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ABSTRACT

During the last 15–20 years, inequality between Russian regions in terms of real personal incomes per capita was decreasing. This paper aims at revealing the "anatomy" of this phenomenon. To do so, time series of every regional income per capita is tested for catching-up with the national income per capita. Nonlinear asymptotically subsiding trends model the processes of convergence. The data cover 2002–2018 with a monthly frequency. Real incomes are estimated by adjusting nominal incomes to regional price levels. The results obtained suggest that 54.4% of the Russian regions exhibit convergence, and 20.3% of regions retain (approximately) stable income gap. At the same time, there is a significant proportion of deterministically diverging regions, equaling 22.8%. Random walks are detected in two regions only.

KEYWORDS

Russian regions, real income, catching-up, nonlinear trend

JEL codes: I31, R11, O18, C32

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1. INTRODUCTION

One of main issues of regional policy is that of regional inequality in the level of welfare essentially characterized by income per capita. An important question in this regard is whether the inequality tends to decrease over time. In fact, this question can be easily answered. It suffices to trace the evolution of some inequality indicator (standard deviation of log income, coefficient of variation, Gini index, etc.) and find its trend, i.e. to analyze the so called “sigma-convergence.” An econometric exercise called “beta-convergence” is superfluous. It adds nothing if sigma-convergence exists and – because of Galton’s fallacy (Quah, 1993) – can yield wrong results if it does not.

Anyway, results regarding countrywide convergence are rather poor, being of the kind “all or nothing.” It is much more interesting and important to find the role of every individual region of the country in this process, in other words, to reveal its “anatomy.” It seems reasonable to assume that the process of convergence is heterogeneous. Regions for sure differ in convergence rates; a part of them may not converge, having zero convergence rates. It is not inconceivable that there are regions with the deviant dynamics, i.e. divergence. Therefore, only a spatial pattern of convergence can provide a basis for reasonable, region-specific, policy implications.

This paper aims at revealing the “anatomy” of income convergence in Russia. During the last 15–20 years, inequality between Russian regions in terms of real personal incomes per capita was decreasing; the Gini index fell from 15.1% in 2002 to 11.1% in 2018. To find the role of individual regions in this process, time series of regional income per capita are tested for catching-up with the national income per capita. Nonlinear asymptotically subsiding trends model the processes of convergence. The data cover 2002–2018 with a monthly frequency. Real incomes are estimated by adjusting nominal personal incomes per capita to regional price levels.

The results obtained suggest that 54.4% of the Russian regions exhibit convergence, and 20.3% of regions retain stable (on average) income gap. At the same time, there is a significant proportion of deterministically diverging regions, equaling 22.8%. Random walks are detected in two regions only.

Publications on regional income inequality and convergence in Russia number in the tens. Gluschenko (2011) reviews a portion of them prior to 2010. Therefore, only some more recent studies are quoted here. Many of them use the regional GDP per capita as the income indicator, yielding contradictory results. Lehmann and Silvagni (2013), using data for 1995–2010 and beta-convergence, sigma-convergence, and distribution dynamics methodologies, find no evidence of convergence. Akhmedjonov et al. (2013) test stationarity of the gap between regional and national GDP per capita in 2000–2008 for every region, thus deeming a common trend in these two series to be an indication of convergence. They reveal so defined convergence in only 13 out of 79 regions, although conditional beta-convergence does hold. Durand-Lasserve and Blöchliger (2018) find conditional beta-convergence over 2005–2015. Lehman et al. (2020) exploit a modified version of conditional beta-convergence and also find convergence even over a longer period, 1996–2017 – in contrast to the earlier study, Lehmann and Silvagni (2013). Carvelli (2020) considers the period 1994–2015 and discovers that beta-convergence is accompanied by divergence in differences between the regional incomes and their sample average. Tochkov (2021) applies the distribution dynamics approach. With the use of data over 1994–2015, he finds divergence to prevail with the movement from the middle income level to the top and bottom levels.

The next portion of studies deals with personal income per capita as the income indicator. Guriev and Vakulenko (2012) explore convergence of personal incomes per capita and wages over 1995–2010, adjusting them to regional price levels by regional subsistence levels. Their results suggest that unlike the 1990s, when Russian regions did not converge or even diverge, convergence in incomes and wages occurred in the 2000s (accompanied by non-convergence in GDP per capita). Ivanova (2014) deals with the period 1996–2012, finding conditional beta-convergence of incomes adjusted for price levels by the regional cost of a fixed basket since 2002 and regional CPI for earlier years. World Bank Group (2017) reports conditional beta-convergence over 2004–2015.

All considered papers, except for Akhmedjonov et al. (2013), deal with the convergence process as a whole, not discriminating individual regions. It is worth noting that it is typical for the literature on income convergence in general; studies that discriminate individual economies (regions or countries) are very rare.

This paper contributes to the literature in two aspects. First, it demonstrates methodology of straightforward modeling convergence in the time series context. Second, it obtains a spatial pattern of income convergence of Russian regions in the 2000s, that is, reveals the evolution of income in every region with respect to the national average.

The rest of the paper is organized as follows. The next section describes methodology applied. Section 3 considers the data and gives an aggregated characterization of the evolution of real regional incomes per capita. Section 4 reports and discusses the results of the empirical analysis. Section 5 summarizes the study.

2. METHODOLOGY

Currently, the very notion of convergence in the time-series context is ambiguous. It had definitely meant catching-up in the literature on economic growth until, apparently, Bernard and Durlauf's (1995) paper caused confusion in this notion. Oxley and Greasley (1995) even propose to discriminate between catching-up and long-run convergence.

Consider the income gap between two economies: $y_{rst} = y_{rt} - y_{st} = \log(Y_{rt}/Y_{st})$, where Y_{rt} and Y_{rt} are incomes per capita in economies *r* and *s*, *t* denoting time. Bernard and Durlauf (1995) put forward a formal definition of convergence: economies *r* and *s* converge if the long-term forecast of income per capita (conditional on information available by the moment of forecast, *I*) are equal, that is,

$$\lim_{t\to\infty} E(y_{rst}|I) = 0. \quad (1)$$

Despite this definition of convergence is general, procedures of testing applied by Bernard and Durlauf (1995) in fact detect only a partial class of processes satisfying the definition, namely, stationary processes with no trend. This implies that y_{rt} and y_{st} have a common trend, or, in other terms, that these time series are cointegrated with cointegrating vector (1, – 1). It is worth noting that in this case series y_{rst} satisfies the condition of weak stationarity which is much narrower than Bernard and Durlauf's own definition. Since then (apparently) stationarity of income gap started to be considered as an indication of convergence in many studies.

From the viewpoint of common sense, it seems natural to mean by convergence a process of approaching economies to each other, narrowing the income gap between them, i.e. catching-up. It is illogical to call "convergence" a case when the income gap does not narrow, remaining on average stable, albeit with deviations from the average from time to time.

