Research article

Managing urban agglomeration processes in Russia in the context of agglomerative and socio-economic development ☆

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ABSTRACT

Studies on urban agglomeration typically focus on the management of urban agglomerations as special types of spatial organization. The problem of finding an adequate management model which accounts for the level of spatial connectivity and socio-economic development of a given territory remains in the background. This article identifies urban agglomeration management models in Russia which account for the agglomerative and socio-economic development of a given territory. A methodology for assessing urban agglomeration processes is presented which, unlike existing methodologies, includes an assessment of agglomeration maturity and an assessment of the socio-economic development of urban agglomerations. This methodology is based on conceptual platforms within spatial development theory; new economic geography; and agglomeration theory and cluster development. The methodology was tested on the data of Chelyabinsk Region agglomerations. The study determined that the Chelyabinsk and Gorniy Ural agglomerations are socio-economically developed and highly agglomerated, while the Magnitogorsk agglomeration shows high socio-economic development and low agglomeration. The conurbations are underdeveloped in both areas. The paper gives several recommendations on methods for choosing urban agglomeration management models. The developed methodology can be used to assess agglomerations across Russia and to choose the most adequate management model for a territory depending on its agglomerative and socio-economic development.

1. Introduction

Urbanization and production concentration have always been on the international research agenda, since the scientific community of almost all developed countries considers agglomerations to be the leading form of territorial organization in terms of the optimal spatial distribution of productive forces, which ensures maximum economic growth. These processes are particularly relevant in Russia

because of the significant size of its territory. The fragmentation and disunity of Russian regions is a critical factor in national socio-economic development. Researchers in Russia have placed special emphasis on the connectivity of the country's vast territory, which is achieved primarily through the formation, development, and management of urban agglomerations. Urban agglomerations should build a frame to strengthen and bind the depopulated economic space of Russia and, thus, ensure its economic security.

Recent studies show a growing interest in spatial development and agglomeration processes. For example, some researchers have noted the spatial heterogeneity of economic activity due to the heterogeneous allocation of human and investment resources between municipalities within regions [1]. Other researchers focus on agglomeration processes (international trade, market competition, transport system, etc.) and prove the impact of the territorial distribution of companies and population, in particular, innovation systems and knowledge capital, on the economic development of regions [2]. A number of researchers are focusing on assessing the impact of interterritorial connectivity on the development of the economic space of agglomerations and substantiating approaches to determining the priorities of the policy of forming agglomeration formations on this basis [3].

This article examines urban agglomerations of Chelyabinsk Region, which have a number of distinguishing specific features. Chelyabinsk Region is fairly developed, specializing in ferrous and non-ferrous metallurgy, mechanical engineering, and related fields. The population density is high at 39.17 people/km^2 (2021), and 82.69% of the population is in urban areas (2021) [4]. The high level of urbanization and the concentration of industrial production of Chelyabinsk Region promote interest in the agglomeration processes of the region.

The Chelyabinsk agglomeration borders other agglomerations, including one of the largest—the Yekaterinburg agglomeration. These are considered two distinct agglomerations due to the large distances between them—the distance from Chelyabinsk to Yekaterinburg is 203 km (2 h and 8 min of continuous driving at the speed limit [5]), which complicates push-pull migration between the territories.

An urban agglomeration is a compact group of settlements (cities and rural settlements) connected by industrial, transport, economic, and other links, or a territorial concentration of industrial production. Agglomeration development refers to dynamic changes in the socio-economic state of the agglomeration and the transformation of the connectivity between its settlements [6–8].

Socio-economic standing and agglomerative development are influenced by a heterogeneous system of factors, including the supply of raw material to the agglomeration; the concentration of the industrial labor force and population within the agglomeration; the state of the infrastructure; and the economic and geographical position.

The spatial heterogeneity and developmental disproportionality among the largest Russian cities demand methodological tools to assess the depth of urban agglomeration across Russia. These tools can be used to identify specific management models for new territorial units at all levels of government, expand the geographic reach of potential agglomerated territories, and systematize their management.

The purpose of this paper is to justify management models for urban agglomerations of Russia with unique locations (on the border between Europe and Asia), based on a methodology which assesses the degree of agglomerative maturity and socio-economic development of urban agglomerations. To this end, the following tasks are solved.

