# ZIPF'S LAW AS A DETECTOR OF REGIONAL DEMOGRAPHIC ASYMMETRY

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**Abstract**

Regional urban settlement system developments in asymmetrical mode. Some settlements have stable population growing and human capital quality increasing, and thereby local economy rises. Other settlements suffer from population outflow, degrading human capital and infrastructure, hence local economy is slowdown and even depressed. In this regard, assessing regional demographic asymmetry is of great scientific interest.

The paper presents the results of using Zipf's law to test data of 73 cities in Sverdlovskiy region (Russia) to measure the regional demographic asymmetry. We examine if the urban settlement system matches the rank-frequency distribution. Also Zipf's law is used to explore the cities' hierarchy gaps being an indicator of demographic asymmetry of regional space.

The research obtains two detectors of the demographic asymmetry. (1) The regional urban settlement system fits the rank-frequency distribution in general but the largest city overweighs, the cities of middle size are underpopulated, and the small cities are overpopulated. (2) There is a lack of the secondary cities in the regional cities' hierarchy so that the distribution of demographic development is irregular and biased to the largest city. These research results are significant for developing regional social and economic policy and monitoring its performance.

**Key words:** demographic asymmetry, Zipf's law, urban settlement system, city, region (3-5)

**JEL Code:** J11, R12

## Introduction

The uneven distribution of natural resources and the productive forces matched them has historical, national and socio-cultural pecularities of development and so provides significant differences in the levels of socio-economic development of territories. This asymmetry of regional development is resulted in the qualitative and quantitative characteristics of the

settlement system. Some territories show a steady increase in population, an increase in the quality of human capital and labor resources, and these stimulate economic growth. Othe rterritories experience an outflow of population, a decrease in the quality of human capital and a slowdown in socio-economic development in general.

The spatial distribution of the population and its individual groups was studied all over the world, e.g. (Ezcurra, 2019; Lappo, Poliyan, & Selivanova, 2010; Zhang, Xu, & Wang, 2019). Thus, W. Izard suggests estimating the uniformity/unevenness of population distribution by calculating the localization coefficient reflecting the relative degree of concentration of a certain population group in comparison with any other parameter of the national economy (Izard, 1996). Russian researcher explore the spatial population distribution mainly based on ideas of urbanisation and agglomeration. There is a range of estimations such as coefficient of agglomeration development, agglomerative index, and others (Lappo, Poliyan, & Selivanova, 2010). All these researches resulte in goverment policy aimed to overcome the uneven development and improving the life quality of population. Thus, studing the demographic development asymmetry of a region is of great scientific interest concerned both the nature of socio-economic differentiation of territories and development of effective regional socio-economic and spatial policy.

## 1 Data and methods

Strategy for socio-economic development of the Sverdlovsk region until 2030[1] sets one of the goals for the balanced development of municipalities as a goal including to strength intra-regional connectivity and to form the sustainable polycentric urban and socio-economic system. The demographic development asymmetry contributes greatly to the goal above both determining the quality of life of the population and the spatial structure of the region (connectivity, agglomeration of territories).

Zipf law (rank-frequency distribution) is one of the most popular methods for studying patterns of spatial population distribution (Benguigui, & Blumenfeld-Lieberthal, 2007; Moura, & Ribeiro, 2006; Turgel, & Ulyanova, 2019). Zipf's law describes the empirical regularity in the distribution of cities by population is inversely proportional to their ranks, that is, the largest city outnumbers the second by two times, the third by three, and so on.

[1] Law of the Sverdlovsk region of 15.12.2015

According to idea of Zipf's law, the cities located below the Zipf curve have a lack of population, and those located above have an excess of population (Zipf, 1949).

A review of studies has shown that this method is used in two ways. First way is to construct a regression based on actual data of population distribution between the cities ranked by size and then interpret the obtained statistical coefficients (Rastvortseva, & Manaeva, 2015). Second way is to recreate the optimal size of all the cities in the settlement system based on the size of the largest one and the to compare the obtained optimal distribution the actual one assessing the settlement system stability (Fattahov, & Stroev, 2016).

In this paper we combine both these approaches to give a more complete description of the regional settlement system. To conduct the research we employed the data of population size of 70 urban settelments in 1989 and 2019 according to available statistic data of Sverdlovsk region (Russia). Firstly, we ranked the settlments from the biggest one to the smallest one and logged population and rank figures. Using the log(pop)-log(rank) dataset, we create a graph and a regression to estimate real and optimal Zipf's distribution. The second part of the research included calculation of ideal sizes of settlements based on a population of the biggest city and coparision it with the real sizes.