So, the term "convergence" means catching-up in what follows. A convergence process is in fact a superposition of two processes that can be called long-run, or deterministic, convergence, and short-run, or stochastic convergence: $y_{rst} = y^*_{rst} + \mathrm{d}y_{rst}$. The long-run convergence is a deterministic part of the income gap that tends to zero over time as Formula (1) requires: $y^*_{rst} = h(t)$, where $h(t)$ is an asymptotically subsiding trend such that $h(\infty) = 0$ and $d|h(t)|/dt < 0$. (To economize notation, the economy indices are suppressed somewhere.) Short-run convergence is an autocorrelated stochastic process containing no unit root, i.e. a stationary process $\mathrm{d}y_{rst} = (\lambda + 1)\mathrm{d}y_{rs,t-1} + \varepsilon_t$, where $\lambda + 1 = \rho < 1$ is the autoregression coefficient, and ε_t is the Gaussian white noise. (It is this process that Oxley and Greasley, 1995, call "long-run convergence," referring to the above superposition – albeit with a linear trend – as "catching-up.")

Intuitively, the short-run convergence characterizes the behavior of transient random shocks. A unit shock deflects the income gap from its long-run path, dying out over time with half-life $\theta = \ln(0.5)/\ln(\lambda + 1)$, so that the deflection eventually vanish. Thus, the superposition of long-run and short-run convergences is a process that is stationary around an asymptotically subsiding trend $h(t)$. That is, albeit random shocks force the process to deviate from the deterministic trend, it permanently tends to return to the trend, thus satisfying condition (1).

Since $dy_{rs,t-1} = y_{rs,t-1} - h(t-1)$, we get the following econometric model of convergence:

$$\Delta y_{rst} = h(t) - (\lambda + 1)\cdot h(t-1) + \lambda y_{rs,t-1} + \varepsilon_t, \qquad (2)$$

where Δ is the first difference operator.

Similarly to the half-life time of random deviations from the long-run path, the semi-convergence time of the deterministic income disparity, Θ, can be defined as the time the (percentage) disparity takes to halve, that is, $Y_{r,t+\Theta}/Y_{s,t+\Theta} - 1 = (Y_{rt}/Y_{st} - 1)/2$. It can be computed from the following equation: $h(t + \Theta) = \log(0.5(e^{h(t)} + 1))$.

The same Model (2) describe a process of divergence if $d|h(t)|/dt > 0$. It is also a process that is stationary around trend $h(t)$; however, the trend is a rising one. In this case, Θ is the doubling time, i.e. the time the disparity takes to double: $Y_{r,t+\Theta}/Y_{s,t+\Theta} - 1 = 2(Y_{rt}/Y_{st} - 1)$. Here, $h(t + \Theta) = \log(2e^{h(t)} - 1)$. Note that such a process is a superposition of short-run convergence and long-run (deterministic) divergence. Hence, it fundamentally differs from stochastic divergence which is a non-stationary process (random walk).

This study uses three modes of trend $h(t)$. The first one is the log-exponential trend $h(t) = \log(1 + \gamma e^{\delta t})$, $\delta < 0$; the second is the exponential trend $h(t) = \gamma e^{\delta t}$, $\delta < 0$; and the third is the fractional trend $h(t) = \gamma/(1 + \delta t)$, $\delta > 0$. The respective nonlinear econometric models have the forms:

$$\Delta y_{rst} = \log(1 + \gamma e^{\delta t}) - (\lambda + 1)\cdot\log(1 + \gamma e^{\delta(t-1)}) + \lambda y_{rs,t-1} + \varepsilon_t; \qquad (2a)$$

$$\Delta y_{rst} = \gamma e^{\delta t} - (\lambda + 1)\gamma e^{\delta(t-1)} + \lambda y_{rs,t-1} + \varepsilon_t; \qquad (2b)$$

$$\Delta y_{rst} = \frac{\gamma}{1+\delta t} - (\lambda + 1)\frac{\gamma}{1+\delta(t-1)} + \lambda y_{rs,t-1} + \varepsilon_t \qquad (2c)$$

Table 1 reports initial disparities, $Y_{r0}/Y_{s0} - 1$, and semi-convergence and doubling times in terms of the model parameters. As these times for the exponential and fractional trends depend on t, the table reports them for halving/doubling the initial disparity. If $e^{\gamma} \leq 0.5$ with diverging exponential or fractional trend, the doubling time should be computed with γ replaced by its absolute value (which means the permutation of indices r and s in y_{rst}).

Table 1. Interpretation of the model parameters

Trend	Initial disparity, $Y_{r0}/Y_{s0} - 1$	Semi-convergence time	Doubling time
Log-exponential	γ	$\frac{\log(0.5)}{\delta}$	$\frac{\log(2)}{\delta}$
Exponential	$e^{\gamma} - 1$	$\frac{1}{\delta}\log\left(\frac{\log(0.5(e^{\gamma}+1))}{\gamma}\right)$	$\frac{1}{\delta}\log\left(\frac{\log(2e^{\gamma}-1)}{\gamma}\right)$
Fractional	$e^{\gamma} - 1$	$\frac{1}{\delta}\left(\frac{\gamma}{\log(0.5(e^{\gamma}+1))} - 1\right)$	$\frac{1}{\delta}\left(\frac{\gamma}{\log(2e^{\gamma}-1)} - 1\right)$

Non-convergence occurs when the income gap does not change over time. Such a process can be also characterized as a superposition of two processes: short-run convergence and time-invariant long-run path $h(t) = \gamma$. Substituting this "trend" into Equation (2), the conventional AR(1) model with a constant is arrived at:

$$\Delta y_{rst} = \alpha + \lambda y_{rs,t-1} + \varepsilon_t, \qquad (3)$$

where $\alpha = -\lambda\gamma$.

Ignoring random shocks, this case implies a proportional change in incomes: $Y_{rt} = cY_{st}$ with $c = e^{\gamma}$. Alternatively, incomes in r and s (in the logarithmic terms) have the same trends shifted by a constant: $y_{rt} = y_{st} + \gamma$.

An important particular case of non-convergence is that of $\gamma = 0$, i.e. the long-run path of the income gap is $h(t) = 0$. Thus, only short-run convergence remains, generating the conventional AR(1) model with no constant:

$$\Delta y_{rst} = \lambda y_{rs,t-1} + \varepsilon_t. \qquad (4)$$

This means that there is no income gap between the economies under consideration. Accurate to random shocks, $Y_{rt} = Y_{st}$, or incomes in r and s have a common trend. This implies that convergence as such has completed by the moment $t = 0$, the income gap fluctuating around the income parity. Nonetheless, it is this process that is deemed convergence in numerous papers, Bernard and Durlauf (1995) among these.

The empirical analysis in this study follows the general-to-specific approach. That is, Model (2) is estimated and tested at first. If it proves not valid, the analysis proceeds with Model (3). In turn, Model (4) is analyzed if Model (3) is rejected. In the case that no one model proves valid, the conclusion is that a process under consideration is a random walk.

