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The evolution of the cities' size distribution in Belarus and Poland in 1970-2009: a rank-size rule and Markov chains analysis

1. Introduction

The demise of the socialist economic system and its subsequent restructuring has led to profound changes in the spatial patterns of urban economies in cities of CEE and CIS. The most important and visible trend of urban development during the transition period has been the decentralization of economic activities, a process which has played a major part in the transformation of the post-socialist city. The privatization of assets and the introduction of land rent have been the two determinant factors governing the process of urban spatial readjustments within the reality of a new market-oriented social environment (K. Stanilov, 2007 p. 73). The significant territorial adaptation and relocation of production factors among cities became a pressing task causing changes in the structure of urban system.

In present article we consider the evolution of a size distribution of Belarusian and Polish cities in 1970–2009. The aim of the paper is to improve the knowledge on the countries' urban system transformation and answer the following questions. How has the size distribution of the cities evolved over the last 20 years? Has it become more even or more unequal after the command system collapse? Are there any differences in urban system development of Belarus and Poland?

In the study we consider the set of all cities in Belarus and Poland and, using econometric analysis, we estimate the Pareto exponent of the so called Zipf's law. The Pareto exponent can be interpreted as a convergence indicator: its increasing values represent greater dispersion of the population outside the large cities and a more balanced population distribution between urban centers of different sizes. But, not only we estimate and compare the changes in cities' distribution, but also analyze their relative positions within this distribution for two countries. We use Markov chains analysis to determine cities' inter-class transition probabilities and perform a more complete analysis of movement speed and form of convergence in the city size distribution for Poland and Belarus. This is the first such comparative study for the post-communist countries.

2. Evolution of the cities’ zise distribution: review of the literature

By comparing case studies from different countries J. R. Logan and T. Swanstrom (2005) show that cities are affected by three factors: market forces, the socio-political context of the nation and region, and government policy (at both the national and local levels). Market forces drive the movement of population from the countryside to cities. As a country develops, population moves from labor-intensive agricultural production to labor being increasingly employed in industry and services. The latter are located in cities because of agglomeration economies. Peoples and firms take private decisions in an atmosphere of spatial competition. Although cities can be shaped by policymakers as well it is sound to keep in mind that urban development under the influence of public authorities’ attempts to slow down urban decline or compensate cities for the costs of economic restructuring may be compassionate in the short run, but inevitably they slow down economic growth, harming everyone in the long run. So efforts to revitalize urban areas through a national urban policy concerned principally with the health of specific places will inevitably conflict with efforts to revitalize the larger economy (see N. Kleniewski (ed.), 2005 for discussion). This observation raises the question of how cities of different sizes grow and develop influenced by the national urban policy. The size distribution of cities may become more even over time if smaller cities catch up with larger ones. At the other extreme, urbanization and restructuring processes may take the form of the expansion of the largest cities. In this case, the size distribution would become more unequal.

Different models of the urbanization process were developed in the literature to answer corresponding questions and elicit any safe-organizing features in the cities’ development. There is a new generation of two-sector models, namely, the core-periphery models (P. Krugman, 1991; D. Puga, 1999). However such models are unidimensional in focus, asking what happens to core-periphery development as transport costs between regions decline; they are really regional models, with limited urban implications. Urban models are focused on the city formation process, where the urban sector is composed of numerous cities, endogenous in number and size. J. Henderson and H. G. Wang (2005) develop an endogenous growth model with accumulation of human capital, where there is a shift out of the rural sector into an urban sector as per capita human capital and income grow. As the urban sector grows, new cities form in national land markets. Efficient city sizes are limited, reflecting a trade-off between marginal agglomeration economies as a city grows and steadily rising urban diseconomies in the form of commuting, congestion and other urban disamenities. With urbanization and population growth, if existing cities are to stay near efficient sizes, new cities need to form or grow in a time. That timely formation requires local governments to have the autonomy to tax land rents, exclude entrants through zoning provisions and undertake urban infrastructure investments so as to form new large-scale settlements. Such institutions and market environments may not be in place or may be slow to develop, and national politics may delay their evolution, especially in transition countries. These factors retard the timely formation of cities, forcing people into existing oversized cities.

The issue of convergence across spatial units was initially posed at the regional level (J. Williamson, 1965). There is a related urban model of this divergence–convergence phenomenon, which looks at urban primacy and the quantity allocation of resources across cities. Conceptually the urban world is collapsed into two regions: the primate city versus the rest of the country, or at least the urban portion thereof (A. Ades, E. Glaeser, 1995). The question is: to what extent is urbanization concentrated in, or confined to, one (or a few) major urban areas, as opposed to being spread more evenly across a variety of cities? Primacy is commonly measured by the ratio of the population of the largest metro area to the entire urban population in the country. A. Ades and E. Glaeser (1995) and J. Davis and J. V. Henderson (2003) find that primacy first increases, peaks, and then declines with economic development, indicating a later spread of urban resources from the primate city to other cities over time.

