

Article

On the Evolution of Hierarchical Urban Systems in Soviet Russia, 1897–1989

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Abstract: One piece of evidence of the inefficiency of the spatial economy of modern Russia presented in the seminal work of Hill and Gaddy (2004) is that Russian urban agglomerations are non-viable. This was demonstrated using Zipf's rank-size distribution, which does not hold for Russian urban systems. Hill and Gaddy explained this through the legacy of the Soviet command-administrative planning. Having constructed an original dataset, which incorporated comprehensive historical data for all the cities in the former Soviet Union republics and tested the rank-size distributions for the respective years, the study yielded more nuanced findings. First, unlike the modern Russian hierarchical urban systems, the Soviet ones followed rank-size distribution fairly well. Second, the Soviet urban systems were evolving. In the late Imperial era and early Soviet period, they followed the Zipf's law prediction. However, between 1939 and 1959, the rank-size distribution diverged from the predicted one. Yet again, the Soviet hierarchical urban systems revealed a trend of convergence toward the traditional rank-size distribution in the late Soviet era. A corollary to such evidence from data trajectory appears that the evolution of the Soviet hierarchical urban systems was not necessarily the ultimate product of the urban development policies of the command-administrative system. It can be thus presumed that, contrary to the established belief, command administrative urban development might be ineffectual even in centrally planned socialist economies.

Keywords: Zipf's law; rank-size rule; hierarchical urban system; Soviet Union; Russia



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1. Introduction

During the 30 years since the demise of the Soviet Union, numerous studies have confirmed significant drawbacks in the spatial organization of Russian urban systems [1–6]. It is interesting to verify whether Russian economic geography still carries features inherited from the Soviet period. Gaining more clarity on the essence of the problem will better equip us for the necessary policy action. This study attempts to shed light on the evolution of Soviet urban systems and re-evaluate the insights presented in relevant scholarly work.

One of the findings of the seminal work by Hill and Gaddy (2004) on Russia's economic geography was that Russian urban systems do not follow rank-size distribution [7]. According to Hill and Gaddy (2004), such a result is expected given the legacy of peculiar Soviet economic management institutions. This legacy includes the Soviet command-style industrialization policy, the urban development policy backed by the Cold War ideologeme of avoidance of concentration of Soviet factors of production for population and industrial asset dispersion, as well as the pursuit of a regional equalization agenda. Hill and Gaddy (2004) inspired numerous studies that explored this matter further. It should be noted that most contemporary studies focus on the (modern) Russian Federation [2–4,6].

This paper aims to fill gaps in the existing research such as the absence of a comprehensive historical examination of the rank-size rule or Zipf's law for the pre-Soviet and Soviet periods. Additionally, relatively sparse scholarly contributions to the theme of Soviet economic geography tend to focus on the urban systems within the borders of

modern Russia, not the entire Soviet Union. Such an approach is questionable because urban systems take their shape within the territory of a country [8]. The present work examines two principal aspects: whether the rank-size rule/Zipf's law holds for historical data embracing the pre-Soviet and Soviet era and whether the rank-size rule/Zipf's law holds for the entire Union of Soviet Socialist Republics' (USSR) urban population data. In doing so, the study first constructs comprehensive urban population data for the entire former Soviet Union based on the population censuses. It then examines the historical dynamics of the Soviet urban systems.

If only the cities of modern Russia/the then Russian Soviet Federative Socialist Republic (RSFSR) are sampled, the hierarchical urban systems do not follow the rank-size rule as early as during the time of the Russian Empire. However, a comprehensive sample consisting of all the cities of the Russian Empire/the Soviet Union reveals that the urban hierarchy systems appear to follow Zipf's law. For the first time, it is presented that the Soviet hierarchical urban systems were evolving. Around World War II, deviations from the rank-size rule occurred. Yet another shift, this time toward Zipf's law distribution, was identified in the late Soviet period.

The remainder of this paper is organized as follows. In Section 2, Zipf's law literature is briefly reviewed. Section 3 discusses the definitional aspects of Soviet urban agglomeration studies and characterizes the Soviet urban policies. Further, empirical evidence of the evolution of Soviet hierarchical urban systems is presented. The final Section 6 concludes.

2. Rank-Size Rule and Related Literature

There is no strict theoretical basis for the rank-size rule [9]. However, the following three theories may be instrumental in analyzing the pattern of concentration of economic activity and city size distribution. These theories are: (1) of increasing returns, (2) of random growth, and (3) of locational fundamentals [10].

The increasing returns theory postulates that advantages of size may arise from knowledge spillovers, labor market pooling, or the advantages of proximity for both suppliers and demanders. According to this approach, the distribution of city sizes may arise from the technological characteristics of individual industries [11] or competition among locations for mobile factors of production [12]. Important themes within this stream of research include the possibilities of multiple equilibria, path dependency, and spatial catastrophes [13].

The random growth theory holds that a distribution of cities of different sizes emerges from simple stochastic processes [14]. This approach embraces Zipf's law, the central concept of this paper. Zipfian distribution stipulates that the number of cities with a population greater than A is proportional to $1/A$. The idea that the form of the size distribution of cities follows the Pareto distribution was first indicated by [15]:

$$P_i \times R_i = A$$

where P_i is the population size of city i , R_i is its rank, and A is a positive constant.

$$R_i = A \times P_i^{-\alpha}$$

or

$$\ln R_i = \ln A - \alpha \ln P_i$$

Zipf (1949) proposed that the distribution of city sizes not only follows a Pareto law, but also takes a special form with $\alpha = 1$, with the result being that A is the size of the largest city [16]. It was long believed that Zipf's law (or the rank-size rule) holds for most countries [9,17] and that it can even be verified at the regional level [18]. While numerous studies on urban agglomerations in large samples of countries have confirmed the rank-size relationship, several examinations have found that the rank-size rule does not hold strictly [19–21]. Attempting to explain such mixed results, Arshad et al. (2018) indicated

that consistency in the definition of an urban system, as well as improvements in empirical methods, could result in a more accurate fulfillment of Zipf's law [9].

The locational fundamentals theory is a variant of the random growth theory. However, it is not the city growth that is random but the fundamental characteristics of locations. The locational fundamentals theory predictions about the size of specific locations being robust to large temporary shocks were confirmed for a number of countries that had experienced massive war destruction [10,22–24]. The evolutionary process of hierarchical urban systems has been analyzed from different perspectives: a gradual increase in population size [25], the impact of institutional and technological changes [26], the effect of commuting and transportation costs [27], politically determined factors, including the legacy of democratization and federalism (via taxation and transfers policies), and development of interregional infrastructure [28], to name but a few.

Before examining whether the Soviet urban systems followed the rank-size rule, Soviet urban studies and urban policies are reviewed.