All three versions of Equation (3) are estimated for each time series, selecting a version that provides the best fit (the minimal sum of squared residuals) if they turn out to be completive. In the unit root test and test for statistical significance of parameters γ and δ, 10% is accepted as the critical level.

Testing the unit root hypothesis, H_0: $\lambda = 0$ (against $\lambda < 0$), applies the Phillips-Perron (PP) test with the OLS autoregressive spectral method. This makes it possible to avoid size distortions that arise because of the use of kernel-based spectral density estimators (Perron and Ng, 1996). The lag length selection bases on the modified Bayesian (Schwarz) information criterion with a sample-dependent penalty factor (proposed by Ng and Perron, 2001). Besides, the effective number of observations is held fixed when estimating the auxiliary OLS regression with different lag lengths, according to Ng and Perron (2005). The unit root test statistics, t-ratio of λ, $\tau = \lambda/\sigma_\lambda$, for models with nonlinear trends are non-standard and not tabulated. To obtain their empirical distributions under the null hypothesis, τ in models (2a), (2b), and (2c) were estimated over 1 million random walks $y_t = y_{t-1} + \varepsilon_t$.

3. DATA

The Russian Federation consists of constituent units (republics, *oblasts*, one autonomous *oblast*, *krais*, autonomous *okrugs*, and federal cities) termed federal subjects. Despite different designations, all these are equal in legal terms. In this study, a federal subject (including federal cities of Moscow and Saint Petersburg) is meant by a region, "composite" federal subjects (that include autonomous *okrugs*) being considered as single wholes. The spatial sample covers 79 regions, all Russia's regions – as of 2002 – but the Chechen Republic that lacks full time series.

The time span covers January 2002 to December 2018 with a monthly frequency (204 points in time). The use of the monthly data is motivated by the fact that the number of annual observations would be insufficient for time-series analysis. Annual data used for aggregate characterizations below are averages of monthly indicators over a respective year.

Studies on regional income inequality frequently involve regional GDP per capita. However, this indicator is not an adequate characterization of population's welfare, rather reflecting economic performance of regions (even so, it can be distorted, though, because of mismatch between regions where companies actually work and where they are registered). The point is that the final household consumption is typically only a part of regional GRP. However, due to social transfers from the federal budget, it can even exceed GRP in some regions. In 2018, the ratio of final household consumption to GRP varied across Russian regions from 15% to 130% (excluding in-kind transfers; computed from Rosstat, 2020, pp. 490-491, 509, 511). Therefore, this study uses personal incomes per capita which directly relate to population's welfare.

To provide comparability of incomes across regions, they should be adjusted to regional price levels; it is so adjusted income that is referred to as real income in this study. Regional consumer price indices (CPI) are not suitable for this purpose. The point is that the CPI weighting schemes vary across regions, which makes CPI not comparable across regions. There is an alternative indicator in the Russian statistics, the cost-of-living index. It bases on the same set of goods and services as CPI; but, in contrast, the respective basket is uniform for all regions of the country. However, some features of this index prevent its use. First, the cost-of-living index is by city, and not by region (this is surmountable, thou; aggregating for regions is easy albeit time-consuming). Second, the index is annual, and not monthly. And third, the cost-of-living index has been introduced only since 2009. Therefore, a different indicator is used as a proxy of regional price level, namely, the monthly cost of fixed basket of consumer goods and services for inter-regional comparisons of population's purchasing power (hereafter, simply "fixed basket"). This basket includes 83 goods and services and is uniform across regions and time. It is less representative than the cost-of-living index which covers 275 items. However, a comparative study in Gluschenko and Karandashova (2017) suggests that the cost of the fixed basket provides a satisfactory accuracy of estimating real incomes.

So, the regional income per capita is the ratio of nominal income per capita in a region to the cost of the fixed basket in this region. The same relates to the national real income per capita. The Russian statistics estimates personal income per capita in the country as the weighted average of regional incomes; the same is valid for the national cost of the fixed basket. The variable to be analyzed is relative real income per capita in a region. It is the ratio of regional real income per capita to the national income per capita. In terms of the previous section this means that index s in y_{rst} is fixed, corresponding to Russia as a whole.

The data source is the Russian statistical agency, Rosstat. Nominal incomes per capita by region are drawn from: Rosstat (2002–2007) for 2002–2007, Rosstat (2014) for 2008, Rosstat (2016a) for 2009–2012, Rosstat (2016b) for 2013–2015, and for 2016–2019, EMISS (2020a) for 2016–2019. The costs of the fixed basket by region are drawn from EMISS (2020b). They are available since 2002, hence the beginning of the time span of the study. Its end is determined by the fact that the data on personal incomes by region are published with a quarterly (and not monthly) frequency since 2019.

Let us consider characterizations of the data. Figure 1 shows the evolution of different estimates of real incomes in Russia.