- Propose a methodology to assess agglomerative and socio-economic development of urban agglomerations within the economic space of a given region;
- Test the proposed methodology by assessing the urban agglomerations of Chelyabinsk Region; rank the agglomerations according to their socio-economic status;
- Identify models of state and municipal management of urban agglomerations in the economic space of the South Ural area.

The article tests the hypothesis of the impact of the agglomeration and socio-economic maturity of urban agglomerations on the choice of their management models by examining a system of agglomerations located in Chelyabinsk Region.

The research develops methodological approaches (spatial analysis, analysis and synthesis, functional analysis, etc.) and managerial approaches (system analysis, process approach, universal approach, etc.) found in the literature.

2. Theoretical framework

The global contradictory process of population reduction and an increase in the number of cities and their sizes has made the study of spatial and demographic processes and, in particular, the sustainability of cities throughout the world and in individual countries an important issue. A comprehensive study of research on urban agglomerations assists in systematizing the literature about key issues in managing the spatial distribution of productive forces and population resettlement.

The theory of urban agglomeration is based on spatial development theory, new economic geography theory, and cluster development theory. In particular, researchers focus on the optimal concentration of industry in a heterogeneous space in the context of significant knowledge spillover [9]. This primarily concerns the study of the correlation between agglomerations, productivity, and corporate investment [10]. Other authors studied the impact of agglomeration economies (specialization, related and unrelated diversity, urbanization) on the formation of technology companies [11]. Others still evaluate the relationship between industrial technology intensity and the impact of agglomerations on economic growth [12].

Empirical analyses shows that agglomerations contribute to the growth of total factor productivity (TFP) [13]. Other scientists calculates the real energy, environmental, and economic indicators (3E) of urban agglomerations to develop a new model which is able to predict increased efficiency in several large cities [14].

Researchers note the ability of such areas to respond to the tensions induced by major urban change, which raises serious challenges

to governmental institutions at all levels in their search for increased competitiveness and administrative efficiency [15]. In response to this researchers have studied urban systems as a hierarchical percolation resulting from complex geographical, political, and historical processes [16].

Many researchers [17–24] define agglomerations as the main spatial component of new types of territorial urbanization due to the intensified spread of industrial production in large cities to nearby municipalities [25]. Based on this concern, resource constraints (e. g. water resources), environmental problems [26], and the relationship of urbanization and the quality of the environment [24] are under focus.

Significant experience has been gained in assessing monocentric agglomerations in Russia with cores in regional centers, for example: Moscow [27], Belgorod [28], and Yekaterinburg [29]. [30–37] have significantly contributed to the formation of the theoretical and methodological approaches to understanding and assessing the growth dynamics of agglomerated territories.

When justifying and searching for models for managing the development of urban agglomerations, it is important to analyze the current socio-economic state and the specifics of spatial development in the relevant agglomerations. It is thus critical to analyze methodological approaches to assessing urban agglomeration processes.

The initial stage of agglomeration analysis is is to assess the degree of its agglomerative and socio-economic development, for which it is essential to analyze the methodological approaches to assessing urban agglomeration processes. These are primarily based on the concentration of economic activity. Industrial specialization are of scientific interest as reflected in a wide range of studies [38–42]. Lamelin calculated the agglomeration index as the number of interactions between economic entities in a given geographical area [43].

The set of indicators used to determine the development level of an urban agglomeration typically depends on the purpose of the study, but generally includes population size and density; the average number of employees and average wages; investments in fixed assets; and the transport accessibility of settlements [44,45].

Methodological tools used to assess the scale and stability of agglomeration processes include various development indices [17]; ratings systems [21]; assessing the "compactness" of agglomerations in terms of their impact on territorial development [18]; and determining agglomeration boundaries through a system of statistical and morphological modeling methods [46].

Research also focuses on gravitational modeling, that is, assessing the intensity of interaction between settlements forming a territory (for example, a traffic flow analysis model [47] is currently used to determine the territorial connectivity of settlements in urban agglomerations [48]). The intensity of interaction can depend on the population of settlements and the distance between them [23], and on a complex development quality index of the agglomeration reflecting its socio-economic status (the unemployment rate, overall sales of consumer goods, and other indicators).

