Sustainable development of million cities: Spatial evidence from Russia

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Abstract. Modern cities are centers of economic, social, cultural and intellectual life, which makes it crucially important to ensure proper conditions for their sustainable development. The paper is intended to elaborate on some spatial aspects of the sustainable development of million cities in Russia. The study used official statistics, as well as data from the information and analytical system of urban development VEB.RF. The research method consists in comparing the values of indicators characterizing cities' spatial particularities with each other and with the national average. The article analyzes accessibility of objects of interest for the population (social infrastructure facilities, leisure centers). It reveals that million cities differ in these parameters quite significantly and can be categorized into three groups. The most numerous group (8 cities) is one embracing cities with liveability above the national average; in four cities, the liveability level is equivalent to the all-Russia average; and two million-plus cities are lagging behind the others. The research also indicates the factors defining the accessibility of objects of interest for city inhabitants: its area, population density, saturation of urban space with such objects and the specificities of their localization, uniqueness of urban planning, and the quality of the urban environment.

Key words: Sustainable development; Spatial development; Space planning; Million city.

1 Introduction

The concept of sustainable development, formulated several decades ago and regarded as a response to the world community's growing concern about the sufficiency of resources for long-term progress, still remains quite relevant today. In years, the concept's key idea – harmonization of social, environmental and economic relationships and meeting the needs of the present without compromising the ability of future generations to meet their own needs – has not seen significant change. However, some aspects of the concept have been slightly transformed: if at the first stages of its development, special attention was paid to the need to respect the environment, now it underlies a multifaceted anthropocentric approach [1].

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An array of global problems impeding the provision of decent living conditions for the global population determined a variety of goals, which must be achieved for the world community to follow a sustainable development path. According to the Sustainable Development Agenda, formulated by the United Nations General Assembly, there are seventeen interlinked objectives, such as no poverty, zero hunger, reduced inequalities, economic growth, good health, quality education, ecosystem preservation, etc. One of the objectives is to improve the sustainability of cities and communities, turning them into open, safe, resilient and environmentally friendly spaces. It is no coincidence that improving the quality of life in cities deserves special attention: over 50% of the world's population are inhabitants of large cities; they provide about 60% of the world GDP [2], and many global problems (infrastructure congestion, high levels of environmental pollution, etc.) are most acute in the urban environment [3].

The novelty of this study resides to the fact of jointly employing one representative anthropocentric factor and one representative spatial factor that are primarily determining the sustainable development of contemporaries cities in Russia. In particular, the anthropocentric factor of liveability was deployed considering the national average of liveability. Under this criterion/factor of analysis the examined cities were grouped in highest, equal and lowest liveability level of the all-Russia average. Besides, the spatial factor of defining the accessibility to objects of interest was deployed for city inhabitants. Under this criterion/factor of analysis the following key-aspects were considered: urban area, population density, saturation of urban space with such objects and the specificities of their localization, uniqueness of urban planning, and the quality of the urban environment. The ultimate research target is the definition and the investigation of those aspects that contribute to the Russian urban space planning, being an essential characteristic that determines the possibilities of its sustainable development. For this, the applied methodology was focused on the comparative analysis of Russian million cities based on identification of these peculiarities.

2 Literature review

According to the UN definition, a sustainable city is a resilient habitat for existing populations designed with consideration for social, economic, environmental impact and without compromising the ability of future generations to experience the same. Nevertheless, it is rather difficult to identify the factors and conditions that determine such a state or provide the prerequisites needed for the sustainable development of a city. For instance, among the important attributes of a city that can be called sustainable are the following: the use of advanced technological and digital solutions in the urban economy and urban transformation management [4, 5], favorable environmental conditions (for example, a sufficient number of urban green zones [6, 7]), the involvement of the city in national and world events [8, 9], the balance of all components of its development, all spheres of life of citizens and business communities [10]. All these aspects are crucial and workable only in combination, and the key resulting characteristic of using these attributes to improve urban processes is ensuring maximum liveability for those living, working, and resting there.

There are many signs to judge on city liveability for residents and guests: well-ordered public open spaces [11], provision with convenient infrastructure [12], green spaces [13], etc. However, the mere fact of these facilities available within a city is not enough: space should be organized in such a way that anyone can easily use them without spending much time or resources on it. In other words, the specificity of urban space arrangement is an important characteristic of its liveability and sustainability of its development [14]. Not for nothing has the 15-minute city concept grew in popularity in recent years. It is premised on the idea of

urban life decentralization (residents should have access to all facilities needed for a comfortable life, work and leisure in close proximity to their homes) [15].