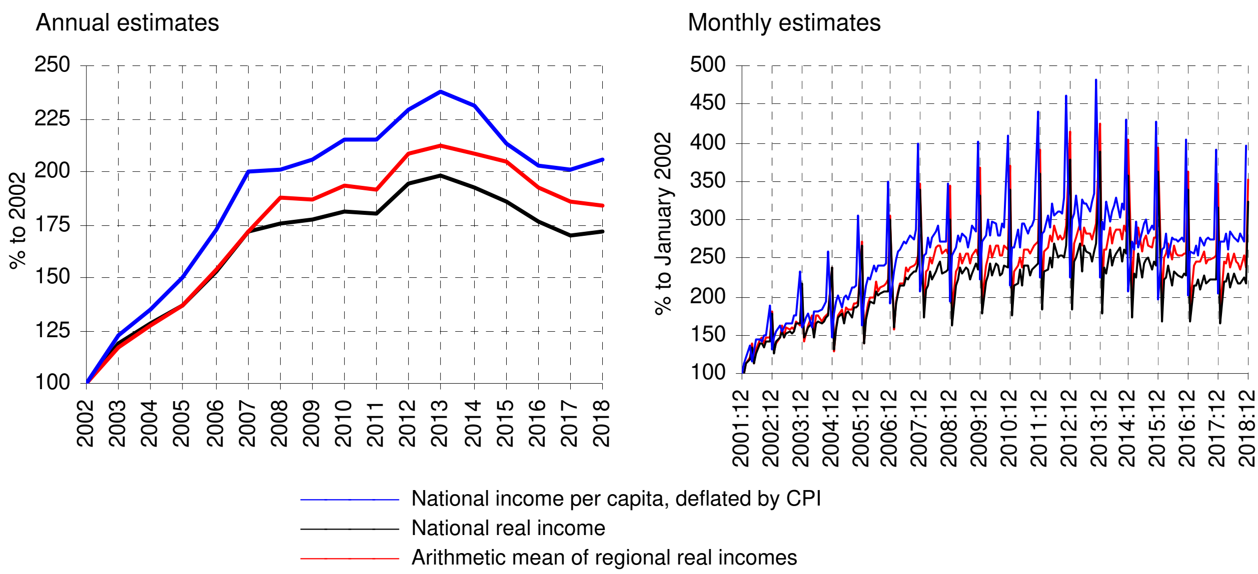

Figure 1. Real incomes in Russia

The left panel of Figure 1 plots annual averages of monthly incomes depicted in the right panel. The real national income per capita is estimated in three ways. First, the nominal income per capita in the county as a whole is divided by the national CPI (this estimate seems the most exact). Second, the national real income per capita is the ratio of the nominal income to the cost of the fixed basket. Third, the real income is computed as the arithmetic mean of regional real incomes. Quantitatively, these estimates do not coincide; however, their behavior is the same qualitatively. It suggests that the real income in the country progressively rose till 2013. Since 2014, it started falling. In 2018, the regional average suggests further fall, while two other estimates show a minor rise. The reason is that increases in real incomes in more populated regions have exceeded decreases in less populated (and more numerous) regions. The arithmetic mean does not capture this, attaching equal weights to all regions. Turning to the right panel of Figure 1, it is seen that the real income is highly volatile (the same is true for the nominal income). It follows a sawtooth trajectory. Every December, personal incomes skyrocket because of yearly bonuses, repayment of wage arrears, etc. In January, incomes regularly fall because of 10-day New Year holidays and shortage of wage funds caused by additional payments in the previous month. Moreover, both additional payments and shortages considerably differ across regions, increasing income dispersion.

Figure 2 reports the distribution of regional real incomes per capita related to the national real income in the initial and final years of the time span under consideration. Despite the histogram for 2002 is seemingly bimodal, so causing a suspect of convergence clubs, a test for multimodality (Fischer et al., 1994) does not corroborate this suspect. It rejects the hypothesis of more than one mode with confidence (the same is true for other years). Comparing 2002 and 2018, some indications of convergence are seen. The outliers of 2002 have shifted to the main body of the distribution by 2018. These were Moscow City (2.34 in 2002 and 1.33 in 2018), the Tymen Oblast (1.75 and 1.15), and Republic of Komi (1.34 and 0.91). The most poor regions became richer, leaving the income class [0.3, 0.4) empty. These regions were the Republic of Ingushetia (0.31 in 2002 and 0.57 in 2018) and Ivanovo Oblast (0.44 and 0.77). However, there are indications of divergence as well. For instance, a sole region in the class of the most poor in 2018, the Republic of Tuva, with its relative income of 0.48, had income of 0.62 in 2002. In general, the mean of the distribution changed from 0.80 to 0.86 and the median increased from 0.76 to 0.83, so approaching the national average. At the same time, the standard deviation decreased from 0.27 to 0.18, evidencing a decrease in dispersion of regional real incomes.

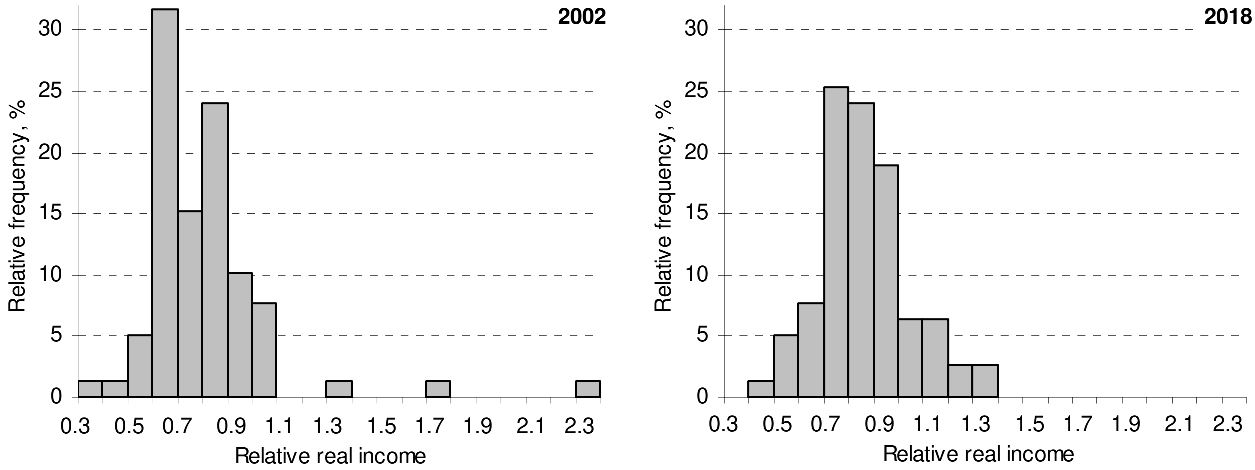

Figure 2. Distribution of regional real incomes per capita

Figure 3 provides more detailed pattern of the descriptive statistics. It plots their evolution over the whole time span for monthly relative incomes and their annual averages.

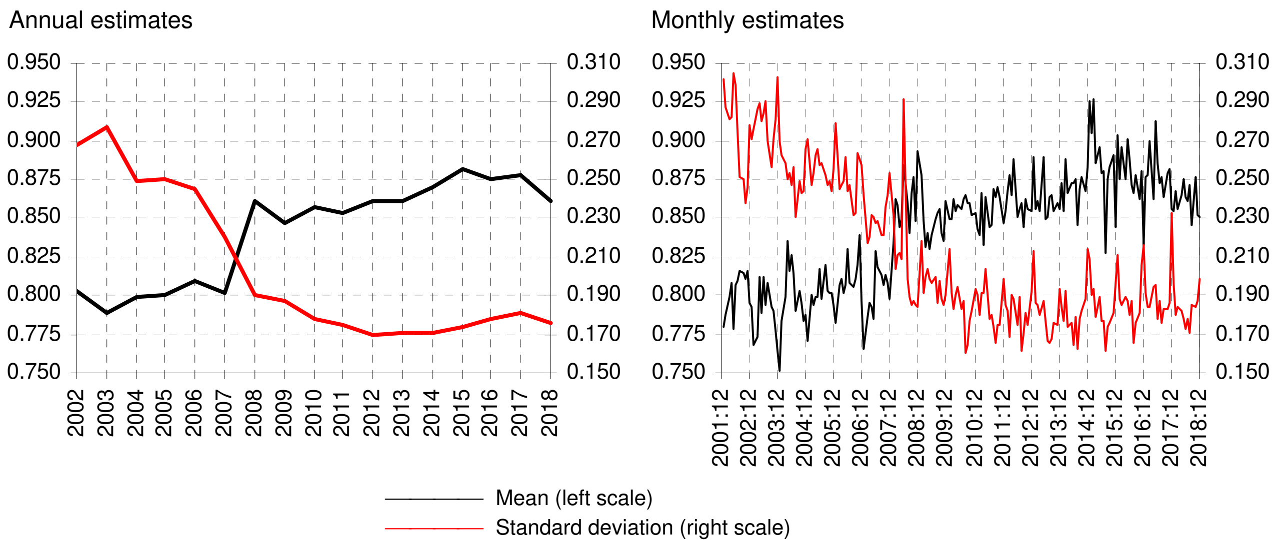

Figure 3. Descriptive statistics of regional real incomes related to the national average

While the evolution of the standard deviation also suggests the overall tendency to income convergence, it shows that this process is not permanent. Since 2015, income dispersion slowly rose (except for the final year of the time span). The mean reached its peak in 2015 and started decreasing then. This evidences that regions were becoming on average poorer since 2016.