## 2 Results and Discussion

The available data show that in 1989 urban population in Sverdlovsk region (Russia) urban population was 4011,3 thousand people distibuted between 73 urban settelments of different size. In 2019 it had declined to 3645,4 housand people distibuted between 70 urban settelments. Hereby, all the urban settlemens of the region have lost their population except the largest city for 30 years. This reflects a concentration of population and indicates a decrease of settelment system sustanability. Table 1 shows some details.

**Tab. 1: Urban population dynamics in Sverdlovsk region (Russia)**

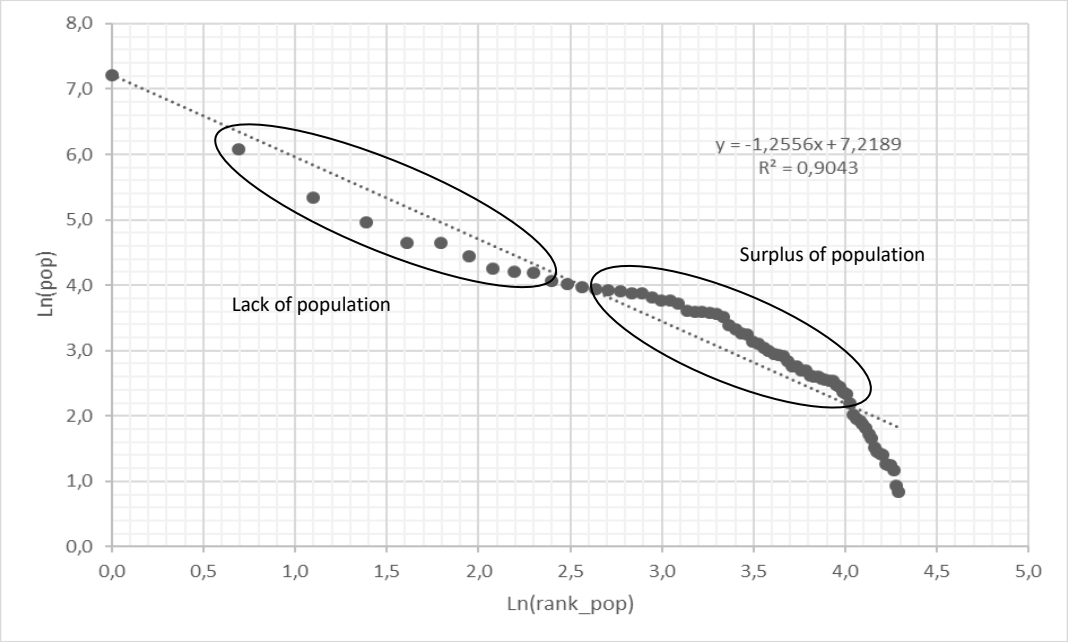
| Size of city (thousand people) | 1989 | | 2019 | |
|---|---|---|---|---|
| | Number of cities | Total population (thousand people) | Number of cities | Total population (thousand people) |
| Largest (more 1000) | 1 | 1364,6 | 1 | 1483,1 |
| Large (100 -1000) | 5 | 998,4 | 3 | 643,4 |
| Midlee (50-100) | 10 | 607,4 | 8 | 550,9 |
| Small (10-50) | 39 | 951,1 | 32 | 810,5 |

| | | | | |
|---|---|---|---|---|
| Township (less 10) | 18 | 89,7 | 26 | 157,3 |
| Total | 73 | 4011,3 | 70 | 3645,4 |

Source: City population. Population Statistics for Countries, Administrative Areas, Cities and Agglomerations – Interactive Maps and Charts. URL: http://www.citypopulation.de/php/russia-sverdlovsk.php (date of access 20.01.2020)