The significance of how the urban space is arranged makes researchers pay careful attention to various aspects of the spatial organization of the city: distribution of infrastructure objects across the territory [16], the development of public transport [17], conditions for individual vehicles [18], as well as the ease of pedestrian travel [19, 20]. At the same time, data about the arrangement of the urban space and its special features are often based not on regular statistical observations (which basically provide only a generalized description of the processes unfolding in the city without indicating what is happening with intracity territories), but survey findings [21], open source data from applications for itinerary organization and traffic conditions [22], expert assessments of the quality of certain accessibility factors for urban areas [23].

Among the most important aspects of the spatial organization of the city contemporary urban planning policies have been recently concentrated on enhancing the wellbeing and the social mobility, especially among today segregated families. In this context policymakers are eager to create socially mixed neighbourhoods, even though evidence for the positive impact of social mixing is patchy, considering the relationship between social mixing, social capital, and the lived experience of residents affected by the desegregation of typical urban areas of western industrialized economies [24]. Subsequently, it was argued that desegregation sustains complex and contradictory impacts on lived experience, being unavoidably related to changes in social forms of capital (and its multifaceted nature (of social capital) as a resource). Therefore, while it is apparent that the presence of strong negative neighbourhood effects, acknowledged by marginalized residents themselves, imply that social mixing can contribute to the enhancement of wellbeing and social mobility for segregated families, the desegregation alone is insufficient thus further policies have to be fostered aiming to increase socio-spatial integration and deal with the social, economic, and cultural causes of extreme poverty [24]. Similar studies have been focused on the process of urban development in post-socialist cities from the side of place branding, such as in the case of Timișoara, Romania [25]. In this study the reproduction and the adaptation of global urban development policies were overviewed in the light of post-socialist urban politics, demonstrating specific circularity between city branding and urban development, which can be proven useful to align the city to the regional inter-urban economic competition and to promote it as a space of rapid development, even in cases of disparate histories and representations of cities, which are assembled in ad-hoc and often contradictory branding discourses [25]. In such a context of contradictory branding discourses it is noteworthy the study of Vesalon and Crețan [26] who studied the role of gentrification in inner London while deploying an interview and survey data to compare the Docklands with the gentrification that had taken place elsewhere in inner London. These authors showed that for many of the respondents in Docklands, the kind of life they are seeking is often associated with some conceptions of suburban life. It was also denoted that both gentrification and suburbanization as concepts need to be used with care in understanding contemporary processes of re-urbanization such as prevail in Docklands and the central areas of other British cities [27, 28].

It also worth noting that the number of foreign publications on urban space arrangement significantly exceeds the number of works authored by Russian researchers, which highlights the importance of the given analysis.

3 Materials and methods

The study is centered on cities with at least a million inhabitants that are the key elements of the settlement system concentrating a considerable amount of resources within their borders and of particular importance for the national (and in some cases for the world's) economy.

The space of such cities is typically heterogeneous, accommodates a large number of objects and has a complex organization logic. We have analyzed data on Russia's 14 million cities, excluding the country's two largest cities – Moscow and Saint Petersburg, as they enjoy a special administrative status (cities of federal subject significance) and radically differ from other million cities in size and functions. They are, therefore, unsuitable for comparative analysis and beyond the scope of this paper.

As mentioned earlier, urban space is primarily a space that is liveable for people, therefore, it should be arranged so that it is comfortable for residents to use objects located in the city (elements of social infrastructure, shopping facilities, etc.). The lack of statistical indicators in the Russian practice for evaluating this accessibility makes it necessary to turn to alternative data sources. To perform the comparative analysis of Russian million cities' spatial organization, the information and analytical system of urban development designed by the state corporation VEB.RF was used. The database contains more than 200 indicators characterizing various aspects of life in 115 cities of the country and is based on the data retrieved from statistical services, relevant ministries and departments, the Central Bank, as well as data obtained from surveys and geoanalytical systems.

For the purposes of our study, we have selected seven indicators characterizing the share of population living within walking distance from objects of interest (schools, hospitals, sports facilities, green areas, etc.). Having compared the values of each indicator of the analyzed cities with the national average (also provided in the database), we divided the studied objects into two groups: if, relative to the Russian average, a city's indicator deviates upwards, the quality of its spatial organization is rather high (in the context of the indicator under review); if downwards, it is relatively low.

Data integration within all seven indicators can contribute to a comprehensive understanding of the spatial characteristics of the cities under consideration. To this end, it is necessary to calculate the mean value of all the studied indicators (A):

$$A = \left(\sum_{i=1}^{n} \frac{X_i}{X_{iav}} \right) \div n \tag{1}$$

where X_i is a value of the analyzed city by the *i*-th indicator, X_{iav} is the national average value of the *i*-th indicator, *n* is the number of indicators considered.