At last, let us consider the income dynamics directly in terms of inequality. Figure 4 plots the evolution of the Gini index of regional real incomes per capita during 2002–2018.

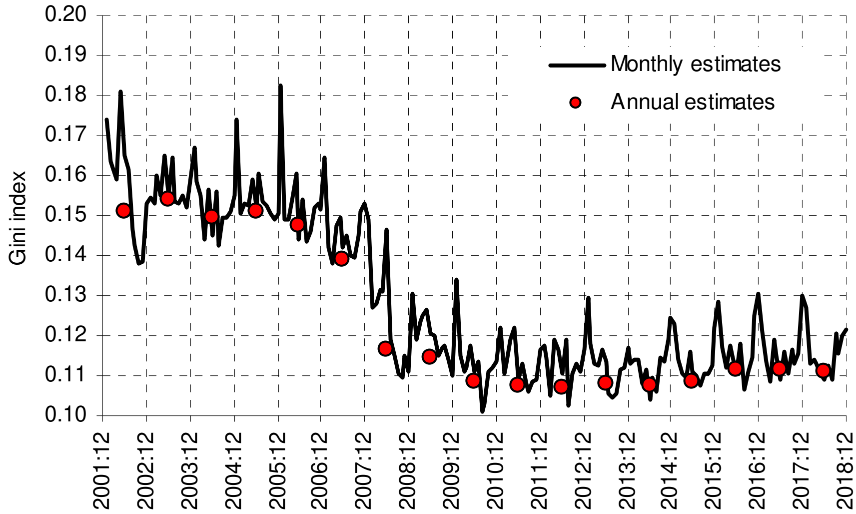

Figure 4. Regional income inequality in Russia

Figure 4 also unambiguously suggests convergence of regional real incomes. The regional inequality measured by the annual Gini index decreased from 0.151 in 2002 to 0.111 in 2018. However, convergence seems to stop after 2012, having reached the annual value of 0.107. After that, the inequality started rising, albeit very slowly.

Based on the preliminary analysis in the section, we can expect processes of convergence to be widespread among regions of the country. Along with this, it is probable that divergence occurs in some regions as well.

4. EMPIRICAL RESULTS

Table 2 tabulates the results of the econometric analysis. Recall that convergence of regional real income per capita to the national one is analyzed. For every region, the table reports a model that the most adequately describes the time series of income gap between the region and Russia as a whole, coefficient estimates, and results of testing for unit root. For Models (2a), (2b), and (2c), the semi-convergence or doubling time is also reported (the bold font marking the latter as well as the relevant model). Figure 5 relates the results to geography.

