighboring districts with respect to wages.

Local Moran's *I* statistic I_i is calculated in next way:

$$I_i = \sum_{j=1}^{n} W_{ij}^{std} \left(\frac{x_i - \bar{x}}{\sigma_x} \right) \left(\frac{x_j - \bar{x}}{\sigma_x} \right) = W_{ij}^{std} \cdot z_i, \tag{10}$$

where σ_x – defines the standard deviation of real wages; W_{ij}^{std} – defines the elements of a row-standardized spatial weights matrix, where $W_{ii}^{std} = 0$.

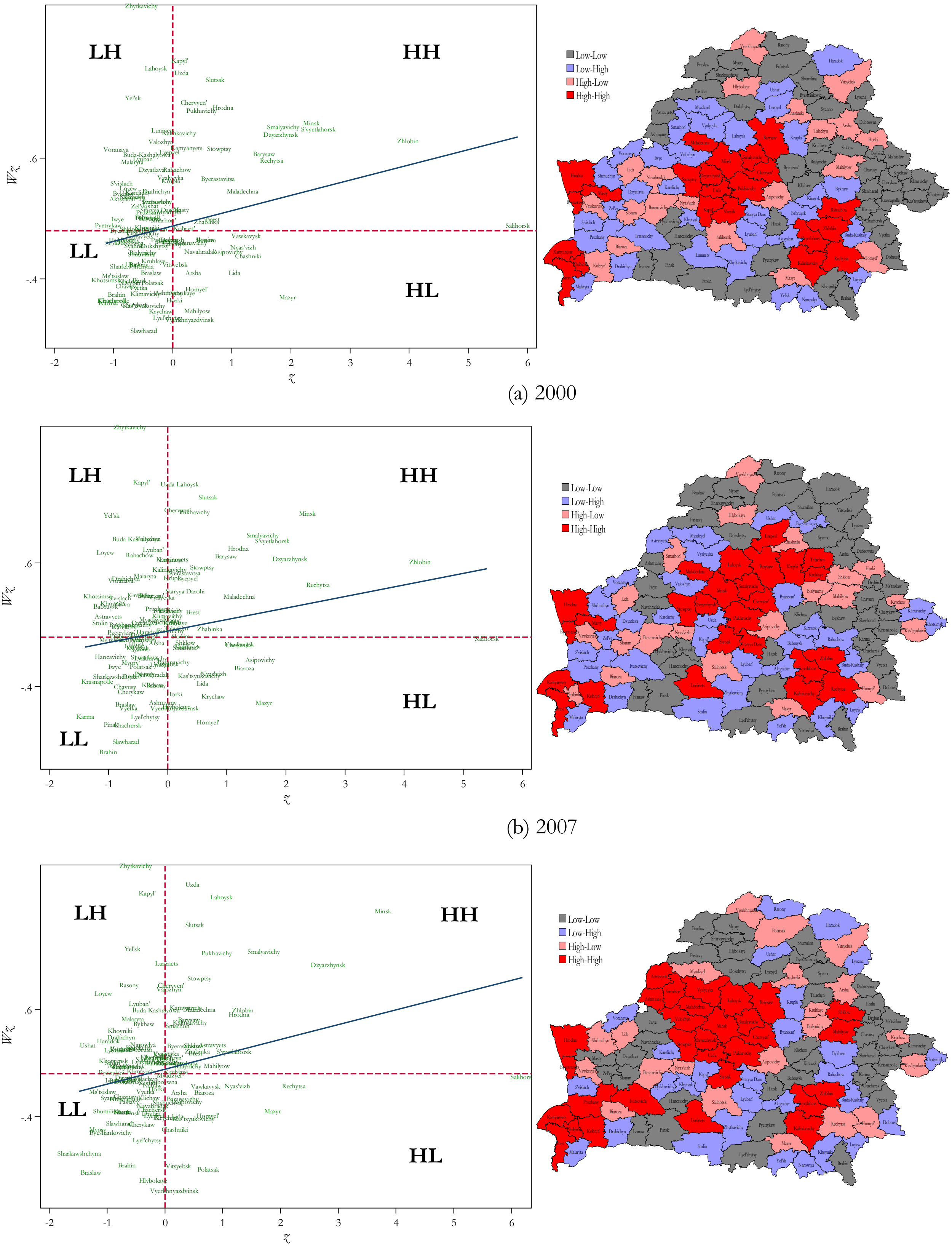
If $I_i > E(I_i)$, than that district r_i is surrounded by districts that, on average are similar to r_i with respect to real wages, indicating presence of positive spatial autocorrelation. Additionally:

- if $(x_i - \bar{x}) > 0$, then r_i defines a *hot spot*;
- if $(x_i - \bar{x}) < 0$, then r_i defines a *cold spot*.

If $I_i < E(I_i)$, than that district r_i is surrounded by districts that, on average are different to r_i with respect to real wages, indicating presence of negative spatial autocorrelation.

The calculated Local Moran's *I* statistic for all Belarus' districts are used to construct Moran's scatter plots and corresponding scatter maps (Anselin, 1996) in order to determine the association between each district in Belarus with their neighbors in 2000, 2007 and 2015 (see Figure 5). The horizontal axis of the scatter plot determines z value of the Local Moran's *I* statistic, and the vertical axis - Wz value (see Formula (10)). Each district is linked to only one quadrant on the scatter plot.

Therefore, Figure 5 comprises of three Moran scatter plots and three corresponding to them Moran scatter maps of district wages in Belarus for the years 2000, 2007 and 2015. The districts located in Quadrant I represent high wage districts with high-wage neighbors, districts in Quadrant III represent low-wage ones with low-wage neighbors, correspondingly HH and LL marks on the graphs. Thus, both of them specify a spatial cluster with similar wages (due to positive spatial autocorrelations). Other Quadrants II and IV with LH and HL marks consider low- and high-wage districts neighbored by high- and low-wage districts, correspondingly, and determine spatial outliers (due to negative spatial autocorrelations).