Concentrated territories must be managed according to the characteristics of their agglomerative and socio-economic development. The developed model is tested on the agglomerative territories of Chelyabinsk Region. This approach allows the concentration of production and population within this territory, and, consequently, the coherence of this territory to be analyzed and determined, suggesting possible management models.

3. Research methodology

The paper elaborates a methodology for assessing the development of agglomerated territories, which was subsequently tested on the urban agglomerations of Chelyabinsk Region (Chelyabinsk[1] and Magnitogorsk agglomerations,[2] Gorniy Ural[3] agglomeration, and the Northern Conurbation and Troitsk-Kartaly Transport and Logistics Conurbation (TLC) (Fig. 1).

Table 1 describes the tools used to analyze the agglomeration and socio-economic development (maturity) of agglomeration processes in Chelyabinsk Region.

A preliminary assessment was performed by determining the "spatial and economic connectivity of the territory" created by the frame of urban agglomerations [37]. The assessment delimits the territory and classifies it as agglomerated, if applicable. This analysis studies both the periphery and the core, the socio-economic interaction between them, and the availability of transport links. Each criterion is considered separately.

1. The lower threshold value of the population criterion for an urban agglomeration core ranges from 50,000 people (World Bank and OECD [52]) to 250,000 people (the Institute of Geography of the Russian Academy of Sciences [50]).
2. The transport accessibility criterion is difficult to calculate due to the lack of data characterizing push-pull migration along transport corridors. To this end, the gravity model to delimit urban agglomerations depending on the population of the main city of the agglomeration was used. This model was first proposed by Pivovarov [53] and revised by Sokolov [51]. The initial hypothesis of this approach is that the force of interaction between the inhabitants of the peripheral zone and the center of attraction (the core) decreases in a power law dependence further from the core. When a certain *maximum distance* is reached, the force of attraction of the urban agglomeration core is no longer significant, and any points located further than this maximum distance no longer belong
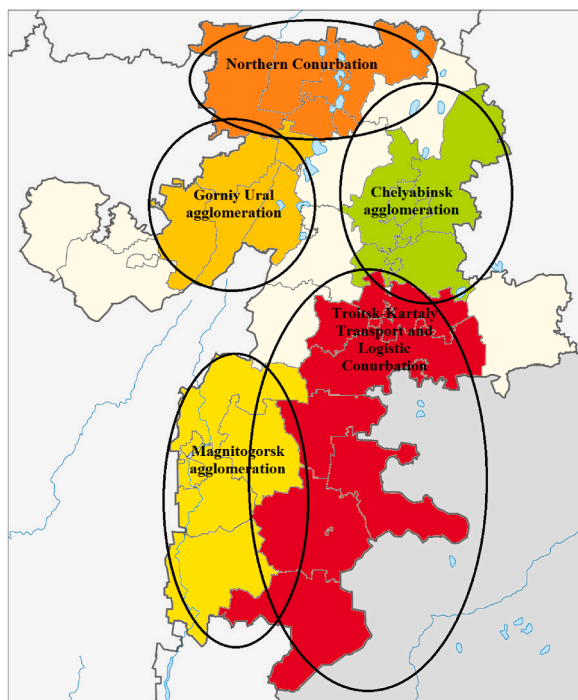

Fig. 1. Agglomerated territories of Chelyabinsk Region.

to the agglomeration [54]. The proposed approach to assessing the "zone of influence" of cities is implemented by creating a circle around the core with some satellites within its radius. Sokolov considers an urban agglomeration to be fully developed if more than two satellites fall within the zone of influence of the core city [54].

3.The urban agglomerative development coefficient [34] reflects the scale (population density) and structure of agglomerated territories. According to the Institute of Geography of the Russian Academy of Sciences [50], an agglomeration has formed if the development coefficient is ≥ 1.0. For the purposes of this study, if this criterion has not been satisfied, but the criteria of core population and accessibility are met, then the region is potentially undergoing agglomeration.

The degree of agglomerative development of the territory is assessed at the second stage by evaluating.

a) the agglomeration coefficient (with a threshold value of 0.1);
b) the agglomeration index [33];
c) the centrality coefficient (the compactness of the economic space), a modification of the method proposed by Beaujeu-Garnier and Chabot [55], who assess the relationship between the city and *umland* (its zone of influence);
4. The coefficient of settlement gravitation to the core was proposed by Nymmik [29] and is used in zoning the regions of Russia [56].