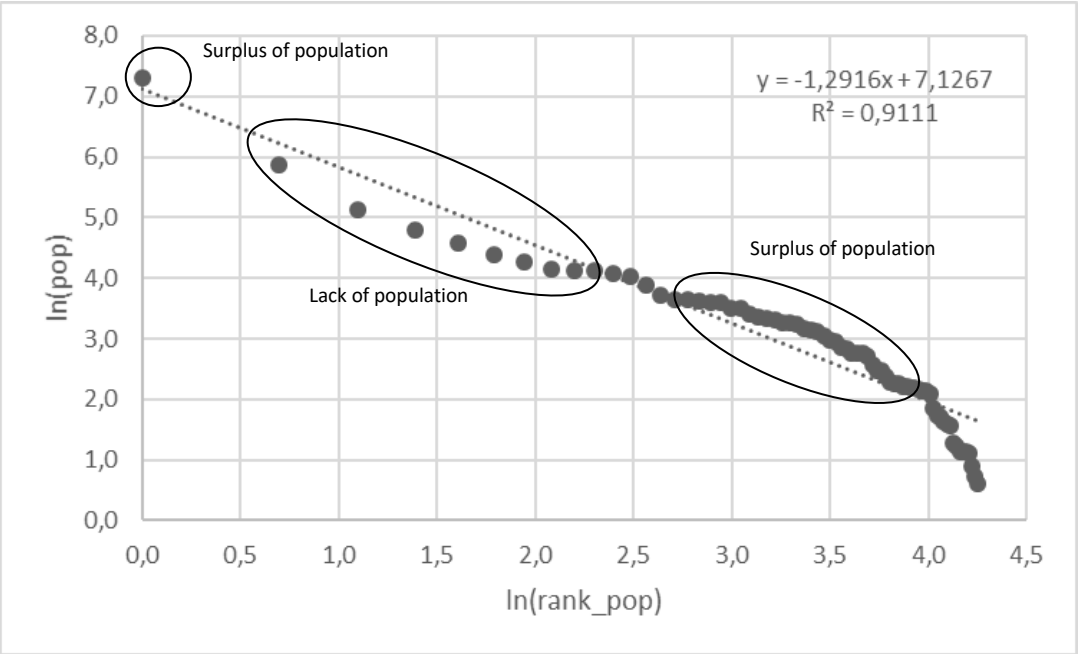
Fig. 1 and Fig. 2 show the urban population distribution in Sverdlovsk region in 1989 and 2019 accordinly. In 1989 the urban settlement system had a significant deviations from the Zipf's law (35.3%). And there were two zones of deviation: (1) large and middle cities had a lack of 574,1 thousand of people; (2) small cities had a surplus of 255,8 thousand of people (Fig. 1).

**Fig. 1: Zipf's distribution for urban settelments of Sverdlovsk region in 1989**




Source: author's calculations

**Fig. 2: Zipf's distribution for urban settelments of Sverdlovsk region in 2019**

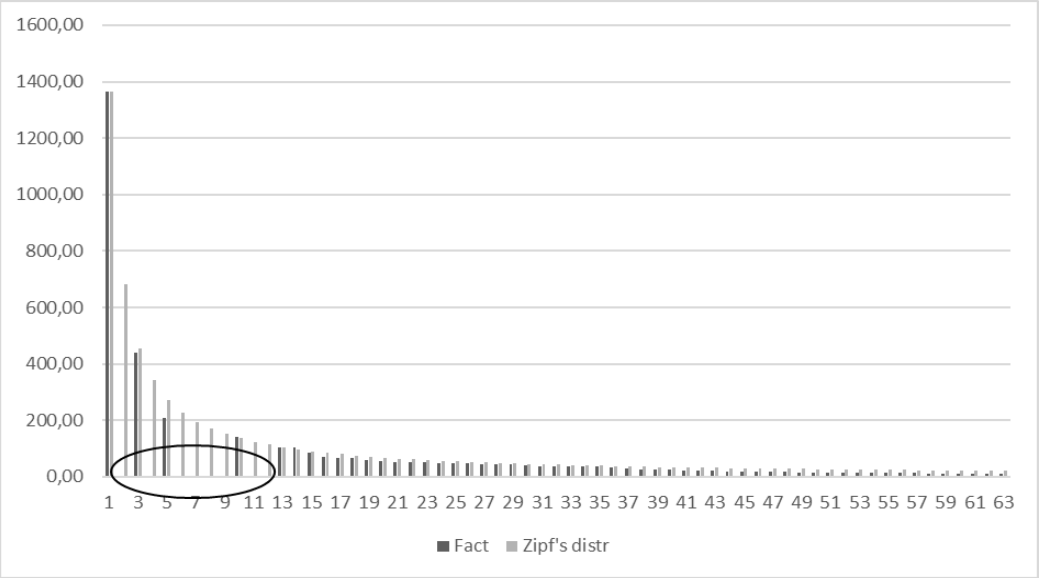



Source: author's calculations

Since 1989 the significant economic, political, institutional, social changes transformed demographic behavior and spatial population distribution. Year of 2019 demonstrates a positive dynamics comparing with 1989 (Fig. 2). Total deviation from Zipf's distribution cut almost in half and reached 19.4%. Two zones of deviation still are noticed: (1) large and middle cities had a lack of 793,8 thousand of people (133% comparing with 1989); (2) small cities had a surplus of 34,7 thousand of people (13% comparing with 1989). So the first zone of deviation got worse. Also the largest city starts to develop a new zone of deviation and to overweight other cities (118,1 thousand people of surplus); so that it is a kind of worsening the sustainability of urban settlement system.