(a) 2000

(b) 2007

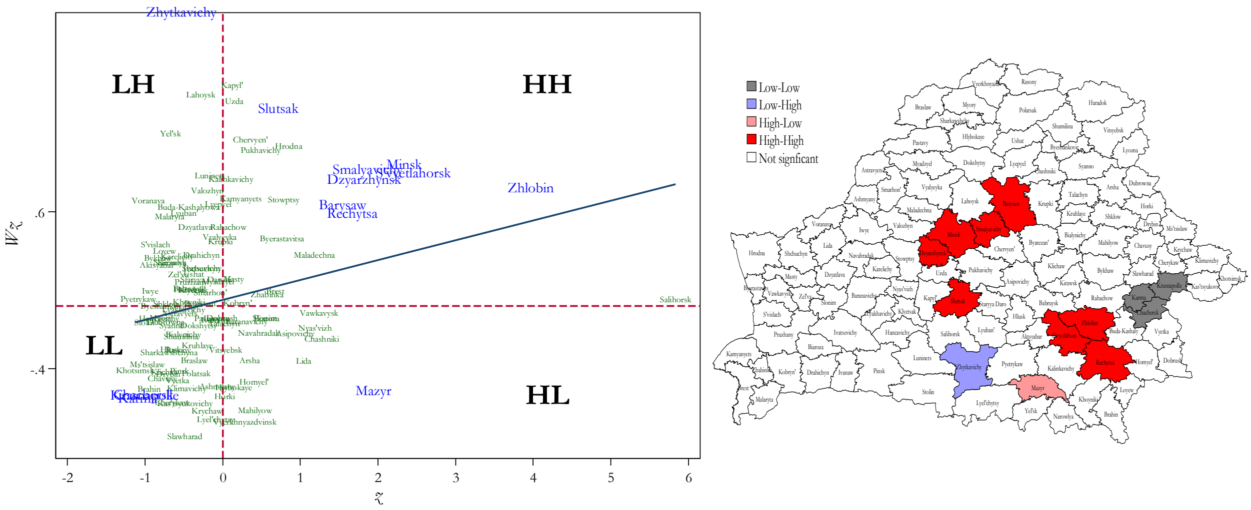
(c) 2015

Figure 5. Spatial pattern of real wages in Belarus at district level, 2000, 2007, 2015

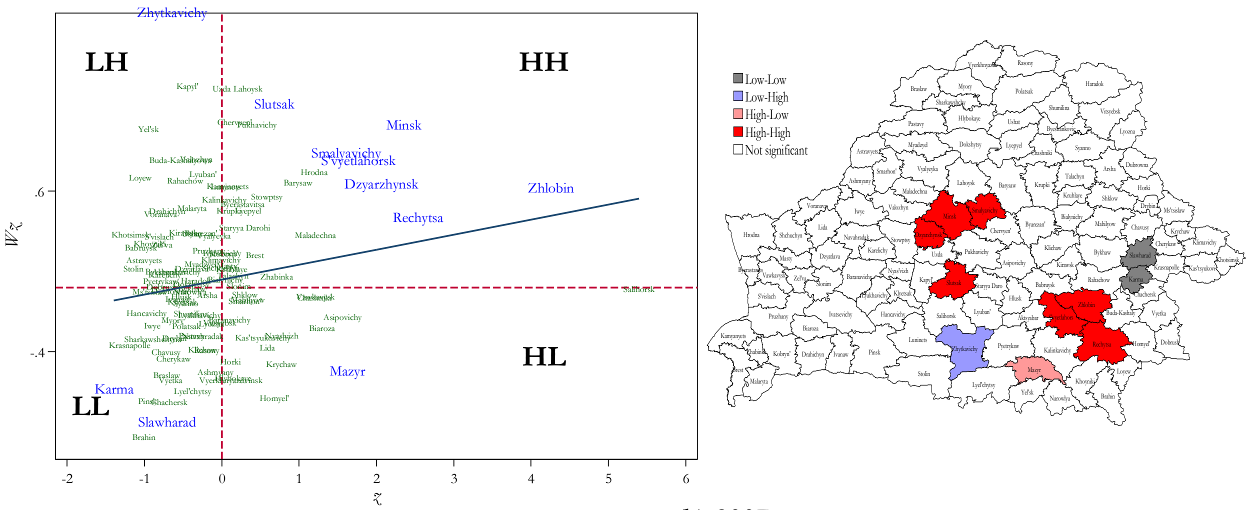
Corresponding Moran scatter maps on Figure 5 illustrate the geographic locations of the points in the Moran scatter plots in 2000, 2007 and 2015. A comparison of those three maps confirms the results obtained in the previous sections. First, most districts in Belarus with high wages and similar high-wage neighbors are located in the central part of the country and additionally in the East-South and Western border regions. Those with low wages are located in the North and East of the country, and at the South border. Second, the Figure 4 indicates that district wages in Belarus may not only depend on district's own economic development, but also on the growth of its neighboring districts.

Next, the significance of local associations for each district in the Moran scatter plots are tested, in order to find economic centers of high wages and economic outliers of low wages (Guillain et al., 2006). The results presented on the Figure 6 are next: first, the main economy cores of high wages in Belarus are centered only around capital (Minsk city) and at the Zhlobin district (the center of metallurgical industry of Belarus); second, the economic periphery of low wages is located in the north part of the country; and, third, the other economic center of Belarus, namely the Soligorsk district (the centre of extraction and production of potash fertilizers) does not play a significant role in spatial clustering between neighboring districts, that is, it does not generate positive economic impact around it.