We assess the socio-economic development of urban agglomerations by four social, economic, infrastructural, and environmental blocks of indicators (Table 2).

By analyzing these indicators, shifts in the socio-economic development of agglomerations can be assessed. By estimating the coefficients of variation for these indicators it is possible to assess the degree of differentiation in the functioning of municipalities in order to determine the measures that contribute to homogeneous agglomeration in the region.

To determine the internal factors constraining development, a method is proposed to ensure the comparability of different-sized indicators of municipalities using the index method. This approach is universal and can be used to assess the socio-economic development of agglomerations, the impact of medium-term and long-term state policies of urban agglomeration, and measures to stimulate the agglomeration and socio-economic development of urban agglomerations.

These assessments can help select a scientifically-grounded model for managing the development of urban agglomerations most suitable for the specific conditions of each region.

The main limitations of studying agglomerations include.

- Lack of consensus among researchers on certain theoretical aspects of urban agglomerations (for example, delimitation of agglomeration boundaries);

Table 1

Methodology for assessing the agglomerative and socio-economic development of urban agglomerations in the Chelyabinsk region.

1. Preliminary assessment
Purpose: Assess the composition and structure of a territory for compliance with the criteria of urban agglomeration delimitation

Criterion 1. Population of the urban agglomeration core

    Task: Assess whether or not a territory can be classified as agglomerated; determine the type of agglomeration, if applicable (monocentric/polycentric, major city/large city)

Criterion 2. Accessibility of the agglomeration core

    Task: Determine the zone of influence of the urban agglomeration core.

    The zone of influence is determined by constructing a circle reflecting the transport accessibility of the core city, expressed in kilometers:

$$L = \sqrt[3]{\frac{P_i}{2}}, \quad (1)$$

where L is the zone of influence of the municipality, km, and P_i is the population of the municipality, people.

Criterion 3. Development of urban agglomeration

    Task: Assess the development of the territory in terms of agglomeration links; identify existing and potential urban agglomerations.

    Agglomerative development coefficient:

    $K_{dev} = P * (M * m + N * n), \quad (2)$

where P is the urban population, million people, M is the number of cities, N is the number of urban-type settlements, m is the percentage of the population of the agglomeration made up by cities; and n is the percentage of the population of the agglomeration made up by urban-type settlements.

2. Assessment of the intensity of agglomeration (agglomerative development) within the territory

    Purpose: Identify key features of urban agglomerative development

2.1. Assessment of the "launch positions" of urban agglomerative development

    Task: Assess urban agglomeration

The agglomeration coefficient is an assessment of the density of urban settlements relative to each other and to the agglomeration as a whole:

$$K_a = \frac{N}{S}L, \quad (3)$$

where K_a is the agglomeration coefficient, N is the number of urban settlements, S is the agglomeration size, km,^{2} and L is the average shortest distance between urban settlements.

The agglomeration index is the percentage of the total agglomeration population made up by the population of satellite settlements:

$$I_a = \frac{P}{P_a}, \quad (4)$$

I$_a$ is the agglomeration index, P is the total population of satellite settlements, people, and P$_a$ is the population of the agglomeration, people.

The centrality coefficient is the percentage of the total population of the agglomeration made up by the population of the agglomeration core:

$$K_c = \frac{Q}{Q_a} * 100, \quad (5)$$

where K_c is the centrality coefficient, Q is the population of the agglomeration core, people, Q$_a$ is the total population of the agglomeration, people.

The coefficient of gravitation of settlements to the agglomeration core is estimated as:

$$K_{att} = \frac{Q}{R^2} * 100, \quad (6)$$

where K_{att} is the coefficient of gravitation of the periphery to the core, Q is the population of the urban agglomeration core, people, R is the distance between the core and the satellite, km.