As part of this spatial convergence process, J. Kolko (1999) explores the relationship between changes in urban concentration and industrial restructuring for USA. The idea is that manufacturing is first concentrated in primate cities at early stages of development, and then decentralizes to be relatively more concentrated in rural areas. Initial concentration fosters “incubation” and adaptation of technologies from abroad in a concentrated urban environment. But once manufacturing has modernized with fairly standardized technologies, firms decentralize to hinterland locations where rent and wage costs are cheaper. The largest metro areas became business service-intensive. This spatial separation, with headquarters’ activities of firms in large cities and production facilities in smaller specialized cities, is called ‘functional specialization’ (G. Duranton, D. Puga 2005).

There is econometric evidence indicating that politics plays a role in increasing sizes of primate cities. Based on cross-section analyses, A. Ades and E. Glaeser (1995) find that, if the primate city in a country is the national capital, it is 45% larger. If the country is a dictatorship, or at the extreme of non-democracy, the primate city is 40–45% larger. The idea is that representative democracy gives a political voice to hinterland regions, so limiting the ability of the capital city to favour itself; and fiscal decentralization helps level the playing field across cities, giving hinterland cities political autonomy to compete with the primate city (see J. Davis and J. R. Henderson 2003 for a panel data analysis).

Given the urban primacy relationships, it is natural to ask whether urban concentration is important to growth. J. Henderson (2003) examines this question with panel data methods and finds that there is an optimal degree of primacy at each level of development which maximizes national productivity growth. That optimal degree rises as country income declines: high relative agglomeration is important when countries have low knowledge accumulation, import technologies, and have limited capital to invest in widespread hinterland development.

The popular device to analyze cities' size distribution is the rank-size rule. This rule (or Zipf's law), which emerged from regularly observed features of the data lacking any theoretic foundation, has recently been analyzed, among others, by P. Krugman (1996), H. G. Overman and Y. M. Ioannides (2001), X. Gabaix and Y. M. Ioannides (2004), K. T. Soo (2005). X. Gabaix (1999) has derived a statistical explanation of Zipf's law for cities. He shows that if different cities grow randomly with the same expected growth rate and the same variance, the limit distribution of city size will converge so as to obey Zipf's law.

Zipf's law allow the characterization of the evolution of the global distribution, but it does not provide any information about the movements of the cities within this distribution. For example, they city size distribution does not say whether the right tail of the initial distribution (year 1989) contains the same cities as the right tail in the final distribution (year 2009). A possible way to answer these questions is to track the evolution of each city's relative size over time by estimating transition probability matrices associated with discrete Markov chains. This line of analysis has first been pursued by J. Eaton and Z. Eckstein (1997) and then by D. Black and J. V. Henderson (2003).

3. Methodology

We propose to base our exploration of the evolution of the cities' size distribution in post-communist Belarus and Poland on the Zipf's law. Zipf in 1949 claimed that the size distribution of cities follows a Pareto law:

$$R = a \cdot S^{-b} \qquad (1)$$

where R is the city rank order of the population distribution; S is the population of the cities; and a and b are parameters, with the latter being the Pareto exponent, always positive by construction.

According to this rule, city populations among any group of cities at any time are proportional to the inverse of the ranking of their populations in that group. The Pareto exponent can therefore be interpreted as a convergence indicator. Indeed, values that fall over time indicate relatively more important roles (increasing weights) for the largest cities. More precisely, as b decreases, a 1% increase in city size produces a smaller fall (in %) in rank and the city size distribution becomes more spread out. Therefore, this will cause a divergence trend inside the group of cities or greater metropolitan concentration. Likewise, a 1% increase in city size produces a larger fall (in %) in rank as b increases. Therefore, increasing values of the Pareto exponent represent convergence dynamics, or in other words, greater dispersion of the population outside the large cities and a more balanced population distribution between urban centers of different sizes.

To study a dynamics of the within distribution of cities we assume that the frequency of the distribution follows a first-order stationary Markov process. In this case, the evolution of the city size distribution is represented by a transition probability matrix, M, in which each element (i, j) indicates the probability that a city that was in class i at time t ends up in class j in the following period. The way of cities' division on classes will be chosen by considering the performance of the test for Markovity of order one. Then each element p_{ij} of the transition matrix is estimated as a conditional probability $p_{ij} = P(A_j(t+1) \mid A_i(t))$, where $A_i(t)$ is the event that "city is in a state i at time t". In other words we find shares of cities remained in each size class at the end of the period and moved up or down by the end of the period. Denoting by $F_t = \; p_1(t) \quad p_2(t) \quad \dots \quad p_k(t)$ the vector of probabilities that a city is in class i at time t, the dynamics of this vector is given by:

$$F_{n+1} = F_n M = F_0 M^{n+1} \qquad (2)$$

Next, we determine the ergodic distribution that can be interpreted as *the long-run equilibrium* city-size distribution. Explicitly, given that the transition matrix M is regular, then M^n tends to a limiting matrix M^* when n tends to infinity (Kemeny and Snell, 1960). Therefore, with the passage of time, the distribution of cities will not change any more and will converge to the ergodic or limit distribution. Concentration of the frequencies in a certain class would imply convergence (if it is the middle class, it would be convergence to the mean), while concentration of the frequencies in some of the classes, that is, a multimodal limit distribution, may be interpreted as a tendency towards stratification into different convergence clubs. Finally, a dispersion of this distribution amongst all classes is interpreted as divergence.