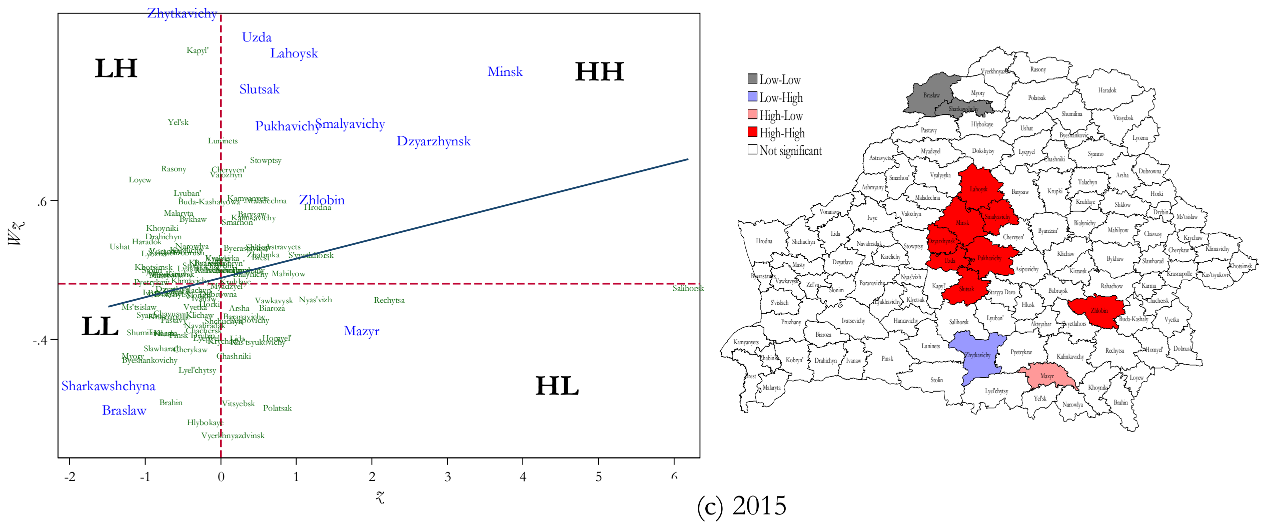
Overly, the findings in this section confirm two empirical results that stem from regional macroeconomic studies in developed and developing countries. First, the regional outcomes in Belarus are conditioned by their neighbors' outcomes as it was established for many countries (especially developed). Second, the lack of a neighbors' effect (as it was found for Belarus) is mostly concern to the developing countries.



(a) 2000



(b) 2007



(c) 2015

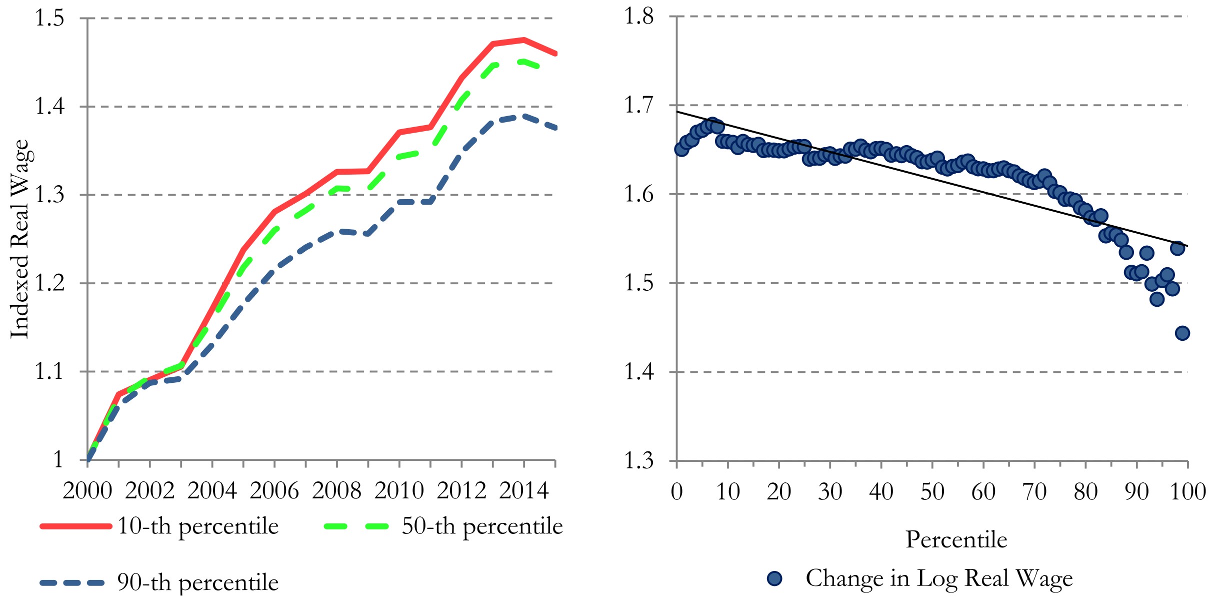
Figure 6. Significant spatial pattern of real wages in Belarus at district level, 2000, 2007, 2015

5.3 Wage inequality between Belarus' districts

In this section the district wage inequality in Belarus will be studied from two perspectives: first, the overall wage inequality among Belarus' districts will be evaluated using different percentiles of real wages for all districts in Belarus and, then, several specific measures of inequality will be calculated (the Gini coefficient, the Theil index and the coefficient of variation) for real wages in Belarus at district level.

From the first perspective, following Juhn et al. (1993), the difference between 90th, 50th and 10th of the log wage distribution is analyzed in order to evaluate the overall wage inequality among Belarus' districts. Additionally, the 90th–50th percentile wage gap and the 50th–10th percentile wage gaps are employed to evaluate wage inequality in the upper half and the lower half of the wage distribution, correspondingly.

Figure 7a demonstrates the trend in the wage differentials in the Belarus's districts using the indexed log real wage of the 90th, 50th and 10th percentiles in the districts for 2000-2015 (2000=1)[3]. As can be seen from the graph real wages have increased for all three percentile groups. However, the rate of real wage increases in the lower percentile exceeds the rate of real wage increases in the higher percentile, which suggests declining inequality between Belarus' districts. However, the differences between these three wage percentiles are still large. For example, in 2015 the 10th, 50th, and 90th percentiles of district wages were 4.6, 5.2 and 6.1 million of Belarusian rubles, correspondingly.