3. The Subject Matter: Soviet City and Urban Agglomeration

3.1. Types of Soviet Cities

There are different approaches to identifying the typology of Soviet cities. Focusing on a historical perspective, Frost (2018) distinguished between two groups of cities—"socialist cities" formed by the command-administrative style for the sake of accelerated industrialization and cities of "permanent transition," which first saw the arrival of socialism, then experienced post-socialist transformations [29]. More traditional systematization highlights the functional aspect. In line with this, there are two types of cities: centers of trade, administration, and cultural life, and highly localized clusters of cities with specialized industrial functions. Harris pointed that "nearly 90 per cent of the 304 larger Soviet cities fall into two classes: diversified administrative centres and industrial cities" [30] (p. 61), which is the result of the political administrative structure that underpinned the Soviet economy.

Typically, the capitals of Soviet republics were their largest cities. This can be explained by the multifaceted role played by such cities. For example, Moscow used to function as a quadruple capital, specifically, that of the USSR, RSFSR, and Moscow region as well as the center of the Central Economic Region. Similarly, the size of Leningrad (currently Saint Petersburg) can be linked to its former role as the capital of Imperial Russia as well as its role as the center of the Leningrad region and the Northwestern Economic Region during the Soviet era. Typically, there was a "close association of size of the administrative centers ... and the degree of development of industry" [30] (p. 82). While administrative cities were "widely spaced from one another, industrial cities displayed sharp localization and clustering" near the sources of natural resources or transportation routes [30] (p. 90).

Planning authorities have practiced economic zoning since the early Soviet era, with the Economic Regions being the units for the territorial distribution of plans. In the latest Soviet taxonomic design of 1963, there were 18 Economic Regions. Ten were located in the RSFSR and three in the Ukrainian Soviet Socialist Republic (SSR), while the Belorussian SSR and the Kazakh SSR had one each. The center of the Baltic Economic Region was Riga, of the Central Asian—Tashkent, and of the Caucasus—Tbilisi. The largest cities in the respective territories were the centers of their Economic Regions.

In the Soviet planning tradition, the task of accelerated comprehensive development of resource-rich regions was implemented through the introduction of another planning unit—the territorial-production complex [31], which facilitated industry-driven urban agglomeration.

3.2. Delineation of Urban Agglomerations in the Soviet Union

The USSR lacked clear parameters for a "city." The General Statute on Urban and Rural Settlements of 15 September 1924 classified all populated places of the RSFSR into urban settlements or cities, rural settlements or peasant villages and cottages, and workers' and resort settlements. An adult population of not less than 1000 and non-agricultural pursuits as the primary occupation of at least two-thirds of the residents were listed as

the threshold criteria for the urban category. Later, a population of 12,000 was fixed as the minimum numerical requirement for a city [32]. Although the latter was frequently used as the all-Union standard, the republican criteria varied greatly. De facto, the “city” title could have been used discretely for even much smaller settlements.

Similarly, there was definitional ambiguity regarding “urban agglomeration” [33–36]. Early Soviet approaches to defining urban agglomeration can be dated to the 1960s [37]. Within the functional-settlement paradigm, the individual approach relied on empirical methodologies adapted to study specific urban agglomerations. This non-standardized approach incorporated data (traffic flows and transport accessibility, real migration flows, population gravitation towards certain centers, etc.) obtained during field studies. In the 1980s, a more universal network-wide approach to defining urban agglomerations was developed, and the respective study methods were applied. This approach relied on statistics, allowing for the computation of relatively simple and universal metrics gauging the degree of population concentration.

Underlining the lack of terminological precision peculiar to the Soviet era, Antonov (2020) offered definitional references to urban agglomeration [37]. In the late Soviet period, the following standardized methodology for urban agglomeration delimitation was developed (Table 1).

Table 1. Standardized methodology for urban area delimitation.

Stages of Delimitation	Criteria	Urban Region		
		Largest	Big	
			Polycentric	Monocentric
1	core city	large city, $\geq 250,000$	two big cities ($\geq 100,000$) within 50 km of each other	big city ($\geq 100,000$)
2	urban area boundaries	1.5 h from core city and 0.5 h from big and middle towns on the periphery	1 h from core city and 0.5 h from middle towns on the periphery	1 h from core city and 0.5 h from middle towns on the periphery
3	satellite zone	≥ 4 urban settlements	≥ 6 urban settlements	≥ 4 urban settlements
4	development coefficient	≥ 1	≥ 1	≥ 2

Note: Development coefficient ($K_{dev.}$) is defined as $(K_{dev.}) = [P \times (M \times m + N \times n)]$, where P is the population of the urban area, M and N are the number of cities and urban-type settlements, respectively, and m and n are the shares of M and N in the total population of the urban area, respectively. Source: adapted from [36].

The Soviet practice was centered on the functional urban areas approach, but it differed significantly from the Western tradition wherein metropolitan areas were/are delineated based on two key criteria: the population size and the intensity of pendulum migration to the core city. The latter was assessed not based on calculation (as was the Soviet tradition of assessing the size of the population living within isochrones of transport accessibility) but based on the actual flows from detailed and relatively reliable population censuses. A limited amount of Soviet research mentions the within-metropolitan area pendulum migration criteria as an attribute of the Soviet urban area. For instance, Vishnevskiy (1967) defined the periphery to the core migration ratio as not less than 25% [38]. Strongina (1970) and Zaslavskiy et al. (1988) set a labor migration threshold of not less than 20%, including not less than 12% migration to the core city [39,40]. Hence, a serious limitation of the Soviet approach was its normative character. Such an approach disregarded the differences in core city sizes; urban areas were delineated based on the same criteria.

3.3. Soviet Urbanization Policies

The Soviet Union experienced urbanization at an unprecedented pace from the outset of the Soviet era and throughout the 1970s [30]. Soviet urbanization was a product of a policy mix which comprised regulation of internal migration, caps on large cities' growth, industrialization modeled on the development of medium-sized and small cities, regional

policies targeted at easing interregional economic differences through state investment, subsidies, and transfers, among other levers.

3.3.1. Regulation of Interregional Migration

Propiska, an instrument for space equalization, was both a residency permit and a migration-recording tool. The Soviets resumed the Russian Empire's practice of propiska in 1932. By 1935, the nature of registration became more permissive. Literally, propiska could have been denied to citizens with a willingness to migrate but no solid employment prospects. Propiska in the most attractive cities (Moscow and Leningrad) was stringent and it required the fulfillment of a set of conditions. Even enrolment in a higher education institution would only grant temporary propiska.

It is important to note that between 1935 (response to the intensified rural outmigration in the aftermath of collectivization) and 1974, rural outmigration was nearly impossible for the village residents who did not possess passports. The issuance of passports was at the discretion of the village soviets/kolkhoz administrative quarters. The young leaving for their studies or army service could obtain their documents more easily, while others (at some point, as much as 37% of the total Soviet population) were literally limited to their home villages throughout their entire lives, pretty much as it was during the serfdom era [41].

The alleviation of propiska restrictions enhanced interregional migration, which was especially important for the development of the eastern regions. The Far East was the only region that steadily recorded positive net migration during the end of the USSR [42].