We also determine the *speed of the movement of a city within the distribution*, using the mean first passage time matrix M_P, that can be easily constructed for the transition matrix M (Kemeny and Snell, 1976). The (*i*,*j*) element of the matrix M_P indicates the expected time for a city to move from class i to class j for the first time. Thus, using Markov chains we can perform a more complete analysis of movement speed and form of convergence within the city size distribution.

In order to carry out the methodology described, we should choose a discretization of the cities' sizes. As pointed out by S. Magrini (1999), an improper discretization may have the effect of removing the Markov property and therefore may lead to misleading results, especially as is in our case when computations of ergodic distributions are based on the estimates of the discrete transition probabilities. D. Quah (1993) and J. Le Gallo (2004) choose to discretize the distribution in such a way that the initial classes include a similar number of elements. P. Cheshire and S. Magrini (2000) base their choice between possible classes in terms of the ability of the discrete distribution to approximate the observed continuous distribution.

In our paper following the paper of J. Le Gallo and C. Chasco (2009), we have tried different ways of discretizing the distribution, divided it on 5, 6 and 7 classes. Finally, the discretization has been chosen by considering the best performance of the test for order one for Polish cities. We choose Poland to be a benchmark providing we have the biggest dataset for this country (890 cities) and this country is one of the most successful among transition economies.

The assumption of a first-order stationary Markov process requires the transition probabilities, p_{ij}, to be of order 1, that is, to be independent of classes at the beginning of previous periods (at time t − 2, t − 3, …). If the chain is of a higher order, the first-order transition matrix will be misspecified. Indeed, it will contain only part of the information necessary to describe the true evolution of population distribution. Moreover, the Markov property implicitly assumes that the transition probabilities, p_{ij}, depend on *i* (i.e., that the process is not of order 0).

In order to test this property, F. Bickenbach and E. Bode (2003) emphasize the role of the test of time independence. In determining the order of a Markov chain, B. Tan and K. Yilmaz (2002) suggest, firstly, to test order 0 versus order 1; secondly, to test order 1 versus order 2; and so on. If the test of order 0 against order 1 is rejected, and the test of order 1 against order 2 is not rejected, the process may be assumed to be of order 1.

4. Empirical study

Data on population in Belarusian and Polish cities are extracted from the national statistics prepared by the National Committee of Statistics of the Republic of Belarus and Central Statistical Office (GUS) of the Republic of Poland.

Some descriptive statistics for Belarusian and Polish urban system are presented in the table 1 and 2. Groups of cities are based on Belarusian national definition.

Table 1. Belarusian urban system in 1989-2009

Group of cities	Population	Number of cities			Population, th. (January 1)		
		1989	1999	2009	1989	1999	2009
Big	>50	22	22	22	4 949.1	5 163.9	5 406,0
	>1000	*1*	*1*	*1*	*1 607.1*	*1 680.5*	*1 829.1*
	300-500	*3*	*4*	*5*	*1 201.8*	*1 474.3*	*1 863.8*
	200-300	*3*	*2*	*1*	*746.7*	*507.1*	*219.0*
	100-200	*5*	*8*	*7*	*641.5*	*988.9*	*886,9*
	50-100	*10*	*7*	*8*	*752.0*	*513.1*	*607.2*
Medium	20-50	16	18	16	503.8	583.4	537.3
Small	10-20	45	47	46	620.3	645.3	633.3
	<10	119	118	122	561.1	561.9	571.9
Total urban system		202	205	206	6 634,3	6 954.5	7 148.5

Source: Own calculations based on National Committee of Statistics of the Republic of Belarus data.

Table 2. Polish urban system in 1989-2009

Group of cities	Population	Number of cities			Population, th. (January 1)		
		1990	1999	2009	1990	1999	2009
Big	>50	90	92	86	14 959.9	14 873.0	14 178.5
	>1000	*1*	*1*	*1*	*1 651.2*	*1 618.5*	*1 709.8*
	500-850	*4*	*4*	*4*	*2 822.2*	*2 763.5*	*2 691.2*
	300-500	*5*	*5*	*5*	*1 968.7*	*1 965.0*	*1 881.5*
	200-300	*10*	*10*	*7*	*2 320.1*	*2 308.1*	*1 640.6*
	100-200	*24*	*22*	*22*	*3 109.1*	*2 855.2*	*3 044.4*
	50-100	*46*	*50*	*47*	*3 088.5*	*3 362.7*	*3 211.0*
Medium	20-50	128	139	134	3 964.6	4 260.0	4 192.3
Small	10-20	170	181	180	2 446.8	2 629.5	2 643.9
	<10	442	463	497	2 084.0	2 160.3	2 273.4
Total urban system		830	875	897	23 455.3	23 922.8	23 288.2

Source: Own calculations based on GUS data.