(**a**) Indexed real wage at the 90th,50th and 10th quantiles in Belarus' districts

(**b**) Change in log real wage by percentile, 2000-2015

Figure 7. Wage Inequality in Belarus, 2000-2015

Using the log real wage changes between 2000 and 2015 by percentile group of the Belarus' districts, Figure 7b demonstrates that the decline in wage inequality is relatively persistent across all wage percentiles. As shown, wage differentials among the districts have increased at all percentiles, but

[3] The three wage percentiles were normalized to 1 in the base year (2000) in order to better present the relative changes in district wages at different points of the distribution.

with a larger decline in the wage inequality in the lower part of the distribution. However, the wage gaps in the upper and lower parts of the wage distributions contribute not equally to the overall decreasing wage inequality in Belarus' districts: in the lower half wages increased substantially higher than in the upper half.

To compare district wage inequality in different regions of Belarus most commonly used inequality measures (the Gini coefficient, the two versions of the Theil index) and the coefficient of variation) were calculated for each region separately. Results are presented in Table 5 and Figure 8 for better illustration.

Table 5. District wage inequality measures in Belarus regions, 2000-2015

	Number of districts	Gini	CV	T(0)	T(1)
National level					
2000	118	0.097	0.206	0.017	0.018
2007	118	0.066	0.137	0.008	0.009
2015	118	0.068	0.144	0.008	0.009
Brest region					
2000	16	0.061	0.109	0.006	0.006
2007	16	0.048	0.090	0.004	0.004
2015	16	0.041	0.074	0.003	0.003
Gomel region					
2000	21	0.131	0.271	0.029	0.032
2007	21	0.091	0.195	0.015	0.017
2015	21	0.069	0.134	0.008	0.008
Grodno region					
2000	17	0.081	0.147	0.010	0.010
2007	17	0.052	0.096	0.004	0.004
2015	17	0.051	0.094	0.004	0.004
Mogilev region					
2000	21	0.054	0.109	0.005	0.005
2007	21	0.053	0.098	0.004	0.005
2015	21	0.045	0.081	0.003	0.003
Minsk region					
2000	22	0.115	0.250	0.023	0.025
2007	22	0.076	0.165	0.011	0.012
2015	22	0.090	0.20	0.015	0.017
Vitebsk region					
2000	21	0.053	0.104	0.005	0.005
2007	21	0.033	0.065	0.002	0.002
2015	21	0.054	0.096	0.004	0.004

Table 5 and Figure 8 display the changes in several dimensions of district wage inequality at both the national and regional level during 2000-2015. In general, the wage disparity in Belarus' districts obviously decreased over the sample period irrespective of the calculated index. The highest wage inequality in the initial year was in Gomel and Minsk regions. In the former case this was due to consequences of Chernobyl disaster and subsequent economic downturn and the existence of such economic leaders as Zhlobin and Mozyr (which, however, does not significantly influence the development of neighboring districts). In the second case, Minsk region represents the central region, thus, the disparity may be influenced by the proximity to country's capital – Minsk city.

Additionally, the results from Figure 8 indicate, first, that starting from 2005 wage inequality dynamics shows stagnation in the convergence process. Second, at the same time in the Minsk region wage inequality started to increase.

Finally, the bottom part of Figure 8 shows that, first, during high and stable periods of economic growth the wage inequality at district level in Belarus was also stable (2000-2002, 2005-2008), second, in the years of accelerating economic growth district wage inequality diminished (2003-2004), and, third, in the years of decreasing economic growth or its negative levels the district wage inequality increased in Belarus (2009, 2014-2015).

According to empirical findings of Kuznets (1955) and encouraged by him large amount of subsequent research studies during 1980s and 1990s there is a negative correlation in the degree of income inequality and economic growth (Perotti, 1996).

However, correlation does not mean causation, that is, causation can go in opposite direction: slow or negative economic growth can lead to increase in inequality and, furthermore, equality could generate greater economic growth.

From this point of view this is what happened in Belarus during 2000-2015 (see bottom part of Figure 8). Accelerating levels of economic growth led to decrease in wage inequality among Belarus' districts. Next, persistent levels of wage inequality coincide with the high and stable economic growth. Finally, negative economic growth corresponds to increase in district wage inequality in Belarus (as stated in Piketty's hypothesis (see Piketty, 2014)).