3. Final assessment of the socio-economic development of agglomerations, ranking of agglomerations

    Purpose: Build an integral index of urban agglomerative development by calculating the economic, infrastructural, social, and environmental indicators of the municipalities forming an urban agglomeration:

    3.1. Determining the development index of a municipality as part of an urban agglomeration by calculating indices for upward-trending (7) and downward-trending indicators (8).

$$I_i = \frac{I_{i_{mean}}}{I_{UA_{mean}}}; \quad (7)$$

$$I_i = 1 - \frac{I_{mean}}{I_{UA_{mean}}}, \quad (8)$$

where I_i is the development index of the i-th municipality for the considered period, I_i is the mean value of the municipality development index for the considered period, and $I_{UA_{mean}}$ is the arithmetic mean of development index for all municipalities in the regional agglomerations for the considered period.

    3.2. Determining the general development index of an urban agglomeration settlement as the arithmetic mean of the settlement's development indices:

$$GI_{ST} = \frac{\sum I_i}{n}, \quad (9)$$

where GI_{SD} is the general index of agglomeration settlement development, I_i is the index of the i-th agglomeration settlement development, and n is the number of indices of settlement development.

    3. Determining the integral index of the urban agglomerative development, taking into account various aspects of the development of all its constituent settlements:

$$GI_{UAD} = \frac{\sum GI_{SD}}{m}, \quad (10)$$

where GI_{UAD} is the integral index of agglomerative development, GI_{SD} is the general index of agglomeration settlement development, m is the number of constituent settlements in an agglomeration.

Source: compiled by the authors from adapted methodological approaches [32,36,49–51].

- Lack of statistical data, which prevents the calculation of certain indicators of the agglomerative maturity of the territory (for example, the transport accessibility in Russia cannot be calculated because there are no data characterizing the intensity of traffic flow along transport corridors). This limitation can be mitigated by using gravity models that estimate the gravitation of the population of one settlement to another, or sociological surveys that characterize the specifics of commuting.

Table 2
Indicators of socio-economic development of urban agglomerations, by blocks.

1. Social block
1.1 Average monthly salary (weighted by the population of municipalities), thousand rubles
1.2 Available housing, m^2
1.3 Migration gain/loss per capita, people
1.4 The number of establishments providing preschool education, childcare
1.5 The number of outpatient clinics
2. Economic block
2.1 Transaction density (turnover among commercial organizations (profit and non-profit) in actual prices per square kilometer), million rubles/km^2
2.2 Business density (balanced financial result (profit minus losses), in actual prices per square kilometer), million rubles/km^2
2.3 Investment density (investments in fixed assets, in actual prices per square kilometer), million rubles/km^2
2.4 Fixed assets (average annual cost of fixed assets of commercial organizations per square kilometer), million rubles/km^2
2.5 Retail trade density (turnover of retail trade, in actual prices per square kilometer), million rubles/km^2
3. Infrastructural block
3.1 Highway density (total length of general-purpose highways per square kilometer), km/km^2
3.2 Water supply (total length of water supply lines to residential buildings per square kilometer, km/km^2
3.3 Labor force density (average annual number of employees per square kilometer), people/km^2
3.4 Jobs density (the labor demand declared by employers to state employment services, per square kilometer), people/km^2
4. Environmental block
4.1 Pollution level (pollutant emissions from stationary sources per square kilometer), tons/km^2
4.2 Environmental protection quality (capture and neutralization of pollutant emissions from stationary sources per square kilometer), tons/km^2

4. Results

Our analysis focused on urban agglomeration processes in Chelyabinsk Region, using data from 2010 to 2019 on 31 municipalities of the region, which make up five agglomerations.[4] Indicators from federal, regional, and municipal statistical books were used.

We first analyzed the composition and structure of the agglomerations of Chelyabinsk Region per the delimitation criterion (Table 3). The Chelyabinsk, Magnitogorsk, and Gorniy Ural agglomerations meet the population criterion; the first two are mono-centric and the last is polycentric. The Northern Conurbation and TLC meet the population criterion and the criterion of the number of cities in the agglomeration zone. However, the former has no clear, dominant core, while TLC has two cores that do not meet the population criterion. Both are scattered agglomerations.

Table 4 presents the coefficient of development of large cities in terms of the formation of agglomeration links (agglomeration development).

The Chelyabinsk and Gorniy Ural agglomerations are classified as developed, while the rest are undeveloped.