3.3.2. City Size Control

City size control was a doctrine of the Soviet government [43,44] which, in a certain way, was inherited from the tsarist governments [45]. The Soviet Union practiced limiting city growth (especially after 1959) in order to achieve economic sustainability, enable effective administration, and avoid overconcentration of population in the more developed western part of the USSR. In addition, the preference for a dispersed population and industry was dictated by the communist leaders' security and defense considerations [46]. Restrictive policies were applied to fifteen Soviet cities, including Moscow, Leningrad, and Kiev [32,47].

In the 1960s, the concentration of economic activity and population in the European part of the Soviet Union was perceived as a problem. Accordingly, the 22nd (1961) and 23rd (1966) Congresses of the Communist Party of the Soviet Union adopted specific programs to foster the growth of small and middle-sized cities [30].

Among the Soviet plans were the General Scheme of Productive Forces Distribution and the General Scheme of Population Distribution of the USSR [48,49]. The latter proposed the five-tier hierarchy of urban systems. This meant an all-union system of settlements with the center at Moscow, regional systems with the center at a city with a 1 to 3 million population, large group systems with the center at a city with a population between 500,000 to 1 million, middle-size group systems with the center at a 100,000 to 500,000 population city, and small group settlement systems with the center at a town with 10,000 to 100,000 inhabitants. Thus, between the 1959 and 1970 population censuses, the Soviet Union was seeking a more balanced development of settlement networks by restraining the growth of large cities (over 1 million) and promoting the role of urban settlements with populations under 1,000,000, especially settlements with populations below 100,000 [50–52].

3.3.3. Regional Equalization

The Soviet ideology aimed to assemble an egalitarian space with uniform cities evenly distributed across the USSR. However, the pre-Soviet history of urbanization, as well as the economics of shortage, among other factors, affected policy implementation. The rate of urbanization varied across the Soviet Republics. Kazakhstan saw the most dramatic urbanization, reaching 57.2% by 1989. In contrast, Uzbekistan experienced relatively

modest progress, recording 41% in 1989. The most urbanized Soviet Republic was the RSFSR, with a 73.6% urbanization rate.

Although the urbanization progress was affected by the republics' specialization (agricultural versus industrial), it was primarily affected by the Soviet policies for urban development, which aimed to achieve a more uniform distribution of cities across the Soviet Union. During 1947–1989, the number of cities in Latvia decreased by two, Turkmenistan acquired four new cities, and Kyrgyzstan founded nine new cities. Simultaneously, the largest number of new cities appeared in the RSFSR (305), Ukraine (176), Uzbekistan (97), and Kazakhstan (48) [29]. This may suggest that the implementation of the Soviet urban development policy came at the expense of certain regions. Industrial centers were especially promoted in Siberia, the Far East, and Central Asia [8]. Senyavskiy (2019) argued that the movement of the city-forming industrial base to the East and Central Asia, with the subsequent development of new industrial centers, was largely a product of the transfer of the Soviet productive assets from the European part to regions far from the theater of the Soviet-German War [53].

The Soviet Union steadily pursued two goals: modernization and regional equality [54], or growth and equality [55]. Senyavskiy (2019) proposed that urbanization was prompted by the pursuit of one of the key Soviet ideologemes—leveling the differences in socio-economic advancements across the national republics [53]. The triangular pattern of resource distribution—plentiful fuels and raw materials in the Asiatic part (conventionally, Siberia), majority of the population and the most developed industries in the European part, and an ample and rapidly increasing workforce in Central Asia—made Soviet spatial economic planning a multifaceted problem. The equalization of economic development was attempted through administrative decisions about the distribution of resources, mostly investments. Such policies resulted in growth centers shifting from the European part of the USSR to priority areas in greater Siberia, with backwash effects on Central Asia [54].

3.3.4. Forced Urbanization

The Soviets' urban policies were distinct in many respects. The most egregious of them was the notorious GULAG—forced labor camps—system, which had profound and long-lasting effects on the spatial economy of the Soviet Union [56]. Scholars differ in their assessments of the scale of the Soviet GULAG system which was composed of 475 camps (of which 408 were located inside the borders of modern Russia). Cumulative data for the 1929 to 1953 period shows that the number of GULAG prisoners ranged from 4 to 9 million people [57,58]. Siddiqi (2021) estimates that 18 million people passed through the GULAG and approximately 2.5 million people were in the camps in the early 1950s [59].

In the process of dismantling the GULAG system, a large number of remote settlements operated under the secrecy regime were turned into closed cities [59]. In the RSFSR, the majority of such cities were located in the European part, the North, and the Far East. Although closed cities were not penitentiary settlements, they retained some of the GULAG's traits dictated by the regime of rigid secrecy. Such cities could not have been incorporated into the network of urban agglomerations, thus propelling the phenomenon of atomized urbanism [59].

4. Rank-Size Rule and Urban Development in Studies on Russia/USSR

As domestic Soviet urban studies were unique in their abundance of normative approaches and absence of statistical approaches, most of the existing quantitative scholarly work was undertaken by foreign researchers. Soviet urban studies on hierarchical urban systems are scarce. Drawing upon the available statistical explorations of urban growth and hierarchical urban systems in the Soviet Union, the key findings can be summarized as follows (Tables 2 and 3). Urbanization accelerated around the late Soviet period, and the RSFSR took the lead in this sphere with the largest number of metropolitan areas. The republics' capitals grew faster in the late Soviet era. In the course of urbanization, a city's size might have initially been affected by its historical size, transport infrastructure, and

functional role. However, non-administrative cities in the non-European part of the USSR grew faster, possibly owing to the government-led development projects for the peripheral regions. It is almost apparent that urbanization was enhanced by industrialization, but social aspects were unattended, and restrictive migration policies constrained the growth of cities (Table 2).

Table 2. Examination of urban development patterns.

Source	Sample	Method	Findings
Harris 1972 [30]	633 cities of $\geq 15,000$ in the RSFSR; 614 urban settlements of $\geq 10,000$ in the rest of the USSR for 1897, 1926, 1939, and 1959	Principal component analysis, 30 characteristics checked.	Size, density, and growth account for 80% of the variation among the 30 variables; city's age and latitude do not show variation.
			Largest correlation of variables with size factor: population in 1959; city's functions (manufacturing); transport facilities (airlines); and spacing (proximity to the next largest city).
			Largest correlation of variables with density factor: positive for urban population potential, especially within economic regions; negative for distance to the nearest neighbor, nearest larger neighbor, and Moscow.
			Largest correlation of variables with growth factor: increase in population in Soviet time; distance from Moscow, particularly in the eastern part; clustering in non-administrative settlements.
Rowland 1998 [33]	Cities of $\geq 15,000$ in the USSR, 1897–1989	Computations of the number of metropolitan areas, ⁽¹⁾ population of metropolitan areas, and shifts in both.	Number of metropolitan areas increased from 23 in 1970 to 40 in 1989; the metropolitan population doubled from 45 M to 79.9 M; urban population concentrated in metropolitan areas.
	Russia, 1897–1997	Computations of the number of metropolitan areas.	Despite deconcentration/suburbanization, metropolitan areas were central city dominated.
		Computations of population and share of population in central cities, inner suburbs, and outer suburbs in metropolitan areas.	The formation and growth of metropolitan areas were enhanced by rapid industrialization at the expense of social aspects.
Gang and Stuart 1999 [60]	308 cities of $\geq 50,000$, 1939, 1959, 1970, 1979, and 1989	Net migration rates.	77 of the 308 cities were under migration restrictions.
			Restrictions mattered; restrictions mattered less in earlier post-war period and more thereafter through the late 1980s.
			Faster expansion of cities in the RSFSR than in other republics.
			Republican capitals grew faster.