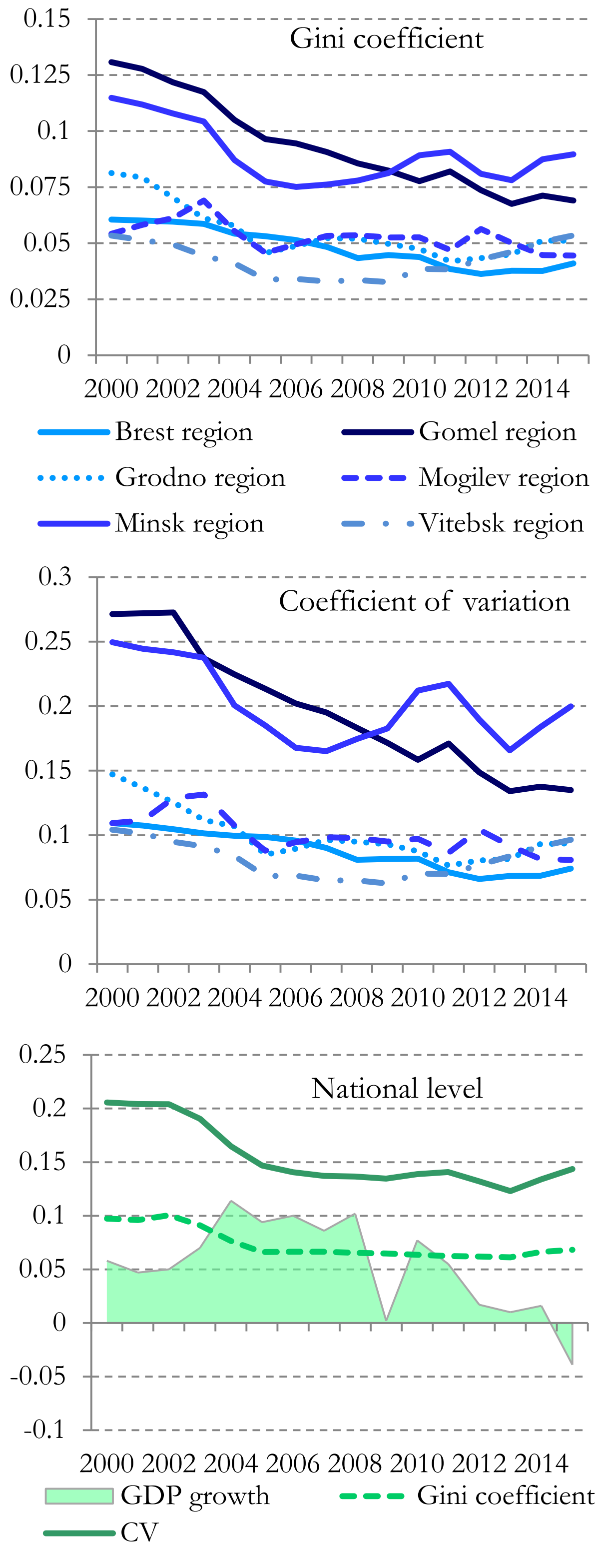


Figure 8. Measures of wage inequality in Belarus' districts at national and regional levels, 2000-2015

5.2. Distributional dynamics of regional wage inequality in Belarus

In this section the paper tries to see, first, what happened with the overall distribution of district wages and, second, what is intra-distributional dynamics of district wages in comparison with national average wages during 2000-2015.

The overall changes in the wage distribution of Belarusian districts were studied by computing the non-parametric kernel densities using Gaussian kernel with optimal bandwidth chosen according to Silverman's rule-of-thumb (Silverman, 1986). Figure 9 presents results, where the distribution of relative real monthly wages of the Belarusian districts (*Relative wages*) are presented for 2000, 2007 and 2015. The district wages has been measured relative to the national average wages, first, to take into account the possible non-stationarity of the individual district wage trends, and, second, because during the long period of time the entire country has been growing steadily, thus, to remove this country-wide co-movement.

Figure 9. Kernel densities of relative wages at the district level in Belarus, 2000, 2007, 2015

As the figure shows, shifts in the external shape of the distribution occurred between 2000 and 2007. More specifically, the wage distribution strongly moved to the average values in this period. In addition, the long tail at the upper end of the distribution that existed in 2000 has disappeared in 2007. The main mode in 2000 was located at 68% of the national average, while in 2007 it was shifted up to 78%.

However, several differences can be found when comparing the 2007 and 2015 wage distributions. First, the concentration of the distribution around its mean was slightly higher in 2007 (with the main mode at the same 78% of the average) than in 2015. Second, the wage distribution did not moved to the average national values since 2007. These results show the increase in overall relative persistence during the 2008-2015 indicating that a significant portion of districts does not change its relative inequality positions since the start of economic recession in Belarus.

Following from the above results next two questions concerning mobility or persistence of relative districts' positions, and polarization among them have appeared: first, whether relatively rich and poor Belarusian districts remain relatively rich and poor over time, and, second, whether all districts in the distribution tend to the same level of wages, represented by a single peak in the distribution, or whether clubs of districts within the overall distribution converge, represented by twin peaks (or more).

In order to answer these two questions the distribution dynamics approach (Quah, 1993; 1996) was applied through estimation of stochastic kernel. For these purposes the two distinct spans of time are used in order to subdivide different economic periods for Belarus. The 2000-2008 was a period of substantial economic growth across all Belarus' districts. In contrast the 2009-2015 period was characterized at the beginning by slowing growth, industrial stagnation and then in the last three years by substantial economic recession caused by the world economic crises, inefficient internal economic policy and, additionally, by Russian economic slowdown.

Correspondingly, Figures 10 and 11 show the stochastic kernel (their left part presence 3D view and right part corresponding contour) of one-year transitions for the relative real wages in Belarus' districts for the two sub-periods 2000–2008 and 2009-2015. The time *t* distribution of *Relative wages* is presented on vertical axis (on the corresponding contour plot), and the horizontal axis shows the time *t + 1* distribution, with 1.0 representing the standardized average level of wages. Therefore, a movement from right to left along the period *t* horizontal axis, or from left to right along the period *t + 1* horizontal axis indicates increasing relative wage.

Mobility and persistence is evaluated by assessing how the stochastic kernel corresponds to the 45^o diagonal line. This is more suitably represented on a contour plot, which shows relative wage levels as corresponding contours drawn from above view of the stochastic kernel and projected onto the base of the graph.

There are two possible cases concerning mobility and persistence. In the first case, when most of the stochastic kernel is focused along the diagonal line, it will indicate that mobility is low and change in the cross-section distribution of wages is little. Therefore, an example of persistence (the relatively rich districts stay rich and the relatively poor districts stay poor) will be, when districts' relative wages in period *t + 1* has not changed since period *t*. Taking into account the relatively short transition periods, it is expected that most of the stochastic kernel would be concentrated along the diagonal line.

In the second case, when most of the part of the stochastic kernel has rotated around the diagonal line, this would mean significant changes in the distribution indicating a high degree of mobility. A counter-clockwise movement around the diagonal line would mean that the relatively rich districts tend to become poorer and, contrary, the poor districts tend to become richer, thus, meaning that wages around districts have a trend towards equalization. A clockwise movement around the diagonal line would mean opposite – the rich districts tend to become richer and the poor districts tend to become poorer indicating divergence among districts.

Additionally, the shape of the stochastic kernel also plays a substantial role describing the probabilities of transition from given relative wage levels in time *t* to different relative wage levels in time *t + 1*. A peak indicates a comparatively large number of observed transitions from one particular part of the distribution to another demonstrating clustering over a one-year horizon. Furthermore, when different districts' transitions concentrate in different parts of the distribution (or around different wage poles) the number of peaks may be more than one. In the case of two peaks polarization would be represented by concentration of transitions around a low wage pole and a high wage pole. Finally, if this will be also accompanied by a hollow in the middle of the stochastic kernel this will mean an essential underlying characteristic – the separation between districts, that is, middle wage districts move into either high or low wage parts of the distribution.