The number of indicators with the value above the national average (L) is also quite indicative: it shows how many types of objects are available to a significant number of residents.

Graphic visualization used to combine these two integral characteristics allows grouping cities by the degree of their liveability for residents, and the use of graphs to visually correlate each of them (in the given study, the mean value of all the studied indicators was chosen as such a combined characteristic) with indicators describing the factors affecting urban space arrangement allows one to get a general idea of the reasons for these differences. However, the methodology limitations are mainly attributed to the facts that the definition and the conceptualization of the anthropocentric factor of well being is unavoidably linked with a wide spectrum of how and to what extent well being supports an acceptable level/indicator of liveability among the studied Russian cities, let alone if wellbeing is characterized as the primary causality/indicator of appreciating and valuing liveability in other -non Russian- cities worldwide. Another methodology limitation is that the spatial factor of urban contexts, not only in Russia but also globally, it is not a static criterion/indicator of analysis, but a dynamic criterion/indicator of analysis, being time-evolving, spatial-temporarily defined and land-use-change driven.

4 Results

The spatial organization specificity of Russia's largest cities can be judged by the difference between the indicators' values for each city and their national average (Table 1). It is noteworthy that in most million cities green spaces and forests are much more available for residents than the average across the country. The possible reason for this lies in the landscaping standards: according to federal law, the standards for large and largest cities exceed those for small and medium-sized cities. In terms of other parameters under study, the difference between million cities is more noticeable.

Table 1. Indicators characterizing the spatial organization specificity of Russia's largest cities (2021).

Cities	Deviation from the national average by the following indicators:						
	In1	In2	In3	In4	In5	In6	In7
Chelyabinsk	0.88	0.94	0.97	1.04	1.07	0.91	0.88
Ekaterinburg	1.00	0.99	0.99	1.01	1.15	0.96	0.95
Krasnodar	1.35	1.24	1.18	1.10	0.88	1.13	1.17
Krasnoyarsk	1.07	1.14	1.03	0.89	0.93	1.01	1.05
Kazan	0.98	1.09	1.09	1.03	1.08	1.03	1.05
Nizhny Novgorod	1.22	1.22	1.13	1.17	1.16	1.08	1.12
Novosibirsk	1.17	1.19	1.08	1.07	1.08	1.07	1.08
Omsk	0.96	0.94	0.95	1.09	1.05	0.99	0.92
Perm	0.65	0.69	0.78	0.85	1.03	0.76	0.69
Rostov-on-Don	1.27	1.17	1.11	1.23	1.12	1.08	1.14
Samara	1.04	1.06	1.03	0.93	1.04	1.02	1.03
Ufa	0.99	1.09	0.98	0.93	1.03	0.96	1.00
Volgograd	0.87	0.93	0.97	0.77	0.86	0.94	0.89
Voronezh	1.06	1.11	1.08	1.05	1.16	1.06	1.04

Compiled according to: VEB RF database for calculating the City Life Index. URL: https://citylifeindex.ru/database
Note:
In1 is Proportion of population living within a 15 minute walk from sports facilities, %;
In2 is Proportion of population living within a 15 minute walk from outpatient facilities, %;
In3 is Proportion of population living within a 20 minute walk from schools, %;
In4 is Proportion of population living within a 10 minute walk from public transport stops, %;
In5 is Proportion of population with access to at least 1 ha of green spaces (parks) and forests within a 15-minute walk, %;
In6 is Percentage of the population living within a 3 km radius along public roads from at least one cultural and leisure facility, %;
In7 in Proportion of population living within a 15 minute walk from at least one grocery store, %.

Having analyzed each city's position relative to the mean value, we concluded that the space of Voronezh, Rostov-on-Don, Novosibirsk and Nizhny Novgorod was best organized in terms of accessibility of objects of interest to residents. The least favorable situation was in Volgograd: the city was inferior in all the spatial organization characteristics considered. Perm, Yekaterinburg, Chelyabinsk, and Omsk lagged behind in most of them.