Note: ⁽¹⁾ “[A]rea with an urban population of one million or more people based on the summation of the population residing in a major central city and other urban centers of 15,000 and over within a 50-mile radius (straight-line distance) of that central city” [33] (p. 273). Source: authors.

The scope of studies on the applicability of the rank-size rule to the Soviet Union is limited (Table 3). Several generalizing observations can be made based on the studies reviewed. In the Soviet hierarchical urban systems, large cities dominated. Apparently, the density of transport infrastructure was an important factor in the development of urban hierarchy. Finally, the rank-size rule was not observed in the USSR in general, with city sizes being more homogeneous than predicted by Zipfian distribution. Two size groups, namely, the large and small cities, deviated especially further from the predicted distribution.

Table 3. Evaluation of the applicability of the rank-size rule ⁽¹⁾.

Source	Sample	Method	Findings
Rosen and Resnik 1980 [19]	225 cities of $\geq 100,000$, 1970	Rank-size rule	The rule does not hold.
			The size of cities is more homogenous than predicted.
			Small cities are marked outliers.
Clayton and Richardson 1989 [45]	514 cities of $\geq 50,000$, 1959, 1970, and 1979	Rank-size rule	10 of the 11 largest cities are major outliers with their size below the regression plane.
			Large and small cities are major outliers.
			Restrictions on city size and considerable outmigration are likely reasons.
Medvedkov 1990 [52]	Cities of $\geq 20,000$ in USSR, Ukraine, and six Eastern European members of the Warsaw Pact (command economies), 1959, 1970, 1976, 1979, and 1986	Modified rank-size approach to quantify urban hierarchy systems ⁽²⁾ $\log(H(j)) = \log(H(1)/K) - b \times \log(j)$	Impact of central planning on urban hierarchy systems is debatable; findings vary greatly across the eight cases studied.
		Basic Canonical Correlation Model ⁽³⁾ $Z = F(G)$	Density of freight transported by railroads, density of railroads, density of the network of cities, and index of shape for the national territory are important variables affecting Soviet urban hierarchy systems.
Pumain et al. 2015 [61]	91–1929 cities of $\geq 10,000$, 1840–2010; Russia is not the main target	Zipf’s law	During the Soviet era, urban growth was restrained, resulting in cities not exceeding one million inhabitants.

Notes: ⁽¹⁾ As for the location of major Soviet cities, see the map of cities of the Soviet Union in [62] (pp. 109–110) and [63] (p. 58) for reference. The three-dimensional population distribution map in [52] (p. 12) may help intuitive understanding on the location of Soviet population; ⁽²⁾ $H(j)$ is the population of the j th city; j —rank of a city in a list arranged by decreasing order of city size; K —primacy coefficient to signal a characteristic of the biggest city, a measure of its being within or outside the tendency for all other cities; b —the parameter of hierarchy gradient, numerically the same as the slope of regressing $\log H$ on $\log j$; ⁽³⁾ Z —“Zipf” and G —“geography” multidimensional matrices. G -set incorporates such variables as density of freight transported by railroads, density of railroads, density of the network of cities with population greater than 20,000 per 10,000 km², index of shape for the national territory, and Nearest Neighbor index. Source: authors.

Thus, the effects of Soviet urban policies, which were direct through migration control and indirect through industrialization, have been acknowledged in previous research. Hill and Gaddy (2004) analyzed urban data from the population census for 2002 and demonstrated that the third to tenth largest cities in terms of population were almost identical in population size [7]. This means that several cities were too small compared with the scales that could be expected from Zipf’s law. Hill and Gaddy (2004) explained this phenomenon as an effect of the Soviet era regulation of population inflows [7].

While this result seems to hold for the cities of the Russian Federation, it is important to remember that the urban system shapes within a country. The Russian Federation, as is known, was founded at the end of the 20th century. The examination of the hierarchical urban systems of the entire Soviet Union until its demise might help disclose new evidence. Another aspect explored in this study is the historical perspective of this phenomenon. If the deviation from Zipf’s law is a consequence of the Soviet urban policies, it is reasonable to assume that the deviation from the rank-size rule should increase over time. These novel aspects are examined in the remainder of this paper.

Examining the previous studies, especially those on the evaluation of rank-size distribution of Soviet cities, one can notice the following gaps. The studies conducted so far never thoroughly examined the hierarchical urban systems of the broadly defined Russian territory from the Imperial era to the late Soviet period. Within a narrow timeframe (they discussed mainly the late Soviet era’s urban systems), the applicability of rank-size rule was generally, although not definitely, rejected. After the collapse of the Soviet Union, the existing studies targeted the urban systems of the modern Russian Federation and firmly rejected the applicability of Zipf’s law, arguing that this was an ultimate result of the Soviet urban policies.

These are the principal inconsistencies persisting in scholarly accounts in this field which this article addresses.

5. Verification of Zipf's Law for Historical Data for Soviet Russia, 1897–1989

5.1. Data and Method

The original dataset constructed for this study includes the lists of city names and their population data at the seven-year points for the Russian Empire and the Soviet Union [64]. Data on the population of the Russian Empire and the Soviet Union's cities in 1897, 1939, 1959, 1970, 1979, and 1989 were acquired. Since urban systems can be discussed within the territory of one country, the data until the dissolution of the USSR were collected. Based on the original dataset, the lists of cities, urban-type settlements, workers' settlements, and other urban type category townships for all the years were composed.

Delimitation of the territory (of Russia or the USSR) was a serious problem in compiling the data. For data of the 1897 Imperial census, cities of what are now Poland, Turkey, and Finland were intentionally excluded from the original set. Because the Baltic nations—Lithuania, Estonia, and Latvia—became independent states after the demise of the Russian Empire through the outbreak of World War II, these three countries were not included in the 1926 and 1939 Soviet population censuses. To enable consistent examination throughout the population history of the Russian Empire and the Soviet Union, this study incorporated the Baltic states' population census data for the closest other years. In other words, as a proxy for the 1926 Soviet census data, the data of Estonia's 1922 census, Lithuania's 1923 census, and Latvia's 1925 census were included. Census data of Estonia and Latvia for 1934 and 1935, respectively, were included as a proxy for the 1939 Soviet census data. It is worthwhile to note that because Poland occupied nearly 1/3 of Lithuania's territory, including its capital Vilnius, during the interwar period (1920–1939), the respective years' data for many cities in Lithuania are missing. As no population census was conducted in Lithuania from 1923 to 1959, no approximate population data could be obtained for Lithuania from 1939. For more details on data please refer to [64].