The development of the agglomerations was assessed based on a set of agglomeration indicators. It was found that municipalities within the agglomerations are situated relatively far from each other, except for in the Chelyabinsk and Gorniy Ural agglomerations. The rural population dominates in the satellite zone of the Chelyabinsk and Magnitogorsk agglomerations. In the Gorniy Ural agglomeration, the Northern Conurbation, and TLC, more than half of the urban population is concentrated in the satellite zone. The Chelyabinsk and Magnitogorsk agglomerations have a high coefficient of centrality, the Gorniy Ural agglomeration – average, and the Northern Conurbation and TLC – low.

An assessment of the gravitation of satellites to the agglomeration cores shows that only two municipalities (Kopeisk urban district and Sosnovka municipal district) demonstrate strong attraction to the core city (Chelyabinsk). Most of the municipalities are characterized by low gravitation (11 municipalities have average gravitation, 15 have weak gravitation, and 4 have almost no gravitation).

An integrated assessment of the socio-economic development index of Chelyabinsk region agglomerations (Table 5) was compiled. Chelyabinsk had the highest index, followed by Magnitogorsk, Gorniy Ural agglomeration, Northern Conurbation and, finally, TLC. Fig. 2 is a wind rose of agglomerative development indices, divided into the previously outlined blocks. This diagram reveals weaknesses in the socio-economic development of the urban agglomerations of the Southern Urals and allows for measures to be proposed to eliminate them.

5. Discussion

The results on the development of urban agglomerations in Chelyabinsk Region allow us to highlight the following.

First, this territory is characterized by an average degree of agglomeration and spatial connectivity, which limits the manifestation of agglomeration synergy.

Second, the five analyzed agglomerations demonstrate different results of socio-economic policy, which determines the lines of the relevant socio-economic policy for the authorities. The administrative bodies of the Chelyabinsk agglomeration should focus on

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[4] Certain municipalities of Chelyabinsk Region which are formally declared part of the agglomerations by the Strategy for the Socio-Economic Development of the Region for the Period up to 2035 are classified as closed administrative-territorial entities (CATEs) and do not adhere to the standards of information openness. It is difficult to use data on their internal development when aggregating up to the agglomeration level, so we excluded the socio-economic development of CATEs from the sample.

Table 3
Preliminary assessment of the agglomerated territories of the Chelyabinsk region.

Criterion name	Criterion	Chelyabinsk agglomeration		Magnitogorsk agglomeration		Gorniy Ural agglomeration		Northern Conurbation		Troitsk-Kartaly Transport and Logistics Conurbation	
		Value	Interpretation	Value	Interpretation	Value	Interpretation	Value	Interpretation	Value	Interpretation
1.1 Total population of the agglomeration, thousand people	more than 100,000 people	1604.6	Meets the criterion	519.4	Meets the criterion	461.3	Meets the criterion	258.2	Meets the criterion	305.3	Meets the criterion
1.2 Number of urban settlements in the agglomeration	at least 3	8	Meets the criterion	4	Meets the criterion	11	Meets the criterion	7	Meets the criterion	4	Meets the criterion
1.3 Number of cores	1	1	Monocentric	1	Monocentric	2	Polycentric	–	No clearly dominant center; tends towards the scattered agglomeration model	2	Polycentric model
1.4 Population in the core, thousand people	more than 100,000 people	1196.7	Meets the criterion	413.3	Meets the criterion	Miass urban district – 151,500 people Zlatoust urban district – 163,900 people	Meets the criterion	–	–	Troitsk urban district – 73,400 people; Kartaly municipal district – 49,700 people	Neither center meets the criterion. No clearly dominant center, tends towards the scattered agglomeration model

Table 4

Coefficient of development for urban agglomerations in the Chelyabinsk region.

Agglomeration name	Coefficient of development	Calculated development coefficient	Interpretation
Chelyabinsk	≥1	3.30	Developed agglomeration
Magnitogorsk		0.46	Undeveloped agglomeration
Gorniy Ural		3.04	Developed agglomeration
Northern Conurbation		0.60	Undeveloped agglomeration
Troitsk-Kartaly TLC		0.64	Undeveloped agglomeration

Table 5

Assessment of the integral index of the socio-economic development of the agglomeration.