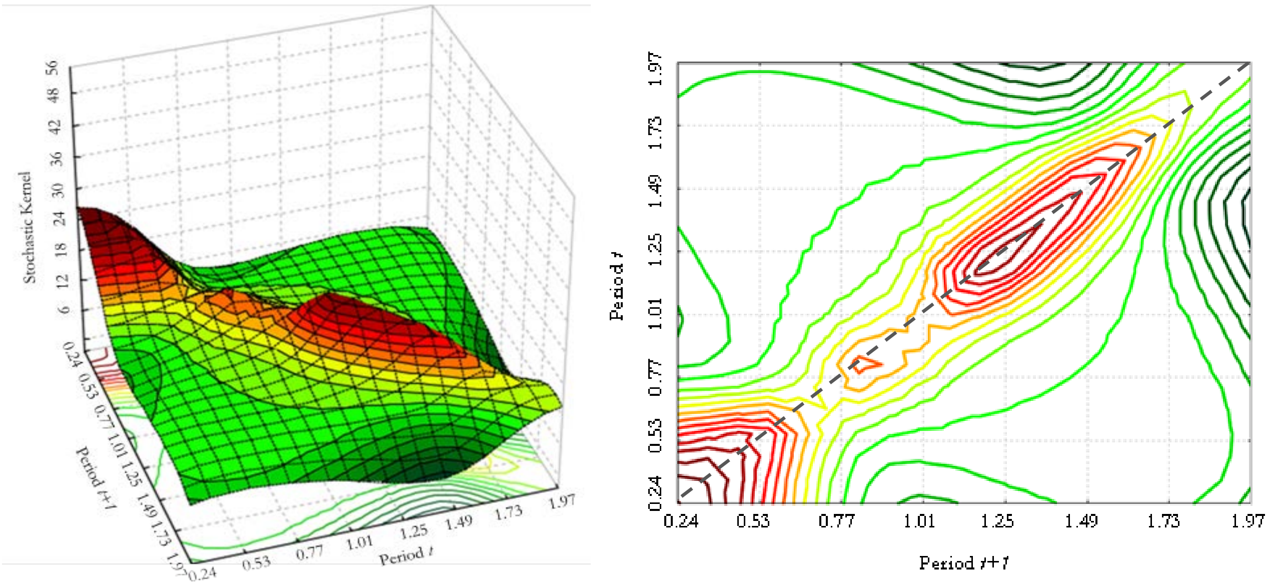


Figure 10. Relative wages across Belarus' districts, one-year transitions, 2000-2008

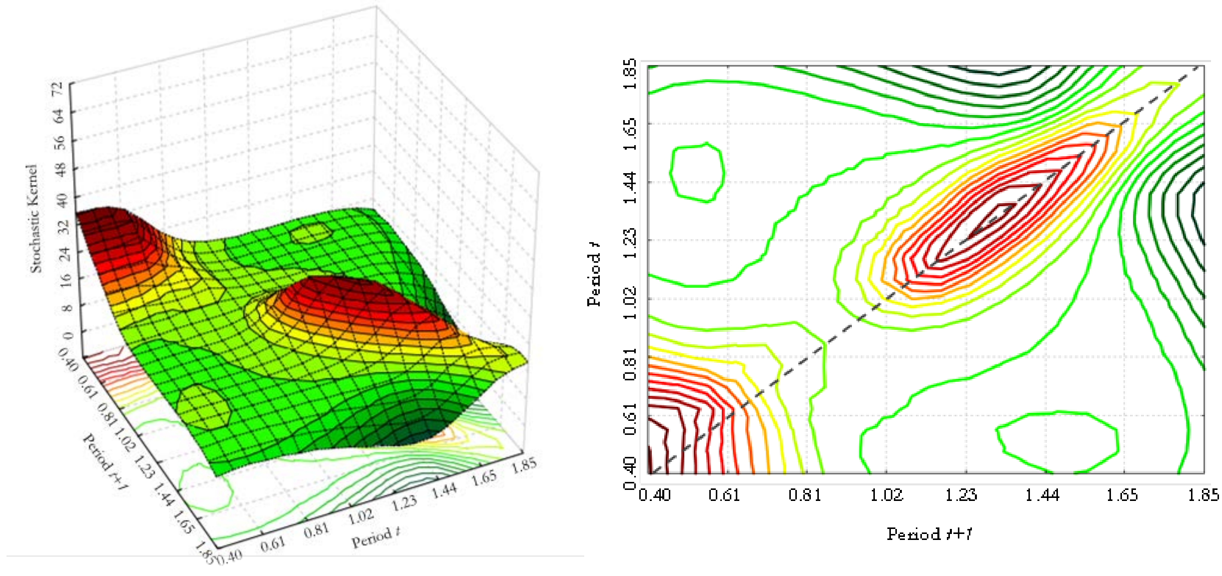


Figure 11. Relative wages across Belarus' districts, one-year transitions, 2009-2015

Therefore, Figures 10 and 11 were constructed for 2000-2008 and 2009-2015 periods. It is clear that a large share of the probability mass stays concentrated along the main diagonal over the one-year horizon indicating persistence and low probabilities of Belarus' districts to change their relative positions from the 2000 to the 2015.

However, there is a limited evidence of mobility among districts – clockwise and counter-clockwise movement in the bottom and upper parts of the distribution, correspondingly. These suggests that, first, the initially poorest districts display a comparatively higher probability of moving into even lower relative wage income part of the distribution than continue to stay where they began; and, second, relatively rich districts display a comparatively higher tendency to move also into a lower relative wage income part of the distribution (indicating that relatively rich wage income districts tended to become poorer over a one-year horizon.).