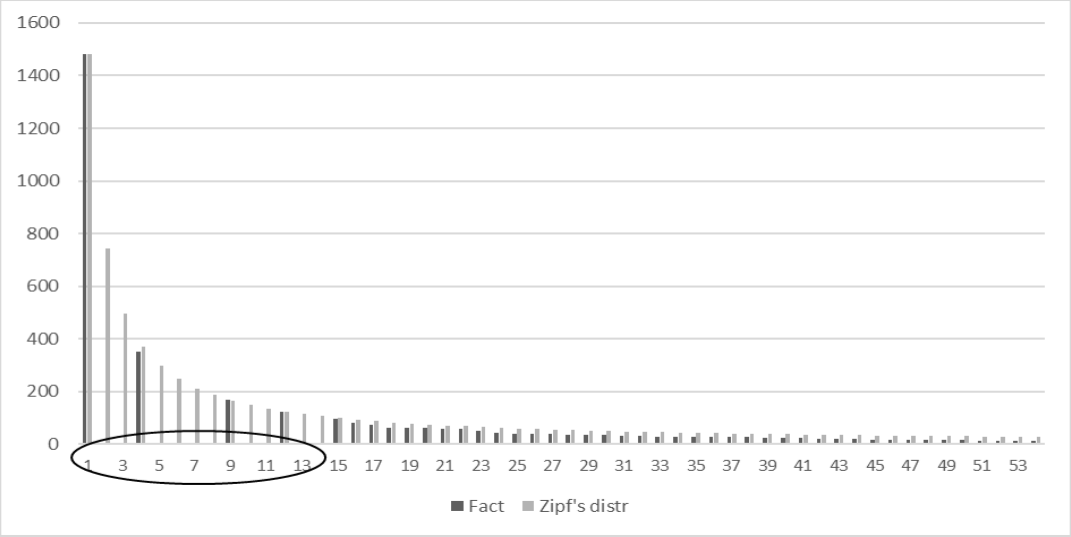
Hereby, the regressions based on Zipf's law indicates the demographic asymmetry in Sverdlovsk region. Moreover, being an essential feature of regional development, this asymmetry of the spatial population distribution is of dynamic mode and transforms constantly increasing or decreasing as a whole or partially. This conclusion is confirmed by the data presented in Fig. 3 and 4.

**Fig. 3: Actual distribution and Zipf's distribution of the urban settelments in Sverdlovsk region in 1989**




Source: author's calculations

**Fig. 4: Actual distribution and Zipf‘s distribution of the urban settelments in Sverdlovsk region in 2019**




Source: author's calculations

Based on the reached population of the the largest city (about 1,5 million people), we calculate the optimal size of cities according to the Zipf‘s law. The graphs show that there is an acute shortage of cities of the second level of the hierarchy (secondary cities) in the settlement system. Meanwhile, such cities perform vital management, logistics and production functions at the sub-regional level within the settlement system, representing centers of public administration and provision of services in the fields of education, science, health, public

services and security, as well as industrial centers or growth poles (Roberts, 2014). It should be noted that over time the situation only worsens. If in 1989 the region had 3d, 5th and 10th secondary cities (Fig. 3), then this gap between primary city and ohers has increased by 2019 and there are only 4th, 9th and 12th secondary cities (Fig. 4). Thus, we once again confirm our conclusion about the concentration of population in the largest city in the region, which increases the demographic asymmetry of regional development and reduces the stability of the urban settlement system.

## Conclusion

Regional development has uneven essence due to irregular distribution of natural resources and the productive forces. Demographic development asymmetry reflects the spatial distribution of population and results in the qualitative and quantitative characteristics of the settlement system. Our researh employed Zipf's law to estimate demographic development asymmetry on example of Sverdlovsk region (Russia). We found that there is a significent asymmetry in two ways. (1) The regional urban settlement system fits the Zipf's distribution in general but the largest city overweighs, the cities of middle size are underpopulated, and the small cities are overpopulated. Total deviation of actual population distribution from Zipf's one has decreased for 30 years. However, this transition is irregular due to growing lack of population in large cities, and reducing surplus of population in small cities. (2) The regional cities' hierarchy has a significant lack of the secondary cities so that the distribution of demographic development (and economic, social, governmental, and infrastructural functions accordingly) is irregular and biased to the largest city. This gap breaks the sustainability of regional development and strengthens the demographic asymmetry.

Thus, the region has considerable concentration of economic, social and administrative functions in its capital, while the rest of the region lacks a variety of resources (labor, investment, administrative) for effective development of the economic space and achieving high rates of economic growth, as defined in the Strategy of socio-economic development of the Sverdlovsk region until 2030. In this regard, the regional executive authorities should pay attention to increasing the attractiveness of other cities in the region (both large and especially small and medium-sized) and encourage the movement of regional residents and external migrants in such a way as to increase the stability of the settlement system and ensure an improvement in the quality of life throughout the region.

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