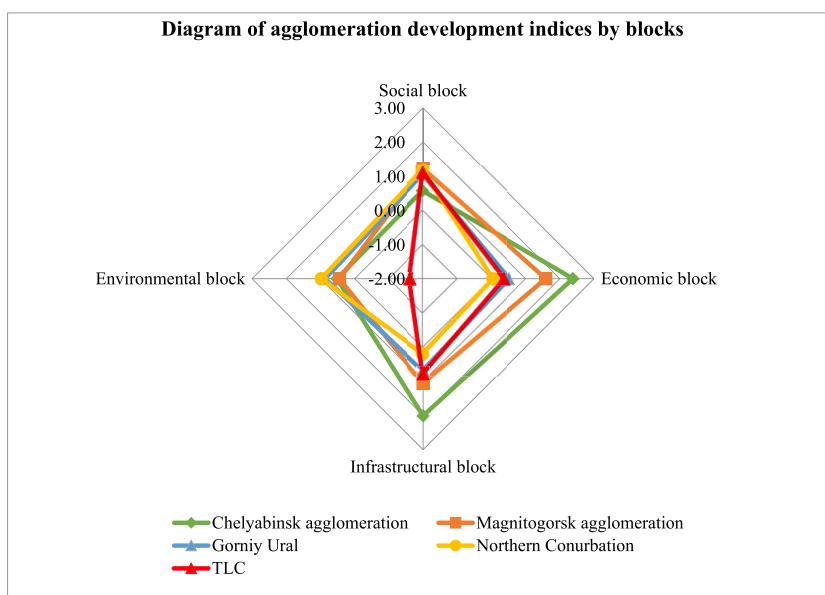| Urban agglomeration	Social block	Economic block	Resource-infrastructural block	Environmental block	Integral index of socio-economic development
Chelyabinsk	0.56	2.38	2.01	0.52	1.49
Magnitogorsk	1.22	1.58	1.05	0.45	1.20
Gorniy Ural	1.04	0.50	0.68	0.86	0.76
Northern Conurbation	1.18	0.03	0.19	0.98	0.55
TLC	1.11	0.36	0.78	−1.61	0.45

Fig. 2. Diagram of the development index of Chelyabinsk region agglomerations, by blocks.

increasing the social development indicators of the agglomeration. The environmental component should be the focal point of the policy for the Magnitogorsk agglomeration. The Gorniy Ural agglomeration should prioritize solving resource and infrastructure supply of the territory. The Northern Conurbation and TLC are distinguished by very low economic development indicators, so the administration should seek out promising specializations for these agglomerations.

Comparing the results of this study with the overview of investigations concerning agglomerations in regional economy on this issue [2] leads to the following conclusions. The scope of the study coincides with modern research trends: a comparative analysis of the patterns, driving forces, and problems of the development of urban agglomerations [57]. A comparative analysis of agglomerations of Chelyabinsk Region, which differ in terms of agglomeration and socio-economic development, was conducted in order to make it possible to "link" disparate territories from the perspective of the spatial development of the region and the whole of Russia.

In addition, this study assumes the concentration of production as the main component, which is studied in the works of Pilyasov and Goncharov, focusing on the placement of productive forces in Russia in an innovative economy: the features and patterns of development of economic clusters and new industrial zones, dichotomies center-periphery, etc. [58].

The methodological section of the article uses indicators that are most often cited in the literature to assess agglomerative development: 1) the population of the agglomeration core, the accessibility of the core to the satellite zone, the development coefficient; 2) the analysis of the "launch" positions of the agglomeration (agglomeration coefficient, agglomeration index, centrality

coefficient, coefficient of gravitation of settlements to the core), etc. [37,59]).

6. Conclusions

1. The paper focuses on developing methodological approaches to assessing the agglomerative and socio-economic development of urban agglomeration in order to choose the soundest management model for the economic space of in Chelyabinsk Region.
2. The proposed methodology for assessing the agglomerative and socio-economic development of agglomeration processes was tested on urban agglomerated territories of Chelyabinsk Region, which lead to the following conclusions:
   – The region has a relatively average level of agglomerative development. There are two territories with high agglomeration (the Chelyabinsk agglomeration and the Gorniy Ural agglomeration) and three underdeveloped agglomerations (Magnitogorsk, Northern Conurbation, and TLC) which reduces the unity and security of the territory. The concentration of production and the concentration of the population of this region is insufficient to ensure the connectivity and integrity of the territory of the Ural macroregion and Russia;
   – The final assessment of urban agglomerations from the standpoint of socio-economic development showed the leading position of the Chelyabinsk agglomeration, followed by the Magnitogorsk agglomeration, Gorniy Ural agglomeration, the Northern Conurbation, and TLC.