Table 2. The pattern of income convergence

Region	Model	λ		PP test p-value	γ/α in (3)		δ		Θ, years
1. Rep. of Karelia	**(2b)**	–0.462	(0.059)	0.000	–0.103***	(0.013)	0.0052***	(0.0009)	**12.0**
2. Rep. of Komi	(2a)	–0.336	(0.053)	0.000	0.430***	(0.094)	–0.0246***	(0.0064)	2.3
3. Arkhangelsk Obl.	(2b)	–0.387	(0.056)	0.000	–0.131***	(0.013)	–0.0035*	(0.0018)	17.4
4. Vologda Obl.	**(2b)**	–0.301	(0.051)	0.000	–0.164***	(0.027)	0.0021*	(0.0013)	**31.2**
5. Murmansk Obl.	(3)	–0.344	(0.053)	0.000	–0.012*	(0.007)			
6. St. Petersburg City	(3)	–0.419	(0.057)	0.000	0.078***	(0.012)			
7. Leningrad Obl.	(2c)	–0.374	(0.055)	0.003	–0.544***	(0.051)	0.0101***	(0.0024)	10.8
8. Novgorod Obl.	(2b)	–0.502	(0.060)	0.000	–0.355***	(0.028)	–0.0073***	(0.0010)	9.0
9. Pskov Obl.	(3)	–0.651	(0.065)	0.000	–0.201***	(0.021)			
10. Kaliningrad Obl.	(2c)	–0.452	(0.059)	0.000	–0.454***	(0.034)	0.0100***	(0.0019)	10.5
11. Bryansk Obl.	(2b)	–0.711	(0.069)	0.000	–0.456***	(0.015)	–0.0077***	(0.0004)	8.8
12. Vladimir Obl.	(2b)	–0.400	(0.057)	0.000	–0.557***	(0.026)	–0.0038***	(0.0005)	18.6
13. Ivanovo Obl.	(2b)	–0.534	(0.063)	0.000	–0.973***	(0.027)	–0.0077***	(0.0004)	10.4
14. Kaluga Obl.	(2a)	–0.406	(0.058)	0.000	–0.419***	(0.022)	–0.0123***	(0.0012)	4.7
15. Kostroma Obl.	(2b)	–0.789	(0.070)	0.000	–0.437***	(0.016)	–0.0042***	(0.0004)	16.2
16. Moscow City	(2b)	–0.552	(0.064)	0.000	0.956***	(0.026)	–0.0067***	(0.0003)	6.0
17. Moscow Obl.	none								
18. Oryol Obl.	(2b)	–0.448	(0.059)	0.000	–0.320***	(0.023)	–0.0040***	(0.0008)	16.1
19. Ryazan Obl.	(2b)	–0.674	(0.066)	0.000	–0.436***	(0.022)	–0.0045***	(0.0006)	14.8
20. Smolensk Obl.	(3)	–0.775	(0.069)	0.000	–0.161***	(0.015)			
21. Tver Obl.	(2c)	–0.357	(0.054)	0.008	–0.488***	(0.032)	0.0060***	(0.0012)	17.6
22. Tula Obl.	(2b)	–0.379	(0.055)	0.000	–0.355***	(0.030)	–0.0079***	(0.0011)	8.3
23. Yaroslavl Obl.	(3)	–0.412	(0.057)	0.000	–0.051***	(0.008)			
24. Rep. of Mariy El	(2c)	–0.595	(0.065)	0.000	–0.737***	(0.025)	0.0058***	(0.0006)	20.8
25. Rep. of Mordovia	(2c)	–0.443	(0.059)	0.001	–0.541***	(0.025)	0.0019***	(0.0005)	56.5
26. Chuvash Rep.	(2c)	–0.461	(0.060)	0.000	–0.466***	(0.020)	0.0013***	(0.0004)	82.1
27. Kirov Obl.	(2c)	–0.483	(0.060)	0.000	–0.498***	(0.028)	0.0049***	(0.0009)	21.8
28. Nizhni Novgorod Obl.	(2b)	–0.261	(0.047)	0.004	–0.306***	(0.047)	–0.0141***	(0.0030)	4.6
29. Belgorod Obl.	(2b)	–0.200	(0.042)	0.098	–0.425***	(0.116)	–0.0239***	(0.0081)	2.8
30. Voronezh Obl.	none								
31. Kursk Obl.	(2b)	–0.496	(0.062)	0.000	–0.430***	(0.025)	–0.0127***	(0.0011)	5.3
32. Lipetsk Obl.	(2b)	–0.433	(0.058)	0.000	–0.254***	(0.045)	–0.0203***	(0.0049)	3.1
33. Tambov Obl.	(2b)	–0.292	(0.049)	0.000	–0.286***	(0.032)	–0.0047***	(0.0012)	13.6
34. Rep. of Kalmykia	(2b)	–0.574	(0.064)	0.000	–0.913***	(0.032)	–0.0015***	(0.0003)	51.5
35. Rep. of Tatarstan	**(2a)**	–0.513	(0.062)	0.000	0.050***	(0.012)	0.0076***	(0.0016)	**7.6**
36. Astrakhan Obl.	(3)	–0.299	(0.049)	0.000	–0.053***	(0.009)			
37. Volgograd Obl.	**(2c)**	–0.354	(0.052)	0.005	–0.189***	(0.017)	–0.0020***	(0.0004)	**22.6**
38. Penza Obl.	(2c)	–0.428	(0.059)	0.004	–0.557***	(0.039)	0.0088***	(0.0016)	12.6
39. Samara Obl.	**(2c)**	–0.468	(0.060)	0.000	–0.006*	(0.003)	–0.0048***	(0.0001)	**8.8**
40. Saratov Obl.	(2c)	–0.601	(0.065)	0.000	–0.377***	(0.015)	0.0021***	(0.0005)	47.4
41. Ulyanovsk Obl.	(2c)	–0.361	(0.056)	0.013	–0.485***	(0.039)	0.0079***	(0.0018)	13.4
42. Rep. of Adygeya	(2b)	–0.188	(0.040)	0.057	–0.792***	(0.093)	–0.0077***	(0.0015)	9.8
43. Rep. of Dagestan	(2b)	–0.246	(0.046)	0.000	–0.869***	(0.150)	–0.0219***	(0.0049)	3.5
44. Rep. of Ingushetia	(2a)	–0.536	(0.063)	0.000	–0.769***	(0.020)	–0.0045***	(0.0004)	12.8
45. Kabardian-Balkar Rep.	(3)	–0.345	(0.053)	0.000	–0.137***	(0.022)			
46. Karachaev-Cirkassian Rep.	**(2c)**	–0.615	(0.066)	0.000	–0.410***	(0.012)	–0.0014***	(0.0002)	**38.5**
47. Rep. of Northern Ossetia	(3)	–0.630	(0.065)	0.000	–0.148***	(0.016)			
48. Krasnodar Krai	(2b)	–0.237	(0.046)	0.032	–0.446***	(0.078)	–0.0137***	(0.0033)	4.9
49. Stavropol Krai	(2b)	–0.389	(0.056)	0.000	–0.502***	(0.021)	–0.0038***	(0.0004)	18.3
50. Rostov Obl.	(3)	–0.265	(0.048)	0.000	–0.048***	(0.009)			
51. Rep. of Bashkortostan	(4)	–0.317	(0.052)	0.000					
52. Udmurt Rep.	(2b)	–0.529	(0.063)	0.000	–0.447***	(0.018)	–0.0059***	(0.0005)	11.4
53. Kurgan Obl.	(3)	–0.221	(0.044)	0.035	–0.074***	(0.015)			
54. Orenburg Obl.	(2c)	–0.651	(0.067)	0.000	–0.404***	(0.021)	0.0099***	(0.0013)	10.3
55. Perm Krai	(4)	–0.415	(0.058)	0.000					
56. Sverdlovsk Obl.	**(2a)**	–0.375	(0.052)	0.000	0.092***	(0.021)	0.0039**	(0.0016)	**14.7**
57. Chelyabinsk Obl.	**(2c)**	–0.268	(0.048)	0.036	–0.040***	(0.013)	–0.0040***	(0.0005)	**10.7**

Region	Model	λ		PP test *p*-value	γ/α in (3)		δ		Θ, years
58. Rep. of Altai	**(2c)**	–0.532	(0.062)	0.000	-0.470^{***}	(0.025)	-0.0010^{***}	(0.0003)	**53.3**
59. Altai Krai	(2b)	–0.576	(0.064)	0.000	-0.470^{***}	(0.021)	-0.0030^{***}	(0.0005)	22.7
60. Kemerovo Obl.	**(2c)**	–0.283	(0.049)	0.038	-0.022^{***}	(0.007)	-0.0046^{***}	(0.0001)	**9.1**
61. Novosibirsk Obl.	(2a)	–0.313	(0.049)	0.000	-0.237^{***}	(0.025)	-0.0032^{***}	(0.0011)	18.2
62. Omsk Obl.	**(2c)**	–0.459	(0.056)	0.000	-0.007^{**}	(0.003)	-0.0048^{***}	(0.0001)	**8.8**
63. Tomsk Obl.	**(2b)**	–0.464	(0.059)	0.000	-0.099^{***}	(0.013)	0.0053^{***}	(0.0009)	**11.8**
64. Tyumen Obl.	(2b)	–0.415	(0.057)	0.000	0.540^{***}	(0.026)	-0.0069^{***}	(0.0006)	6.9
65. Rep. of Buryatia	(2b)	–0.344	(0.053)	0.000	-0.378^{***}	(0.035)	-0.0034^{***}	(0.0009)	19.5
66. Rep. of Tuva	**(2c)**	–0.752	(0.069)	0.000	-0.578^{***}	(0.021)	-0.0007^{***}	(0.0003)	**81.8**
67. Rep. of Khakasia	(3)	–0.642	(0.066)	0.000	-0.222^{***}	(0.024)			
68. Krasnoyarsk Krai	**(2c)**	–0.377	(0.056)	0.006	-0.059^{***}	(0.011)	-0.0031^{***}	(0.0006)	**13.9**
69. Irkutsk Obl.	**(2c)**	–0.382	(0.055)	0.006	-0.124^{***}	(0.011)	-0.0030^{***}	(0.0003)	**15.0**
70. Transbaikal Krai	(2c)	–0.344	(0.051)	0.004	-0.567^{***}	(0.053)	0.0147^{***}	(0.0031)	7.5
71. Rep. of Sakha (Yakutia)	(3)	–0.506	(0.062)	0.000	-0.020^{***}	(0.006)			
72. Jewish Autonomous Obl.	**(2c)**	–0.595	(0.065)	0.000	-0.362^{***}	(0.013)	-0.0009^{***}	(0.0002)	**57.0**
73. Chukotka AO	(4)	–0.378	(0.054)	0.000					
74. Primorsky Krai	(2b)	–0.626	(0.066)	0.000	-0.493^{***}	(0.019)	-0.0064^{***}	(0.0005)	10.7
75. Khabarovsk Krai	(2b)	–0.410	(0.057)	0.000	-0.167^{***}	(0.028)	-0.0041^{**}	(0.0018)	14.9
76. Amur Obl.	(2b)	–0.319	(0.051)	0.000	-0.560^{***}	(0.047)	-0.0074^{**}	(0.0011)	9.5
77. Kamchatka Krai	(3)	–0.620	(0.065)	0.000	-0.148^{***}	(0.017)			
78. Magadan Obl.	**(2c)**	–0.625	(0.065)	0.000	0.016^{***}	(0.006)	-0.0045^{***}	(0.0002)	**9.1**
79. Sakhalin Obl.	**(2c)**	–0.233	(0.045)	0.081	0.042^{***}	(0.014)	-0.0042^{***}	(0.0004)	**9.7**