Urbanization level in Belarus grew from 65.4% in 1989 to 73.9% in 2009. One can see from the table 1 that half of the urban population in Belarus lives in 6 biggest cities. Urban population in Poland is distributed more evenly with urbanization level equal to 61.1% in 2009.

In order to examine urban evolution and answer the preceding questions, we first examine the city size distribution by centering on the question of whether Zipf's law or its deterministic equivalent, the rank-size rule, holds for Belarusian and Polish cities.

Empirically, departing from (1), we take logarithms on both sides and estimate the resulting linear expression for the set of all cities ($i = 1, \ldots n$) for each of the 22 periods ($t = 1, \ldots 22$) under consideration:

$$\ln R_{it} = \ln a_t - b_t \cdot \ln S_{it} + \varepsilon_{it} \qquad (3)$$

X. Gabaix and Y. M. Ioannides (2004) have shown by Monte–Carlo simulations that OLS estimation of equation (3) presents several pitfalls in small samples. In our study we use the set of all cities.

Results of cross-sectional data econometric analysis for Belarus and Poland in 1970-2009 (see tables A1 and A2 in the APPENDIX) have proved the Zipf's law existence. All coefficients and statistics of presented equations are significant. We skip here several important econometric tests for simplicity. Due to the geographical nature of the empirical data used, we need to test for spatial autocorrelation and spatial heteroskedasticity. To check whether OLS is affected by the omission of spatial autocorrelation we need follow the strategy suggested by L. Anselin (1988, p. 203) for the specification of spatial SUR models. In a first stage, we have to estimate (3) by Ordinary Least Squares (OLS) all equations individually considered (i.e., one equation for each period under consideration). For each model, we need to test for the presence of spatial effects (J. Arbia, 2006).

Figure 1 illustartes the dynamics of the Pareto exponents for Belarus and Poland.

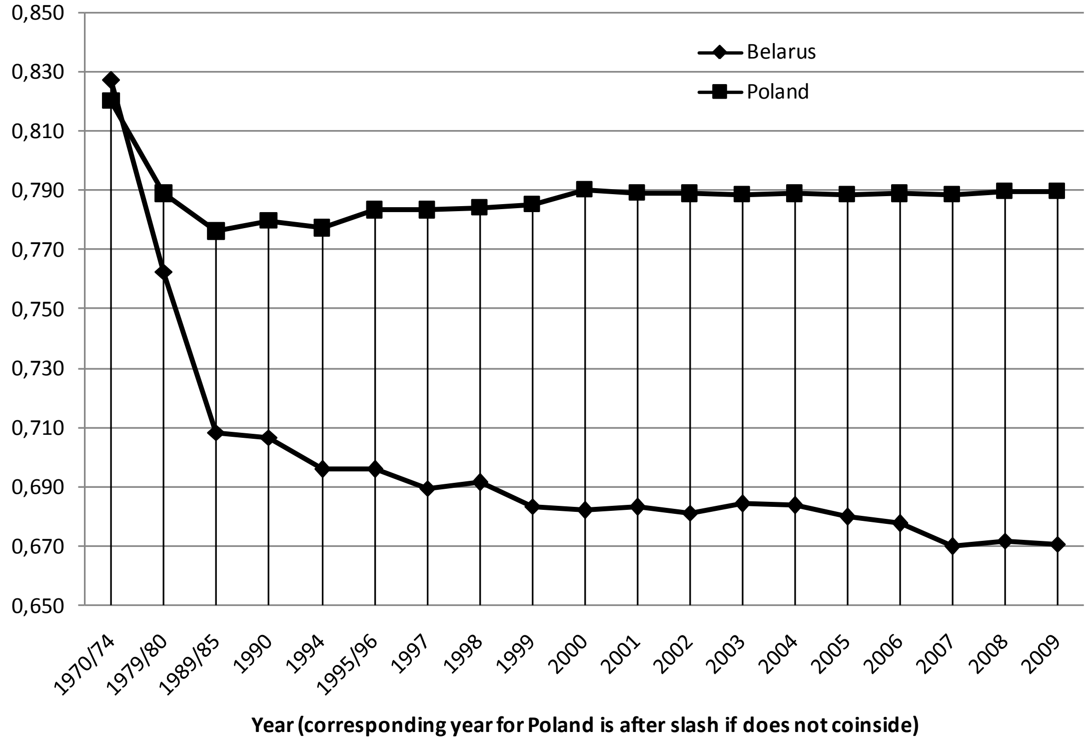

Figure 1. Dynamics of the Pareto exponents for Belarus and Poland

Source: Own calculations based on National Committee of Statistics of the Republic of Belarus and GUS data.