When considering not only the deviation of each city's value (upwards or downwards) from the national average, but also the scale of this difference, it is possible to more reasonably classify the objects according to the specificity of their spatial organization. By placing the markers characterizing the position of each million city in the coordinate system, which combines the indicators exceeding the Russian average (L) with the mean value for each object (A), we categorized the cities under review into three groups (Fig. 1).
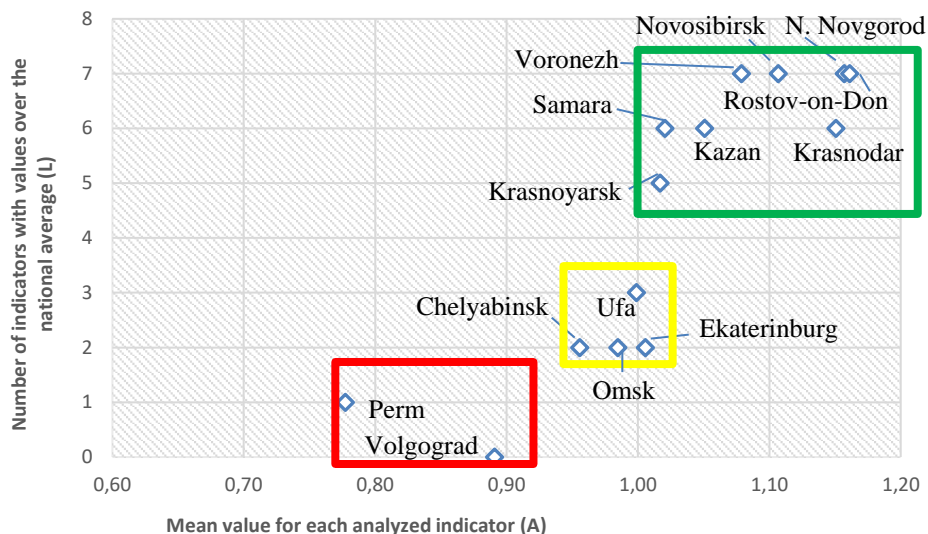
City markers belonging to the same group are located within colored figures.

Fig. 1. Grouping of million cities in accordance with the specificity of their spatial organization.

The space of Perm and Volgograd is the least liveable for residents. Nizhny Novgorod, Rostov-on-Don, Novosibirsk, Voronezh, Samara, Kazan, Krasnodar and Krasnoyarsk demonstrate the best spatial organization in the sample. The situation in Omsk, Ufa, Yekaterinburg and Chelyabinsk is similar to the average across the country.

It can be assumed that one of the important factors determining the accessibility of objects for city residents is its area: in a more compact settlement, points of attraction will generally be more accessible, and with the area expanding, the proportion of the population living in the zone of comfortable access to such objects will be declining (Fig. 2). This characteristic, however, is obviously not always decisive: Krasnodar and Perm – the cities with virtually identical areas – differ significantly in terms of the value of the integral characteristic, which reflects the specificity of the city spatial organization.
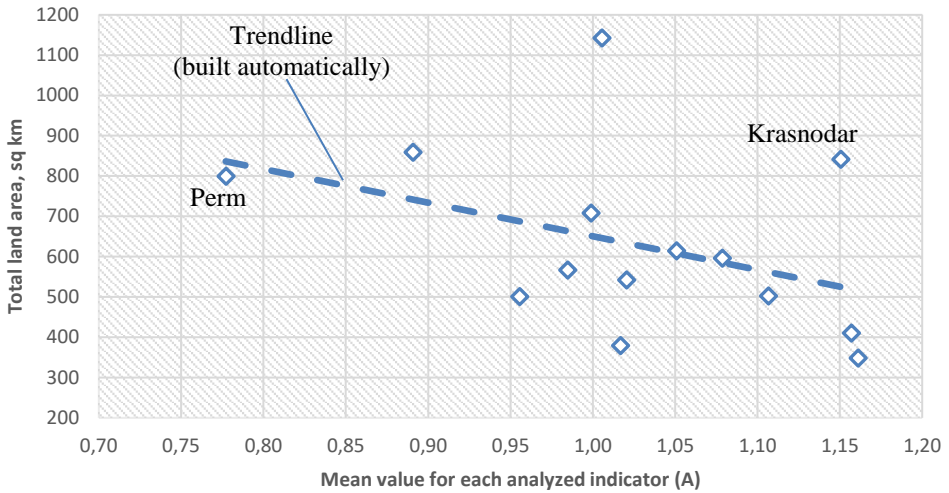
Compiled according to: VEB RF database for calculating the City Life Index. URL: https://citylifeindex.ru/database; Federal State Statistics Service. URL: https://eng.gks.ru/

Fig. 2. Correlation between the million cities' spatial organization characteristics and their total area.