5.2. Evaluating the Law: Territorial and Historical Perspectives Unified

Hill and Gaddy's (2004) work and related literature on the evaluation of the applicability of the rank-size distribution of Russian cities argued that cities in Russia are too small and do not follow Zipf's law or the rank-size rule [7]. This point can be understood from Figure 1. Urban population data for the modern Russian territory from the 1989 Soviet population census results are plotted in a full logarithmic chart for the 100 largest cities. If the cities follow the rank-size rule, they fall on the log–linear curve. The cities that are third to tenth largest in terms of population, indicated by a dashed line, are smaller than predicted by Zipf's law. Although Hill and Gaddy (2004) used data for 2002, the results are almost the same [7].

If the assumptions in Hill and Gaddy's (2004) work and other previous literature were correct, it could be expected that the deviation from Zipf's law would be small in the early Soviet period and, over time, it would become larger [7]. To verify this, figures are drawn for 1897, the Imperial era, and up to 1959 (the mid-Soviet era). This exercise helps reveal similarities across patterns in the established urban hierarchy in the modern Russian territory (Figure 2). Note that the key elements of interregional migration control, such as *propiska*, were introduced after 1926.

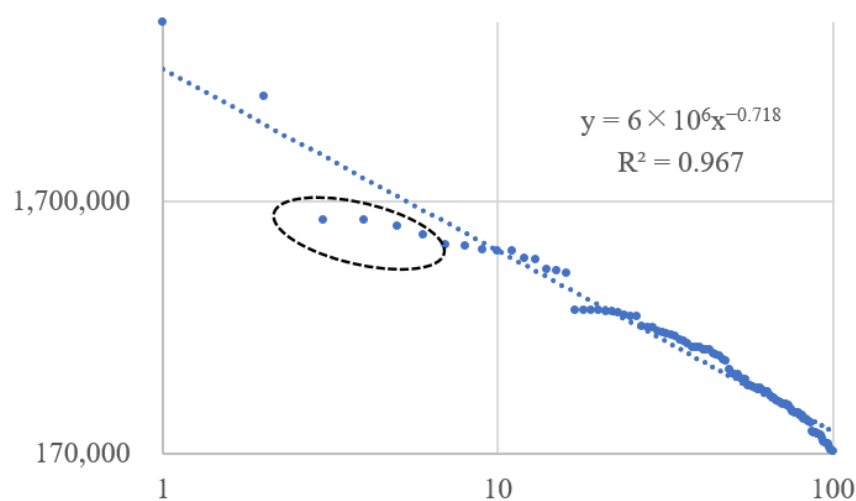


Figure 1. City size distribution for the 100 largest cities in Russia (RSFSR), 1989. Source: authors, based on an original dataset [64].

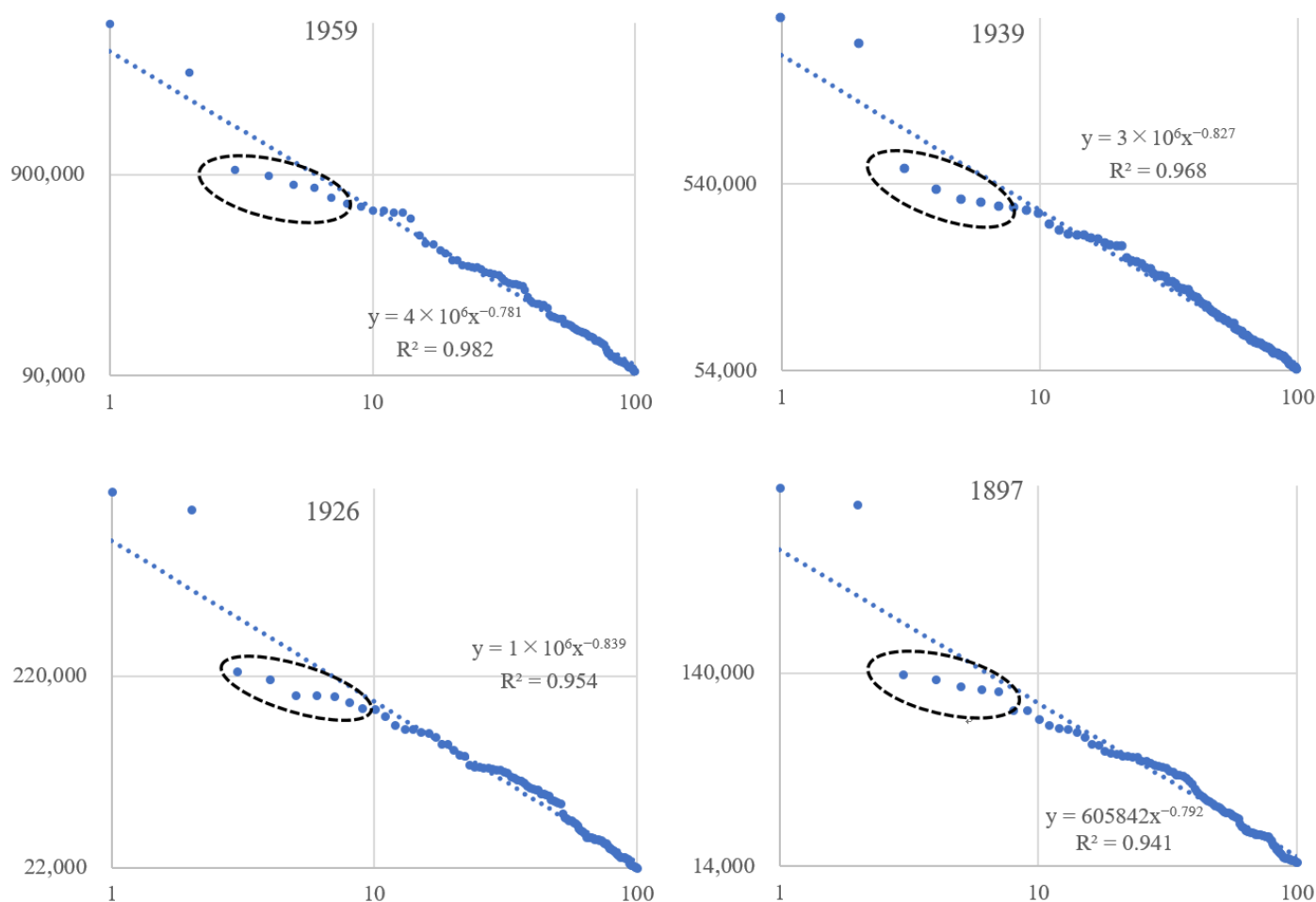


Figure 2. City size distribution in Russia for the 100 largest cities (1959, 1939, 1926, and 1897). Source: authors, based on an original dataset [64].