Econometric analysis shows that Pareto parameter for Belarus and Poland has different behavior. It reveals the sustainable growth of the Pareto exponent value for Poland particularly for the last ten years indicating the convergence of cities' sizes. On the contrary one could see a persistent divergence trend in case of Belarusian urban structure development with the exeption of the last two years.

Rather suprising however are the results for pre 1989 years which show that city size distribution before the transition in both countries was more even. But we need to perform a dynamic analysis to make right conclusions.

As we stated above, Zipf's and other distribution laws allow the characterization of the evolution of the global distribution, but they do not provide any information about the movements of the towns within this distribution. Thus to augment the conclusions from the Pareto exponent dynamics we apply Markov chains analysis. The last one gives the opportunity to study a movement speed and form of convergence within the city size distribution. We employ the same data on population of all cities for Belarus and Poland.

We divided all cities on seven classes: (1) population less than 10% of the countries' average, (2) population between 10 and 20% of the average (3) population between 20 and 30% of the average, (4) population between 30 and 50% of the average, (5) population between 50 and 100% of the average, (6) population between 100 and 200% of the average, and (7) population more than 200% of the average.

Tables 3 and 4 contain the first-order transition probability matrices with the ML estimates p_{ij} of the transition probabilities for population in Belarus and Poland. The average populations for those countries in 2009 are 34701 and 26157 respectively.

Table 3. Probability transition matrix for Belarus, 1970–2009

	1	2	3	4	5	6	7	Number of observations
	<10%	<20%	<30%	<50%	<100%	<200%	>200%	
1	0.979	0.019	0.002	0	0	0	0	838
2	0.096	0.86	0.039	0	0	0	0	508
3	0	0.032	0.94	0.023	0	0	0	686
4	0	0.003	0.029	0.95	0.014	0	0	653
5	0	0	0	0.048	0.938	0.012	0	290
6	0	0	0	0	0.036	0.95	0.012	167
7	0	0	0	0	0	0.006	0.99	324

Source: Own calculations based on National Committee of Statistics of the Republic of Belarus data.

Note that all transition probability matrices are regular. Matrices let us draw conclusions on intensity of interclass movements. Using those matrices according to methodology described, we can extract information related to cities' mobility speed and convergence pattern.

Table 4. Probability transition matrix for Poland, 1961–2009

	1	2	3	4	5	6	7	Number of observations
	<10%	<20%	<30%	<50%	<100%	<200%	>200%	
1	0.94	0.045	0.006	0.004	0.005	0.0005	0	2002
2	0.019	0.958	0.02	0.0003	0.0009	0	0	3477
3	0.0015	0.035	0.927	0.037	0	0	0	2055
4	0.0018	0.0004	0.017	0.941	0.038	0.001	0.0004	2236
5	0.001	0.0007	0	0.0078	0.972	0.018	0.001	2953
6	0.0007	0	0	0.0007	0.013	0.967	0.019	1396
7	0	0	0	0	0.0014	0.006	0.992	1466

Source: Own calculations based on GUS data.

For example, in Poland during the half of a century, there were 2,002 instances of a city having a population size lower than 10 percent of the average. The majority of these cities (94.0%) remained in that size class at the end of the year, while 4.5% moved up one class by the end of the year.

The high probabilities on the diagonal in all countries show a low interclass mobility, i.e., a high-persistence of cities to stay in their own class from one observation to another over the whole period. J. Eaton and Z. Eckstein (1997) interpret diagonal elements of the transition approaching 1 as parallel growth. Since these elements are not exactly 1, we can analyze the propensity of cities in each cell to move into other cells. In particular, it appears that the largest and smallest cities (classes 1 and 7, respectively) have higher persistence while medium-sized cities (categories 3, 4 and 5) have more probability of moving to smaller categories. In classes 2 and 3 a small number of cities if any move up to higher categories more than two steps. Only in case of Poland in classes 2 and 3 the probability of moving up a class exceeds that of moving down. In Belarus the probability of moving down a class exceeds that one in other countries.

This low inter-class mobility of cities is in line with the results found for other cases such as US MSA's (D. Black, J. V. Henderson, 2003) and all Spanish municipalities (J. Le Gallo, C. Chasco, 2009).

Then, in order to determine the speed with which the cities move within the distribution, we consider the matrix of mean first passage time MP, where every element indicates the expected time for a city to move from class *i* to class *j* for the first time (Tables 5 and 6).

Table 5. Mean first passage time matrix for Belarus in years

Class	1	2	3	4	5	6	7
	<10%	<20%	<30%	<50%	<100%	<200%	>200%
1	1.9	53	143	344	885	2971	8951
2	36	8.6	109	309	851	2935.7	8916.4
3	99	63	6	197	741	2822.6	8806.7
4	143	106.7	60	8.3	547.8	2622.8	8613
5	187	150.6	104	45	28.6	2056.6	8063.6
6	269	232	185	128.5	81.7	77	6068.6
7	430	393.5	346	293.7	243.5	167	38.5

Source: Own calculations based on National Committee of Statistics of the Republic of Belarus data.