Notes: 1. Standard errors are in parentheses. 2. Asterisks ***, **, and * denote statistical significance at the 1%, 5% and 10% levels, respectively. 3. Θ in bold font means doubling time in cases of divergence. 4. 'Obl.' = Oblast, 'Rep.' = Republic, and 'A.O.' = Autonomous Okrug.

As expected, convergence is a prevailing type of regional income dynamics. It occurs in 43 regions out of 79, or in 54.4% of regions. In most of them (40 regions), real incomes were below the national income. Thus, the most part of regional convergence in 2002–2018 consisted of faster income growth in poorer regions. In three regions, convergence leaded to a decrease in relative real incomes. These regions were the richest in the country in 2002 (see the left panel of Figure 2). However, as a result, the real income in the Republic of Komi felt below the national one. In fact, this implies divergence. Model (2) is not able to detect such kind of divergence, as the asymptotically subsiding trends cannot intersect the zero line.

Non-convergence takes place in 16 regions (20.3%). In 13 regions, real incomes changed proportionally to the national one, so that their income gap remained on average constant. Out of them, the real income was higher than the national average in Saint-Petersburg only. Thus, 12 regions permanently remained relatively poor with no improvement in the situation. Three regions had real income on average equal to the national one. Surprisingly, the Chukotka Autonomous Okrug, the most remote northern region of the country is among them. The point is that Model (4) describes the income dynamics on average over 17 years. In fact, the real income in Chukotka exceeds the national level since about 2010.

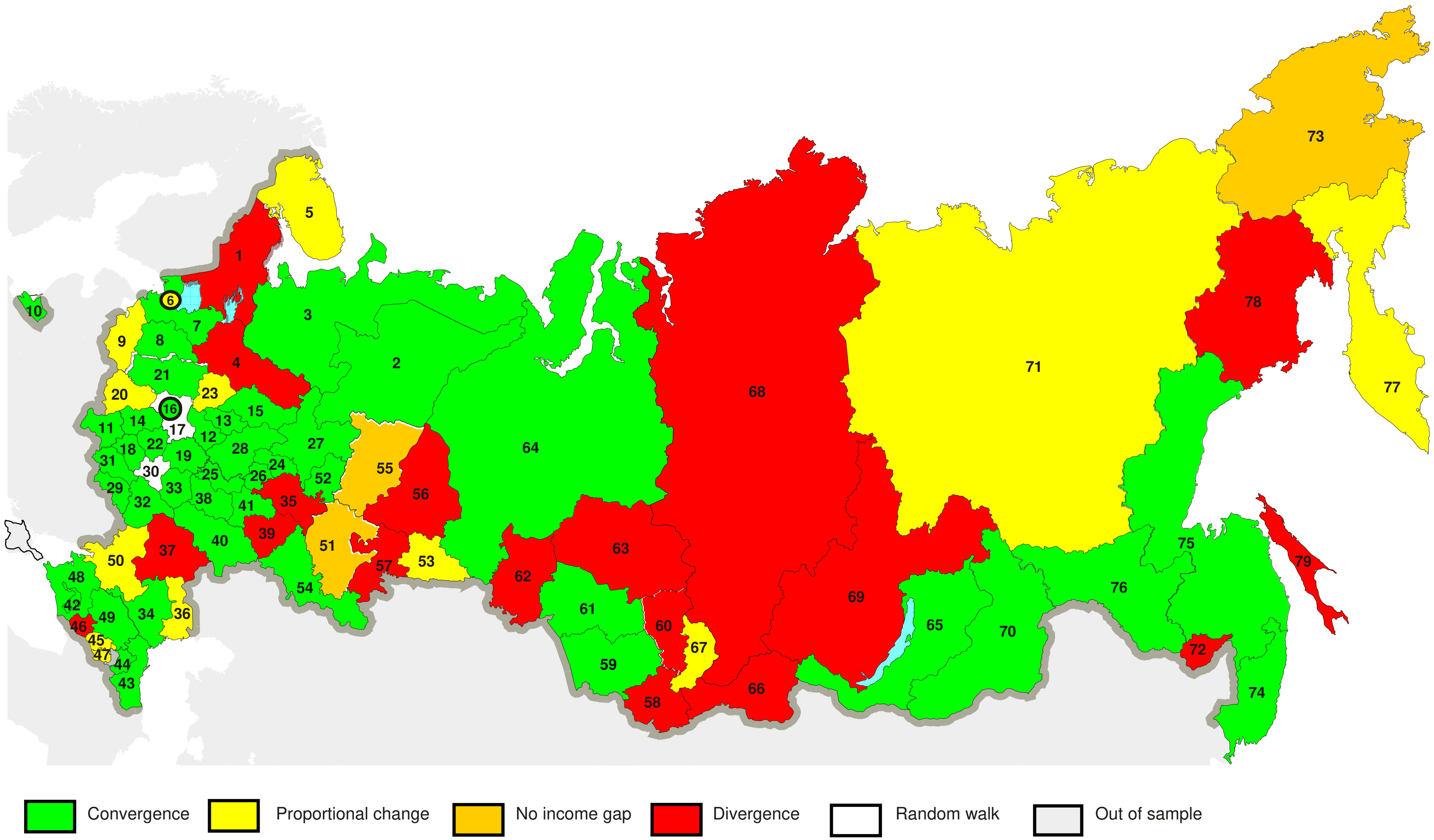

Figure 5. Spatial pattern of regional income convergence in Russia.
Note: See Table 2 for numerical designations of regions.

A significant proportion of regions, more than one fifth (22.8%), prove to diverge. Out of 18 deterministically diverging regions, only four had real income exceeding the national one (the Republic of Tatarstan, Sverdlovsk, Magadan, and Sakhalin *oblasts*). Real incomes in these regions grew further. Other 14 regions became progressively poorer (albeit very slow in some cases, with the doubling time of several decades).