The most evident feature is the formation of three convergence clubs (polarization) in first time period that diminished to only two poles of wages in the second time period (2009-2015). For both periods the bottom cluster of districts comprises of low-wage districts at around 50% of the national average and the upper cluster includes relatively high-income districts at approximately 130% of the national average. The third cluster in the first time period consists of relatively middle-income district centered close to 85% of the national level. However, in the second time period (2009-2015) the third cluster disappeared Thus, the lower and higher wage income districts show a high probability to keep their initial wage positions within the cross-section distribution over one-year transitions.

Finally, it is also evident that the distribution dynamics of wage income is also accompanied by the formation of a dip in the middle of the stochastic kernel indicating existence of increasing separation between districts, that is, middle wage districts move into either high or low wage parts of the distribution.

Thus, in general results from distribution dynamics analysis also confirm the hypothesis stated by French economist Thomas Piketty (Piketty, 2014) that declining growth rates increase inequality.

5.4. Quantile regression

Finally, in order to study factors that influence wage inequality in Belarus' districts, the quantile regression was applied. A vector of coefficients was evaluated for each quantile of [0.10, 0.25, 0.50, 0.75, and 0.90]. Results are displayed in Table 6, where column q50 represents the estimation results for the 50th quantile that relates to the median regression. Correspondingly, each columns q10, q25, …, q90 show a vector of estimated coefficients for each quantile regression of district wage distribution.

Table 6. Quantile regression results

Variables	q10		q25		q50		q75		q90	
	coef	se	coef	se	coef	se	coef	se	coef	se
wrealwage	0.535***	0.044	0.556***	0.044	0.584***	0.032	0.538***	0.035	0.569***	0.026
Ln(Population)	0.004	0.008	0.002	0.008	0.005	0.007	0.014*	0.008	0.021***	0.007
Ln(Industr)	0.018**	0.009	0.013*	0.007	0.010**	0.004	0.017***	0.005	0.014*	0.007
Ln(Invest)	0.015*	0.008	0.012	0.009	0.006	0.007	0.010	0.006	0.023**	0.011
Ln(Retail)	0.036**	0.016	0.043**	0.017	0.048***	0.016	0.042**	0.019	0.020	0.021
Ln(Services)	0.009	0.013	0.017	0.018	0.016	0.014	0.014	0.018	0.031**	0.015
Ln(Expgoods)	0.005**	0.003	0.008**	0.003	0.008***	0.003	0.005***	0.002	0.007**	0.003
Ln(Expservices)	0.001	0.002	0.003*	0.001	0.002	0.002	0.002	0.002	0.004**	0.002
Iagr	0.017	0.031	0.031	0.033	0.066***	0.025	0.042*	0.024	0.048	0.033
Rdpol1	0.004	0.008	0.006	0.009	0.015**	0.007	0.009	0.007	0.010	0.008
Rdpol2	-0.030**	0.013	-0.006	0.015	0.00008	0.013	0.003	0.013	0.004	0.010
Rdpol3	-0.002	0.016	0.005	0.013	0.017	0.015	0.027	0.017	0.020	0.014
Rdpol4	-0.021	0.016	-0.021*	0.012	-0.023*	0.012	-0.015	0.010	0.002	0.012
Trend	0.0002***	9.70E-06	0.0002***	1.09E-05	0.0002***	6.34E-06	0.0002***	5.96E-06	0.0002***	7.45E-06
Const	-297.50***	13.965	-308.80***	16.648	-339.21***	9.118	-347.36***	8.559	-348.72***	10.687
Observations	1003		1003		1003		1003		1003	
Pseudo R^2	0.726		0.722		0.744		0.771		0.774	

Note: Rdpol1, Rdpol2, Rdpol3, Rdpol4 represent dummy variables that corresponds to the level of contamination of agricultural lands by Cesium-137: Rdpol1 0-no contamination, 1 – 1%-25%; Rdpol2 0-no contamination, 1 – 25%-50%; Rdpol3 0-no contamination, 1 – 50%-75%; Rdpol4 0-no contamination, 1 – 75%-100%.
*** Significant at 1%.
** Significant at 5%.
* Significant at 10%.

As can be seen from the above table the influence of population growth (ln(*Population*)) is significant and positive for 75th and 90th quantiles of districts, that is, the richest rural areas in Belarus. For instance, at the 75th quantile, holding all other factors constant, a 10% increase in population is associated with the increase of 0.14% in real wage. The influence of industrial development (ln(*Industr*)) and growth of exports of goods (Ln(*Expgoods*)) is significant and positive for all quantiles. However, the economic significance of exports of goods is very low, that is, holding all other factors constant, and a 10% increase in exports of goods leads to at most 0.08% increase in real wages at the 50th quantiles. Moreover, the influence of exports of services (Ln(*Expservices*)) though also positive is even lower and statistically significant only for 25th and 90th quantiles of districts.

Further, the influence of growth in retail trade (ln(*Retail*)) is positive and significant for 10th, 25th, 50th, and 75th quantiles. For example, holding all other factors constant, a 10% increase in retail trade leads to 0.4% increase in real wages at the 75th quantile. However, the influence of growth in services (Ln(*Services*)) is significant only for 90th quantile of districts, that is, a 10% increase in services is associated with 0.3% increase in real wages at the 90th quantile holding all other factors constant.

Next, the influence of growth in capital investments (ln(*Invest*)) is significant and positive for 10th and 90th quantiles of districts, that is, the poorest and richest rural areas in Belarus. For instance, at the 10th quantile, holding all other factors constant, a 10% increase in capital investments leads to of 0.15% increase in real wages. The influence of agricultural is very high, but statistically significant only for middle-income districts, that is, at the 50th and 75th quantiles. For example, holding all other factors constant, a 1% increase in agricultural efficiency leads to 6.6% increase in real wages at the 50th quantile. The estimated coefficients for technology trend (*Trend*) and Spatial dependence (*wrealwage*) are significant and positive for all quantiles, meaning that greater technology application and spatial dependence leads to higher real wages.