For example, the expected time for Belarusian city to move from class 1 to class 2 is equal to 53 years, while the moving from 2 to 1 will happened in 36 years. In whole the mean number of years to reach any class is relatively high: for example, the shortest time passage for Poland is 67.7 years (move from class 4 to class 5) and the longest is 1661.6 years (move from class 7 to class 1). We should remember that these calculations account for the fact that starting from class 4, a city might visit classes 6, 5, 3, 2 or 1 before going to class 7.

Table 6. Mean first passage time matrix for Poland in years

Class	1	2	3	4	5	6	7
	<10%	<20%	<30%	<50%	<100%	<200%	>200%
1	43.5	271	293.6	210.6	154.7	232.8	340
2	525.5	19.6	179	183.6	161.6	240.6	347.5
3	885	554	33.3	106	128.5	208	314.8
4	1239	1070	704	22.7	67.7	149	254.8
5	1426	1311	1007	480	6	95	203
6	1554	1455	1146	644	209	5.3	123
7	1661.6	1561	1242.6	746	307	151	2

Source: Own calculations based on GUS data.

Belarusian matrix shows the passage from higher class to lower one is more probable than from lower to higher. That is not the truth for Polish cities where the moving to higher class is faster. For example, for Belarusian cities to first visit class 7 from class 1 it takes 8951 years, while for Polish it takes 340 years. On the contrary, to first visit class 1 from class 7 it takes 430 years for cities in Belarus, while for Poland it takes 1661.6 years.

The difference in the models of urban system development and the forms of cities' convergence for Belarus on the one part and Poland on the other part becomes obvious after comparison of initial versus ergodic distribution pattern matching. The ergodic distribution can be interpreted as the long-run equilibrium city-size distribution in the urban system. Given a regular transition matrix, with the passage of many periods, there will be a time where the distribution of cities will not change any more: that is the ergodic or limit distribution. It is used to assess the form of convergence in a distribution. Concentration of the frequencies in a certain class would imply convergence (if it is the middle class, it would be convergence to the mean), while concentration of the frequencies in some of the classes, that is, a multimodal limit distribution, may be interpreted as a tendency towards stratification into different convergence clubs. Finally, a dispersion of this distribution amongst all classes is interpreted as divergence.

The results for Belarus and Poland are reported on the histograms of Figure 2 and demonstrate significant differences among countries.

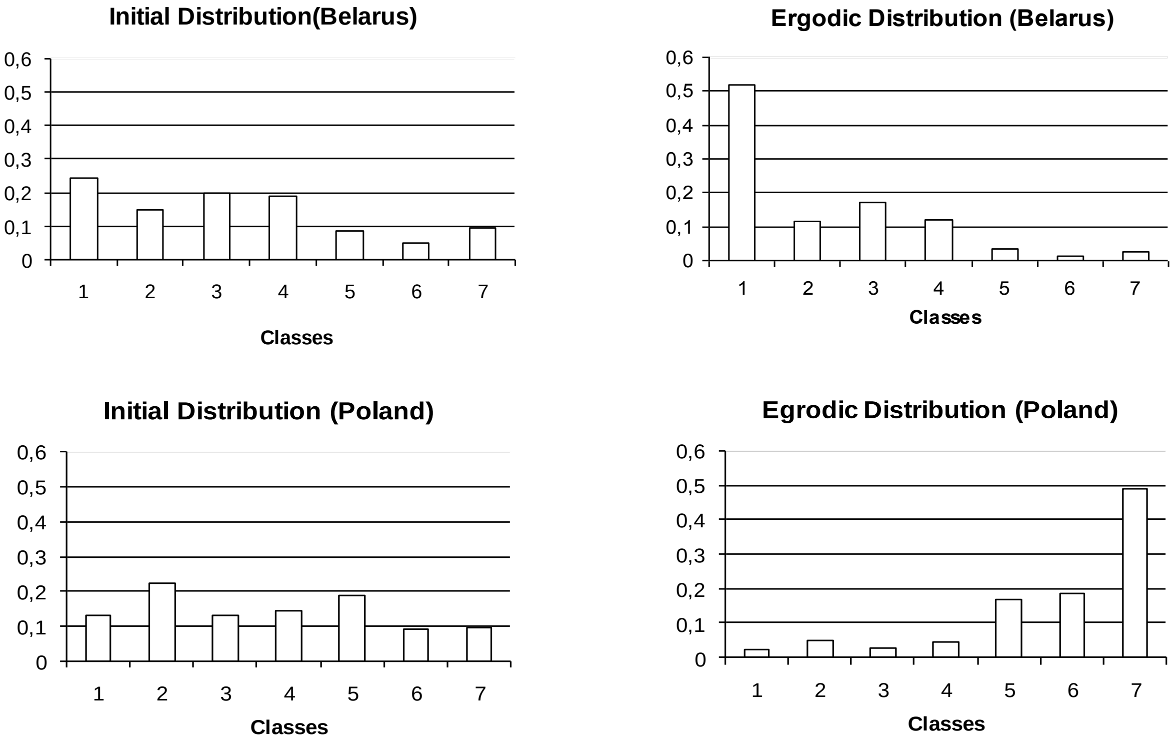

Figure 2. Initial and ergodic distribution of cities' sizes in Belarus and Poland

Source: Own calculations based on National Committee of Statistics of the Republic of Belarus and GUS data.