There are two cases classed as random walks. In the Voronezh Oblast, the relative income approached the national level, however, in an irregular way. The relative income in the Moscow Oblast was below the national one till 2005 and rose after that. Thus, the evolution of income is a combination of convergence and divergence there, which Model (2) cannot capture.

Taking account of greatly diverse natural conditions of Russian regions, the total equalization of real incomes cannot be a goal of the social policy in the country. At least, in the northern regions, real incomes should be above the national level, so compensating unfavorable natural conditions. From this viewpoint, income divergence is not unambiguously a negative phenomenon. It plays a positive role in the Magadan, and Sakhalin *oblasts*, possibly eventually providing adequate compensating differentials. Wage compensating differentials do take place in the northern regions, in Siberia, and the Russian Far East. However, they are not sufficient, as Figure 5 suggests (with the above reservations). In general, the geographical pattern of the income distribution is far from satisfactory. In the most of northern regions (not speaking about more southern Siberian and Far Eastern regions), the real income only approaches to the national level or stagnates on the level below the national average. In 2018, only four such regions had real income exceeding the national level by more than 5% (the Tyumen, Magadan, and Sakhalin *oblasts*, and Chukotka Autonomous Okrug).

5. CONCLUSION

This paper employs time series of incomes per capita across Russian regions over 2002–2018 with a monthly frequency to reveal a spatial pattern of converging regional incomes to the national level. Incomes are adjusted to the regional price levels in order to capture actual differences in well-being of regions' population. Nonlinear asymptotically subsiding trends model processes of convergence. The same models with nonlinear trends can detect divergence. Non-convergence in the sense of a constant (including zero) income gap is modeled by ordinary AR(1) models with no trend.

The results obtained suggest that in general the income dynamics in the country was positive. A significant portion of regions – more than a half – converged to the national level, for the most part from lower to higher income per capita relative to the national average.

At the same time, in many regions real incomes stagnated at levels below the national average. What is worse, not small number of regions diverged, becoming progressively poorer. The geographical distribution of income seems far from satisfactory. Namely, many regions that should have higher incomes compensating unfavorable natural conditions are in fact below the national level.

As regards policy implications, the pattern obtained provides a basis for region-specific implications. These need a more deep analysis of reasons for low income (and its further decrease in the case of divergence) in relevant regions and developing measures to overcome unfavorable income dynamics.

REFERENCES

Akhmedjonov, A., and Lau M.C.K., İzgi B.B. (2013). New evidence of regional income divergence in post-reform Russia. *Applied Economics*, 45 (8), 2675–2682. DOI: 10.1080/00036846.2012.665600

Bernard, A. B., Durlauf, S. N. (1995). Convergence in international output. *Journal of Applied Econometrics*, 10 (2), 97–108. DOI: 10.1002/jae.3950100202

Carvelli, G. (2020). Beyond beta-convergence: Convergence in differences and its application to the Russian regions. *International Journal of Economics and Finance*, 12 (10), 46–56. DOI: 10.5539/ijef.v12n10p45

Durand-Lasserve, O., and Blöchliger, H. (2018). Drivers of regional growth in Russia: A baseline model with application. *OECD Economics Department Working Papers,* No. 1523. DOI: 10.1787/18151973

EMISS (2020a). *Monetary Income per Capita* [Database, Integrated Interagency Informational and Statistical System of Russia (EMISS)]. Retrieved April 16, 2020, from https://www.fedstat.ru/indicator/57039.do [In Russian.]

EMISS (2020b). *The Cost of Fixed Basket of Consumer Goods and Services* [Database, Integrated Interagency Informational and Statistical System of Russia (EMISS)]. Retrieved April 16, 2020, from https://www.fedstat.ru/indicator/31052.do [In Russian.]

Fischer, N. I., Mammen, E., and Marron, J. S. (1994). Testing for multimodality. *Computational Statistics and Data Analysis,* 18 (5). 499–512. DOI:10.1016/0167-9473(94)90080-9

Gluschenko, K.P. (2011). Studies on income inequality among Russian regions. *Regional Research of Russia*, 1 (4), 319–330. DOI: 10.1134/S2079970511040034

Gluschenko, K.P., and Karandashova, M.A. (2017). Price levels across Russian regions**.** *Region: Economics and Sociology*, No. 2, 76–103. DOI: 10.15372/REG20170204 [In Russian; for the

English version, see MPRA paper No. 75041.]

Ivanova, V.I. (2014). Regional convergence of income: spatial analysis. *Spatial Economics*, No. 4, 100–119. DOI: 10.14530/se.2014.4.100-119 [In Russian.]

Lehman, H., Oshchepkov, A., and Silvagni, M.G. (2020). Regional convergence in Russia: estimating a neoclassical growth model. *IZA Discusion Paper* No. 13039.

Lehmann, H., and Silvagni, M. (2013). Is there convergence of Russia's regions? Exploring the empirical evidence: 1995–2010. *OECD Economics Department Working Papers*, No. 1083. DOI: 10.1787/9279f6c3-en

Oxley L., and Greasley D. (1995). A time-series perspective on convergence: Australia, UK and USA since 1970. *Economic Record*, 71 (214), 259–270. 10.1111/j.1475-4932.1995.tb01893.x

Ng, S., and Perron, P. (2001). Lag length selection and the construction of unit root tests with good size and power. *Econometrica*, 69 (6), 1519–1554. DOI:10.1111/1468-0262.00256

Ng, S., and Perron, P. (2005). A note on the selection of time series models, *Oxford Bulletin of Economics and Statistics*, 67 (1), 115–134. DOI:10.1111/j.1468-0084.2005.00113.x

Quah, D. (1993). Galton's Fallacy and tests of the convergence hypothesis. *Scandinavian Journal of Economics*, 95 (4), 427–443. DOI: 10.2307/3440905

Rosstat (2002–2007). *Socio-Economic Situation of Russia*. [Monthly bulletin]. Various issues. [In Russian.]

Rosstat (2014). *Monetary Income per Capita by Subject of the Russian Federation,* 2008. Retrieved April 16, 2020, from http://www.gks.ru/free_doc/new_site/population/urov/urov_11sub2008.xls [In Russian.]

Rosstat (2016a). *Monetary Income per Capita by Subject of the Russian Federation* [2009–2012]. Retrieved April 16, 2020, from http://www.gks.ru/free_doc/new_site/population/urov/2009-2012kv.xls [In Russian.]

Rosstat (2016b). *Monetary Income per Capita by Subject of the Russian Federation* [2013–2015]. Retrieved April 16, 2020, from http://www.gks.ru/free_doc/new_site/population/urov/2013-2015kv.xls [In Russian.]

Rosstat (2020). *Regions of Russia. Socio-Economic Indicators. 2020*. Moscow, Rosstat. [In Russian.]

Tochkov, K. (2021). Regional convergence in large emerging economies: a distribution dynamics approach. *Macroeconomic Dynamics*, 25 (1), 154–177. DOI: 10.1017/S136510051800069X

World Bank Group (2017). Convergence without equity: A closer look at spatial disparities in Russia. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/30045