Finally, dummies that represent the level of contamination of agricultural land with radionuclides (*Rdpol*) are found to have mostly negative effect on wage growth in Belarus' districts and only for lower quantiles of districts, that is, poorer districts. For example, at the 10th quantile in districts where the share of contamination of agricultural land is 25%-50%, holding all other factors constant, real wage is lower by 3% in comparison with the districts where the contamination is zero. The similar pattern was found for 25th and 50th quantiles, that is, in districts where the share of contamination of agricultural land is 75%-100%, holding all other factors constant, real wage is lower by 2.1% and 2.3%, correspondingly, in comparison with the districts where the contamination is zero.

Thus, the above results from quantile regressions indicate, first, that the main economic factors that contribute to decrease in district wage inequality (between poor and rich districts) among Belarus' districts are industrial development, retail trade and agricultural development; second, the main economic factors that influence wage growth in richest districts in Belarus are growth of population and capital investments; and, third, the high positive influence of spatial dependence may indicate that in many cases the economic factors are not the main factors that determine wage growth in Belarus districts, most likely the administrative redistribution (equalization) of wages is a core driver of wage growth in Belarus indicating that labor market in Belarus is highly regulated.

7. Conclusions

The objective of this paper was to explore the heterogeneity of wage inequality among Belarus districts. Particular attention was given to estimating district wage inequality, to determining the spatial interdependencies in wages among Belarus' districts, to exploring intra-distributional dynamics of district wages and to finding the factors that influence district wage inequality. I employed 16 years of data, and applied the Global and Local Moran's *I* statistics, the four inequality measures, the distribution dynamics approach and quantile regression methods.

The main results of the research are next. First, the average district wages in Belarus are by approximately 20% lower than average republican wages and this difference increased in recent years indicating that the relatively poor district population became poorer in comparison with urban population of large cities in Belarus. Thus, from the view of economic policy in Belarus it is proposed in periods of economic recession to allocate more economic stimulus (financial support) in favor of rural population of districts than to urban population of large cities.

Second, the poorest region in Belarus is represented by Vitebsk, where the overall number of depressing districts accounts for 62% in 2015. Also, the number of high and highest class districts in other regions of Belarus does not change considerably in the studied period indicating the persistence in their economic positions and lack for new growth centers. Therefore, from economic policy view it proposed to change the direction of rural development, that is, all districts in Belarus should be subdivided into groups according to their competitive advantages, these advantages should be financially supported in the first place in order to build new economic centers.

Third, I found presence of strong and positive spatial interdependences in district wages in Belarus indicating that districts with similar high or low levels of wages tend to concentrate geographically. However, substantial increase in positive spatial interdependencies in wages between districts coincides with significant decrease in economic growth in Belarus due to economic recession. Therefore, from economic policy view these indicate that if the economic problems occur primarily for main economic districts in Belarus the additional difficulties will arrive at their neighbors.

Fourth, most districts in Belarus with high wages and similar high-wage neighbors are located in the central part of the country and additionally in the East-South and Western border districts. Those with low wages are located in the North and East of the country, and at the South border. Thus, from economic policy of view the district state policy (the financial support) must be mostly concerned about mentioned above territories.

Fifth, the main economy cores of high wages in Belarus are centered only around capital (Minsk city) and at the Zhlobin district (the center of metallurgical industry of Belarus); and the main economic periphery of low wages is located in the north part of the country. From economic policy view these results once again indicate lack of large economic centers at the district level of Belarus.

Sixth, the fourth and fifth empirical results overly indicate that the regional outcomes in Belarus are conditioned by their neighbors' outcomes as it was established for many countries (especially developed), but the lack of a neighbors' effect (as it was found for Belarus also) is mostly concern to the developing countries.

Seventh, real wages have increased more for lower percentiles districts than for higher ones which suggests presence of convergence process in wages among Belarus districts indicating declining spatial wage inequality in the country in the initial years (2000-2005) of studied period. However, starting from 2005 wage inequality dynamics shows stagnation in the convergence process and starting from 2013 the wage inequality in Belarus' districts started to increase. Thus, taking into account the dynamics of economic growth in Belarus during 2000-2015 accelerating levels of economic growth first led to decrease in wage inequality among Belarus' districts; next, the persistent levels of wage inequality coincided with the high and stable economic growth; and, finally, negative economic growth corresponded to increase in district wage inequality in Belarus. Thus, from theoretical point of view these results rejects the hypothesis of inverted-U-shaped relationship between spatial inequality and economic development (during the process of development inequality in the initial years increases, then reaches its peak, and then decreases) stated by Kuznets (1955), and confirms the hypothesis stated by French economist Thomas Piketty (Piketty, 2014) that declining growth rates increase inequality.

Eight, the results from estimated kernel densities indicate that the district wage distribution does not move to the average national values since 2008 indicating the increase in overall relative persistence among Belarus' districts and most probably the increase rural-urban divide in Belarus.

Ninth, the distribution dynamics analysis has also showed the persistence in relative positions of Belarus' districts and also low probabilities of Belarus' districts to change their relative positions from the 2000 to the 2015. Moreover, Belarus' districts formed three convergence clubs (at around 50%, 85% and 125% of the national average) in 2000-2008 that diminished to only two poles of wages (at around 50%, and 130% of the national average) in the second time period (2009-2015). Thus, the distribution dynamics of wages in Belarus indicates the existence of increasing separation between districts, that is, middle wage districts move into either high or low wage parts of the distribution.

Finally, results from quantile regressions indicate, first, that the main economic factors that contribute to decrease in district wage inequality (between poor and rich districts) among Belarus' districts are industrial development, retail trade and agricultural development; second, the main economic factors that influence wage growth in richest districts in Belarus are growth of population and capital investments; and, third, the high positive influence of spatial dependence may indicate that in many cases the economic factors are not the main causes that determine wage growth in Belarus districts, but most likely that the administrative redistribution (equalization) of wages is a core driver of wage growth in Belarus indicating that labor market in Belarus is highly regulated.

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