For Belarus it appears that the ergodic distribution is more concentrated in the small and lower middle-size cities (1st to 4th classes), a result that reveals the existence of convergence towards smaller size populations. For Poland it appears that the ergodic distribution is more concentrated in the middle and big-size cities (5th to 7th classes). At the same time a level of stability of ergodic distribution compared to the initial one for Belarus and Poland is low.

As one can see Belarus evolves to the country of small cities, while Poland to the country of big and upper medium sized cities.

5. Conclusions

In present paper we extended previous studies of a city size distribution making a comparative analysis for the post-communist experience of Belarusian and Polish urban systems. We estimate and compare the changes in cities' distribution, calculating the Pareto exponent that can be interpreted as a convergence indicator which increasing values represent a more balanced population distribution between urban centers of different sizes. In addition we analyze cities' relative positions within distributions for two countries. We use Markov chains analysis to determine cities' inter-class transition probabilities and perform a more complete analysis of movement speed and form of convergence in the city size distribution.

Suprisingly, the dynamics of the Pareto exponents shows that before the command system collapse city size distribution has been more equal for both counties. Econometric analysis reveals significant differences in the urban system development for Belarus and Poland. One can see a sustainable growth of the Pareto exponent value for Poland particularly for the last ten years indicating the convergence of cities' sizes. On the contrary there is a persistent divergence trend in case of Belarusian urban structure development with the exeption of the last two years.

The Markov chains analysis enables to uncover additional differences. A low interclass mobility is obvious. The largest and smallest cities display higher persistence than the medium-sized cities, which have more probability of moving to smaller categories. In general terms, movements up are slower than movements down, especially for high-size classes.

Comparing ergodic distributions and mean first passage time matrices for Belarus and Poland we may conclude that in future 52% of Belarusian cities will concentrate in the smallest class and passage of cities from higher classes to lower is more probable. Future distribution of Polish cities is a bit more uniform and tends to big cities (up to 68% of all Polish cities will be located at two biggest classes) but it happened more slowly than decline of Belarusian cities.

The difference in the models of urban system development and in the forms of cities' convergence for Belarus and Poland is obvious after comparison of initial and ergodic distribution. The latter at the same time can be traced to the differences in the Pareto exponents' behaviour. However it is still not enough explanations that could unmask the nature of those differences. Thereby it is quite natural to uncover the relationship between Pareto exponents' dynamics (or some particular characteristic) and the set of explanatory variables. As we have noticed earlier it is relevant to reveal how cities are affected by the three groups of factors: market forces, the socio-political context of the nation and region, and government policy (at both the national and local levels). So this is a way to build a set of regressors that we are planning to do in our further research. Special attention should be given to an adequate measuring of the institutional differences between countries that can influence the cities' development. For example, there are evidences that local authorities at the district level in Belarus use administrative resources to hinder the restructuring activities of subordinate towns (U. Valetka, 2010).

It is interesting also to disclose the influence of space on urban population dynamism comparing the probability of a city moving down or up in the hierarchy depending whether city is surrounded by towns that contain, on average, less or more population.

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Appendix

Table A1. Results of a rank-size rule econometric analysis for Belarus and Poland