Figure 2 suggests that during the period of Imperial Russia and throughout the entire Soviet era, cities that were third to tenth largest in terms of population were smaller than expected. This fact indicates that the deviation from Zipf's law in modern Russia does not

originate in the urban development policy or population redistribution policy implemented during the Soviet era.

Possible explanations can be derived directly from the data. For this purpose, the graph is drawn using population data for the top 100 cities throughout the Soviet Union, not only the cities in the territory of the modern Russian Federation. On the left side of Figure 3, all the Soviet cities of 1989 are shown, and the RSFSR is shown on the right for better comparison.

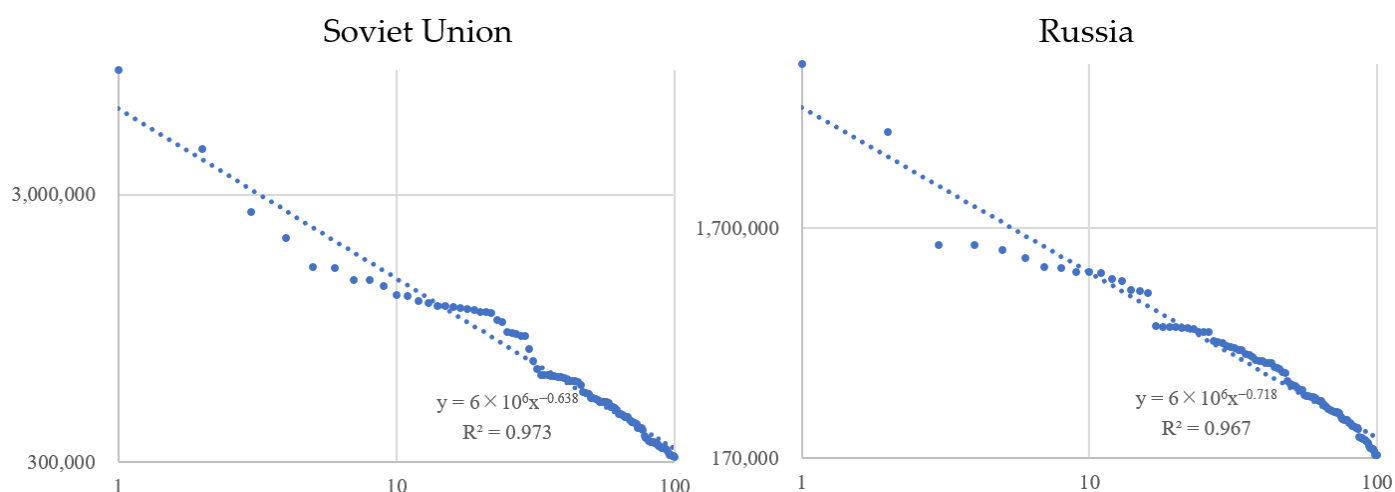


Figure 3. Soviet Union compared with the RSFSR, 1989. Source: authors, based on an original dataset [63].

In Figure 4, the plot for the Russian Empire in 1897 (left) enables one to compare the case of all the cities in the Soviet Union with the sample of only the cities in the territory of the modern Russian Federation (right).

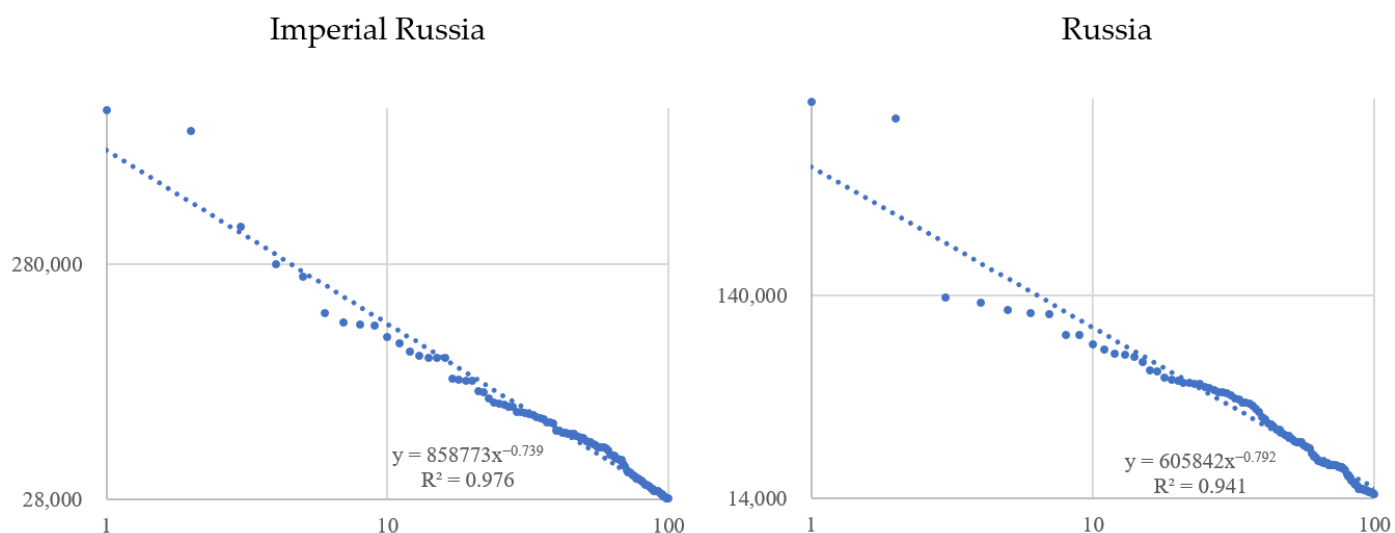


Figure 4. Imperial Russia compared with the RSFSR, 1897. Source: authors, based on an original dataset [64].

By comparing the urban distribution structure for various geographical contours, a significant difference can be observed. These figures imply that the deviation from Zipf's law, which was pointed out by Hill and Gaddy (2004) for the territory of modern Russia, was a result of the dataset design featuring only the modern Russian territory [7]. In other words, the exclusion of non-RSFSR Soviet cities, such as Kyiv (now the capital of Ukraine), Tashkent (Uzbekistan), and Kharkiv (the second largest city in Ukraine), from the empirical examination and the exclusive focus on the Russian Federation is likely to produce inac-

curate results. Although Markevich and Mikhailova (2013) and others speculated about such a probability [8], no study thus far has offered a quantitative elaboration of this. The examinations presented in this section confirm the problem involved with the exclusion of Soviet cities for the evaluation of the applicability of the rank-size rule for the target area.

To identify whether (and if, when) any shifts in city rank distribution occurred during the Soviet era, the urban population data from the population censuses for all available years for the entire territory of the Soviet Union are plotted in Figure 5.