An analysis of the socio-economic development of agglomerations (including social, economic, resource-infrastructural, and environmental factors) is essential for administrative bodies because the results highlight priority areas for socio-economic policy.

3. The analysis of Chelyabinsk Region showed that the region has a very heterogeneous level of maturity of urban agglomeration processes, which suggests the need for federal, regional, and municipal authorities to choose appropriate management models. The main principles of agglomeration management models are:
   – the benefits of a model should outweigh the possible challenges introduced by the model;
   – there should be a compromise in the functions of authorities (bylaw regulations, the execution of management tasks, administrative control over compliance with the law, law enforcement, the provision of information) in regions of Russia and the municipalities located within agglomerations, which will contribute to the revitalization of the satellite links;
   – agglomeration should be carried out in several stages, the first of which is to organize governing bodies (without forming legal entities/non-profit organizations) to participate in the development of strategic and land-use planning documents and agglomeration projects and coordinate the activities of municipalities [60].
4. The article concludes that urban agglomeration management models should be chosen based on an assessment of the conditions for the concentration of population and production, and according to the specialization of the territory. The Chelyabinsk agglomeration is monocentric and mature in terms of agglomeration processes and socio-economic development. A territorial planning scheme for the Chelyabinsk agglomeration has been recently adopted. An organizational form of strengthening ties within such an urban agglomeration can be a contractual model (i.e. an agreement between the constituent municipalities) which serves as an organizational form for strengthening ties within the Chelyabinsk agglomeration and similar agglomerations. A legal entity (an association consisting of municipalities as founders) has been incorporated [61].

The Magnitogorsk agglomeration is monocentric and is socio-economically developed but shows undeveloped agglomeration processes. This prevents proposing a scientifically grounded management model. However, on 03.02.21, an Inter-Municipal Agreement was signed to frame the Magnitogorsk agglomeration. A modification of the contractual model which includes individual municipalities of the Republic of Bashkortostan may be an acceptable model for this agglomeration.

The Gorniy Ural agglomeration is polycentric (two leading cores: Zlatoust and Miass) and is mature in terms both agglomeration processes and socio-economic development. It is therefore advisable to form a management model which includes the appropriate form of inter-municipal cooperation between the cores in the form of contractual agglomeration framing.

Finally, the Northern Conurbation and TLC are underdeveloped both in terms of agglomeration processes and socio-economic development. They are potential agglomeration territories therefore, from a scientific standpoint, it is still premature to choose management models for these conurbations.

The proposed contractual model of urban agglomerations management is generally applicable to agglomerations located in other regions of Russia due to the insignificant degree of concentration of production and the level of urbanization in most regions.

Notably, there are difficulties in organizing integrated management of Russian agglomerations, including.

– A very low level of territorial agglomerativeness, which predetermines the need to develop mechanisms for cooperation and mutually beneficial collaboration of municipalities inside the agglomeration;
– The boundaries of urban agglomerations often do not coincide with administrative-territorial divisions, which can provoke conflict between the municipalities that are part of agglomerations and impede the implementation of a unified policy.

This study provides an assessment of the current state of Chelyabinsk Region in terms of its agglomerative and socio-economic development. According to the estimates of the five agglomerations in Chelyabinsk Region, future studies can be conducted to.

– define agglomeration effects as the impact of individual urban agglomerations on the final indicators of the region (labor productivity, economic growth, employment, etc.);
– assess the inter-municipal interaction within the urban agglomeration in order to optimize inter-municipal cooperation;
– justify a management model for agglomerated territories depending on the degree of agglomerative and socio-economic development of a specific agglomeration.

Data availability statement

Data not available/The data that has been used is confidential.

CRediT authorship contribution statement

Aviral Kumar Tiwari: Writing – review & editing, Supervision, Investigation, Conceptualization. **Valentina S. Antoniuk:** Writing – original draft, Visualization, Supervision, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Anastasiya S. Lapo:** Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Elmira R. Vansovich:** Writing – original draft, Visualization, Supervision, Software, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests

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