Years	***N of cities***	**Variable**	**Coefficient**	**Std. Error**	***t*-statistic**	R^2	***F*-statistic**
1970	198	*b*	-0.8272	0.0070	-117.5	0.986007	13811.41
		C	11.5562	0.0623	185.6		
1979	200	*b*	-0.7628	0.0094	-81.0	0.970718	6563.741
		C	11.1417	0.0851	130.9		
1989	202	*b*	-0.7085	0.0116	-60.9	0.948826	3708.230
		C	10.7778	0.1071	100.6		
1990	202	*b*	-0.7069	0.0119	-59.6	0.946705	3552.706
		C	10.7814	0.1095	98.5		
1991	202	*b*	-0.7043	0.0120	-58.9	0.945502	3469.854
		C	10.7631	0.1105	97.4		
1992	202	*b*	-0.7016	0.0118	-59.4	0.946431	3533.493
		C	10.7429	0.1091	98.4		
1993	202	*b*	-0.6985	0.0117	-59.5	0.946472	3536.361
		C	10.7190	0.1087	98.6		
1994	202	*b*	-0.6960	0.0119	-58.6	0.944992	3435.851
		C	10.7009	0.1099	97.3		
1995	202	*b*	-0.6959	0.0119	-58.4	0.944629	3412.029
		C	10.7033	0.1104	97.0		
1997	203	*b*	-0.6895	0.0120	-57.5	0.942749	3309.872
		C	10.6468	0.1110	95.9		
1998	205	*b*	-0.6914	0.0120	-57.7	0.942531	3329.324
		C	10.6653	0.1108	96.2		
1999	205	*b*	-0.6836	0.0123	-55.5	0.938123	3077.698
		C	10.5690	0.1136	93.1		
2000	205	*b*	-0.6821	0.0123	-55.6	0.938335	3088.966
		C	10.5552	0.1131	93.3		
2001	207	*b*	-0.6832	0.0121	-56.2	0.939142	3163.512
		C	10.5690	0.1119	94.5		
2002	207	*b*	-0.6814	0.0122	-55.8	0.938284	3116.645
		C	10.5491	0.1123	93.9		
2003	206	*b*	-0.6842	0.0120	-57.0	0.940885	3246.907
		C	10.5742	0.1106	95.6		
2004	206	*b*	-0.6836	0.0119	-57.3	0.941460	3280.773
		C	10.5646	0.1098	96.2		
2005	206	*b*	-0.6799	0.0121	-56.4	0.939759	3182.374
		C	10.5248	0.1108	95.0		
2006	206	*b*	-0.6777	0.0121	-56.0	0.938981	3139.215
		C	10.4985	0.1111	94.5		
2007	207	*b*	-0.6698	0.0124	-54.1	0.934634	2931.200
		C	10.4201	0.1135	91.8		

2008	206	*b*	-0.6718	0.0122	-55.2	0.937244	3046.707
		C	10.4401	0.1117	93.4		
2009	206	*b*	-0.6706	0.0121	-55.5	0.937961	3084.277
		C	10.4282	0.1108	94.1		

Source: Own calculations based on National Committee of Statistics of the Republic of Belarus data.

Table A1. Results of a rank-size rule econometric analysis for Poland

Years	***N of cities***	**Variable**	**Coefficient**	**Std. Error**	***t*-statistic**	R^2	***F*-statistic**
1961	800	*b*	-0.8513	0.0062	-136.3	0.95880	18572.42
		C	13.1942	0.0555	237.7		
1974	802	*b*	-0.8205	0.0065	-126.3	0.95222	15941.79
		C	13.1154	0.0593	221.2		
1980	803	*b*	-0.7889	0.0068	-116.0	0.94384	13446.15
		C	12.9049	0.0627	205.7		
1985	809	*b*	-0.7763	0.0070	-111.2	0.93878	12375.71
		C	12.8406	0.0647	198.3		
1990	828	*b*	-0.7798	0.0070	-112.2	0.93842	12587.94
		C	12.9367	0.0648	199.5		
1994	843	*b*	-0.7774	0.0074	-105.2	0.92937	11065.55
		C	12.9415	0.0690	187.5		
1996	859	*b*	-0.7836	0.0071	-111.1	0.93503	12332.67
		C	13.0087	0.0658	197.6		
1997	863	*b*	-0.7835	0.0070	-111.5	0.93523	12432.23
		C	13.0097	0.0655	198.5		
1998	869	*b*	-0.7844	0.0070	-112.0	0.93534	12541.90
		C	13.0215	0.0653	199.5		
1999	874	*b*	-0.7854	0.0070	-112.4	0.93540	12627.81
		C	13.0337	0.0651	200.1		
2000	874	*b*	-0.7903	0.0069	-115.2	0.93837	13277.62
		C	13.0670	0.0638	204.8		
2001	879	*b*	-0.7891	0.0068	-115.5	0.93828	13332.41
		C	13.0550	0.0635	205.6		
2002	883	*b*	-0.7891	0.0068	-116.1	0.93861	13468.86
		C	13.0536	0.0631	206.7		
2003	883	*b*	-0.7889	0.0068	-115.8	0.93837	13414.41
		C	13.0507	0.0632	206.4		
2004	884	*b*	-0.7890	0.0068	-115.8	0.93832	13416.98
		C	13.0496	0.0632	206.4		
2005	886	*b*	-0.7887	0.0068	-115.9	0.93829	13439.88
		C	13.0461	0.0631	206.7		
2006	886	*b*	-0.7890	0.0068	-116.0	0.93827	13451.35
		C	13.0483	0.0631	206.8		
2007	889	*b*	-0.7888	0.0068	-116.1	0.93826	13479.04
		C	13.0442	0.0630	207.1		

2008	890	*b*	-0.7897	0.0068	-116.3	0.93840	13527.03
		C	13.0521	0.0629	207.4		
2009	890	*b*	-0.7898	0.0068	-116.2	0.93830	13504.11
		C	13.0523	0.0630	207.3		

Source: Own calculations based on GUS data.