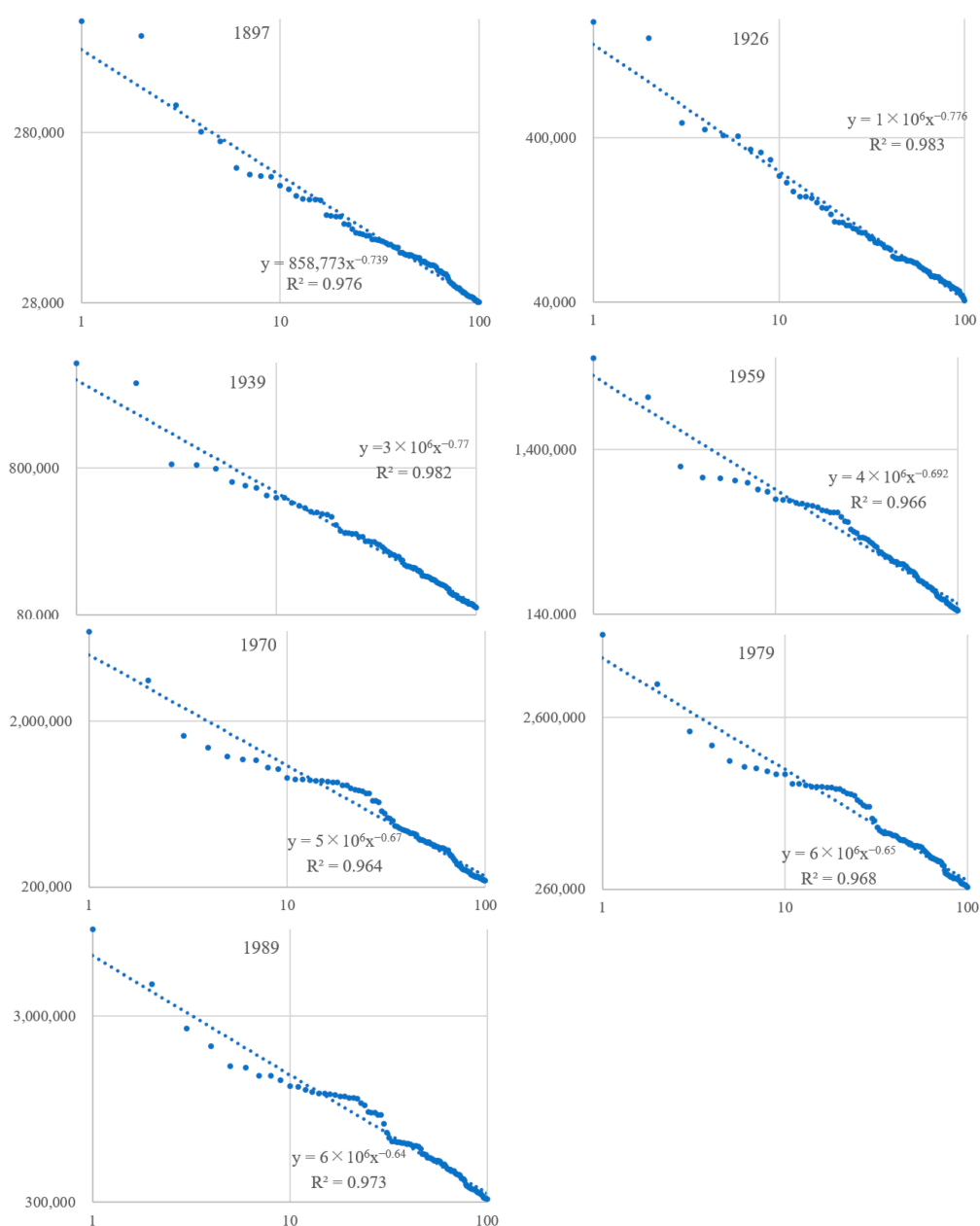


Figure 5. Urban population of the Soviet Union for the top 100 cities, 1897, 1926, 1939, 1959, 1970, 1979, and 1989. Source: authors, based on an original dataset [64].

It is apparent that in both 1897 and 1926, the Soviet urban systems followed the rank-size rule fairly well. It can be detected that the largest deviation occurred in the period between 1939 and 1959. However, the deviation stopped around 1970, as demonstrated by the estimated log–linear regression curves and their R-squared values (R-sq.) for the respective years (Table 4). Judging by the R-sq. values, the deviation entered

an upward phase in 1970. This might suggest that the regional equalization policy or forced/regulated population distribution policy did not affect urban distribution patterns, as previously discussed.

Table 4. Estimated log–linear curve for respective years.

Year	Log–Linear Regression Function and R-sq.
1897	$y = 858,773x^{-0.74}$; $R^2 = 0.976$
1926	$y = 1 \times 10^6x^{-0.77}$; $R^2 = 0.983$
1939	$y = 3 \times 10^6x^{-0.77}$; $R^2 = 0.982$
1959	$y = 4 \times 10^6x^{-0.69}$; $R^2 = 0.966$
1970	$y = 5 \times 10^6x^{-0.67}$; $R^2 = 0.964$
1979	$y = 6 \times 10^6x^{-0.65}$; $R^2 = 0.968$
1989	$y = 6 \times 10^6x^{-0.64}$; $R^2 = 0.973$

Source: authors, from the calculation in Figure 5.

The same picture appears when only the data for the largest cities are examined. Intuitively, the impact of large cities on nations is more critical than that of small ones, and the dynamics of large cities may suggest the direction of the government's urban development strategy more clearly. In order to compare the trajectories between 1939 and 1989 (slow diversion from the rank-size rule) for the entire Soviet cities sample with the 30 most populated Soviet cities sample, the data are plotted in Figure 6.

Similar to the cases plotted in Figure 5, the urban distribution diverged from the expected form in 1959. Furthermore, the subsequent dynamics are consistent with those shown in Figure 5. That is to say, there was no improvement between 1959 and 1970, but in the later period, the distribution of cities was closer to that predicted by Zipf's law. This is also indicated by R-sq. in Table 5.

Table 5. Estimated log–linear curve for each year for the 30 largest cities.

Year	Log–Linear Regression Function and R-sq.
1939	$y = 3 \times 10^6x^{-0.762}$; $R^2 = 0.941$
1959	$y = 3 \times 10^6x^{-0.585}$; $R^2 = 0.890$
1970	$y = 4 \times 10^6x^{-0.553}$; $R^2 = 0.876$
1979	$y = 5 \times 10^6x^{-0.552}$; $R^2 = 0.891$
1989	$y = 5 \times 10^6x^{-0.558}$; $R^2 = 0.903$

Source: authors, from the calculation in Figure 6.

Hence, the distribution of cities in Russia/Soviet Union did not deviate from Zipf's law consistently. On the contrary, the distribution of cities deviated from the rank-size rule during the periods before and after World War II. After WWII ended, the Soviet hierarchical urban systems seemed to move almost consistently toward the distribution predicted by Zipf's law. This observation could counter Hill and Gaddy's (2004) argument that the largest cities followed the direction of decentralization, which was frequently stated in Soviet policy documents [7].

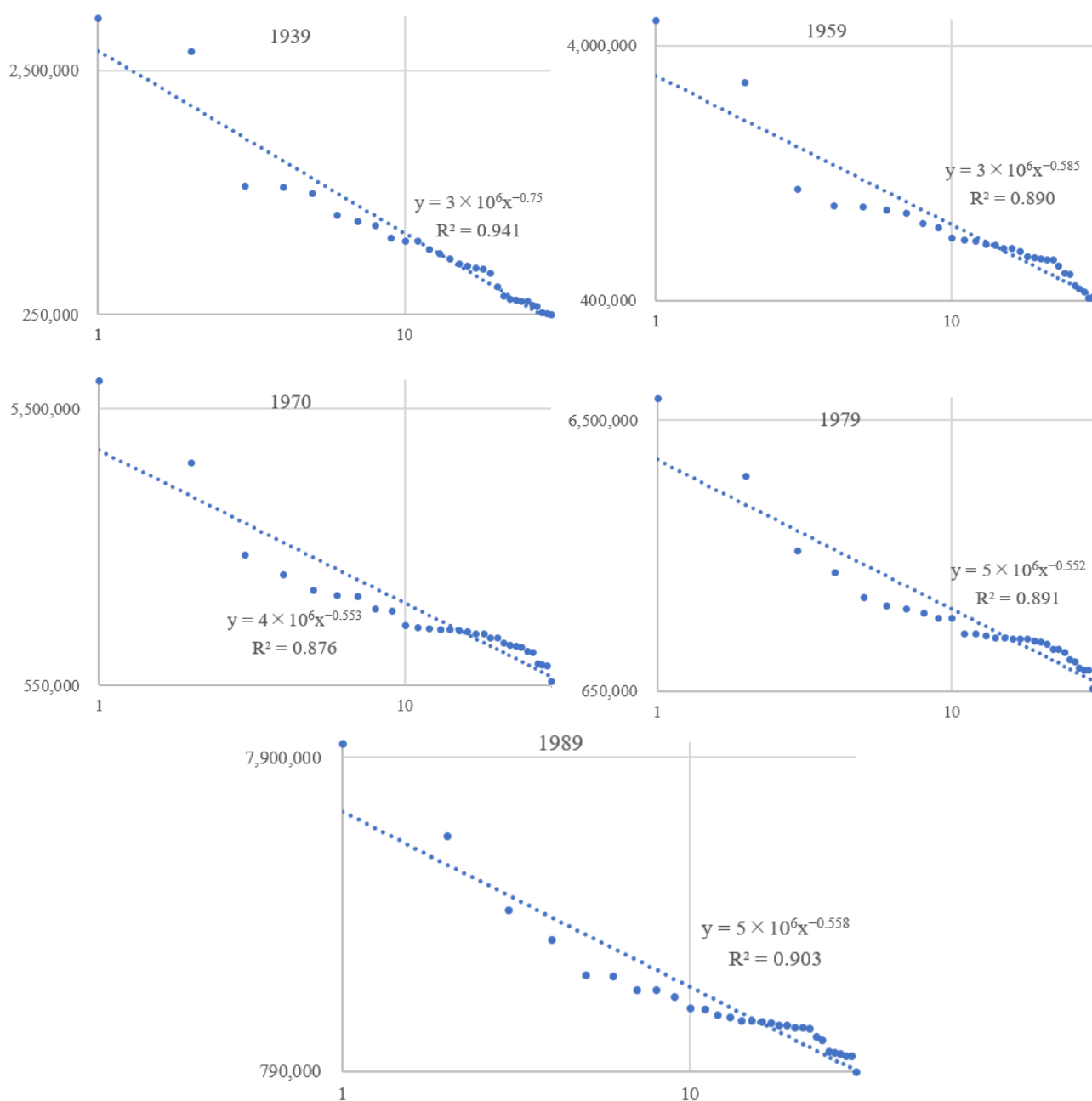


Figure 6. Rank size distribution for the top 30 Soviet cities, 1939, 1959, 1970, 1979, and 1989. Source: authors, based on an original dataset [64].

6. Conclusions

The existing research gaps in this field are, as mentioned in Section 3, as follows: (1) previous studies did not examine thoroughly Russian hierarchical urban systems through the Imperial era to the late Soviet period; (2) mainly the late Soviet period was examined in the field and the applicability of rank-size rule was generally, although not definitely, rejected; (3) after the collapse of the Soviet Union, only the modern Russian Federation was targeted and this resulted in rejection of Zipf's law.

This study examined data for the whole period from the Imperial Russia to the end of the Soviet era, and the entire territory. The authors tested the applicability of Zipf's law, and its validity was clearly confirmed in the Imperial and the early Soviet period. Additionally, the analysis identified that, during the period of the World War II, the Soviet Union's urban systems diverted from the rank-size distribution and demonstrated the convergence toward rank-size distribution in the late Soviet era. For conducting this

research, the authors composed an original dataset containing the names of all cities and urban settlements and their populations as recorded by the censuses in 1897, 1926, 1939, 1959, 1970, 1979, 1989, which enables other scholars in the field to retest our findings or reevaluate the existing studies on the Soviet urban systems in other ways.

Unlike most existing research on hierarchical urban systems focusing on the modern Russian Federation, this study encompasses the urban systems of the entire Soviet Union. The objective of this study was to re-evaluate the rank-size distribution phenomenon using more comprehensive historical and geographical data. With the newly constructed dataset, this study presented several original findings. First, it demonstrated that Soviet cities essentially followed the typical distribution pattern for hierarchical urban systems. Second, the presented data exposed historical dynamics suggestive of the shifts in the pattern. Specifically, the rank-size distribution of Soviet cities changed between 1939 and 1959. This might have been caused by World War II and it is associated with large-scale evacuation from and the loss of civil population in cities such as Kiev (Kyiv, 3rd most populous Soviet city), Khar'kov (Kharkiv, 4th), Odessa (7th), and Rostov (10th). Later, in 1959–1989, the distribution patterns of the largest Soviet cities continuously converged toward the Zipfian distribution. Finally, the presented data exposed historical dynamics suggestive of the shifts in the Soviet rank-size pattern toward the Zipfian distribution. If the Soviet Union's urban development policies were indeed causing the deviation of the Soviet urban system from the rank-size rule or the suppression of urban growth, which are among the common arguments in Soviet urban studies, the phenomenon evidenced in this paper could not have occurred. In this regard, government-led urban development might not be always effective even in the economies with centralized organization such as the socialist states. Thus, such development policies can be futile, as was the case of the Soviet Union presented in this article, or they may be an obstacle to sustainable development of hierarchical urban systems if even partially effectual.

This work is likely to be criticized for not conducting a direct cause-and-effect analysis. However, as is widely known, the rank-size rule is an empirical law that has no theory of consequence. Another limitation of this study is the absence of readily available data on the Soviet Union for the 1939–1959 period, during which the greatest divergence from Zipf's law occurred. Notwithstanding such limitations, the results of the conducted examinations reveal several previously undiscussed aspects of the evolution of Soviet hierarchical urban systems. This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex.

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