Space organization is also affected by saturation with objects of interest to residents (the number of sports facilities, medical institutions, etc., per unit land area), as well as the density of the population, i.e., potential consumers of their services (Fig. 3). In this case, the relationship between the indicators is direct — the bigger the number of such objects or consumers concentrated around them, the higher the degree of their accessibility and liveability.
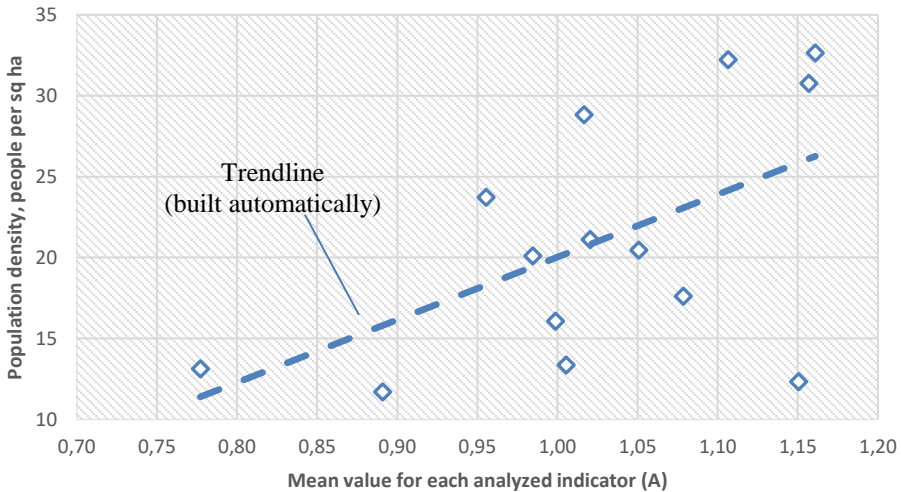
Compiled according to: VEB RF database for calculating the City Life Index. URL: https://citylifeindex.ru/database; Federal State Statistics Service. URL: https://eng.gks.ru/

Fig. 3. Correlation between the million cities' spatial organization characteristics and the density of the population living there.

The way the objects are spatially organized is also of high importance. If they are concentrated in one particular part of the city, residents of remote areas are limited in their ability to use them. In other words, even if the urban space is highly saturated with such objects, the proportion of the population having comfortable access to them will be small. The reason for such spatial imbalances lies in the presence in the city of densely populated new areas of development (where objects of attraction, such as sports facilities or parks, have not yet appeared) or areas distant from the city center, which are not developing as actively as the main urban area (including through the construction of modern shopping and entertainment sites). In particular, these factors impact the space organization specificity of the city of Perm. Deficiencies in urban planning can result in the poor quality of the urban environment for pedestrians, for example, the dissection of the space by large roads, industrial areas, etc. This largely explains the problems inherent in the spatial organization of Volgograd, which lies along the river bank and is not too comfortable for pedestrian travel.

5 Discussion

The present research touched upon only some aspects of the extremely extensive topic of urban space organization: our attention was focused on only fixing the current situation, but the analysis of possible causes of individual objects' peculiarities was not exhaustive — it rather allowed identifying and explaining some hypotheses that should be tested and clarified in further works. The research findings also confirmed the urgency of developing the tools to evaluate spatial specificities of cities (this applies both to choosing the available indicators and the way they are processed to obtain a comprehensive view of the urban space). This finding is also consistent with the findings of Robson and Butler [29] who characterized middle-class life in a modeled city as being essentially unstable, which is largely compensated for by the frisson of living in a cosmopolitan and mixed area. Comparing neighbourhood areas that are more stable, their residents can build a long-term relationship with the area and forming substantial social networks with other residents. However, determinants of wellbeing are that of cultural infrastructure and circuits of education. These determinants are of primary importance especially among middle-class families, enabling the most developed sophisticated educational strategies to be characterized as place-specific among local cities [29].

Another critical issue emerged from the conducted analysis is the urban marginality in diverse contexts in alignment with anthropological perspectives on contemporary urbanity, which should take into account the complexity of the social positions of those city dwellers that are on the margins. In this context "urban margins" can be perceived not as essence or entities, but as forms of relations between urban dwellers shaped by processes of political, economic, spatial and social marginalisation. Seen in this way, urban margins are certainly constituting a perspective on the urban: a lens to entice comparisons of urban agency in the world of cities [30].

Additionally, it is obvious that subsequent research on the topic under consideration should perform not only analytical, but also predictive and advisory functions: the assessment of the current situation is valuable precisely because it highlights the deficits and aspects to be corrected, which determine the directions and mechanisms for solving the existing problems.

6 Conclusion

The comparative analysis of the spatial organization of Russian million cities showed that they were significantly differentiated: even those with similar development characteristics

(for example, of the same area or population density) can differ substantially in terms of their space arrangement. The liveability level of most million cities is higher than the national average, however, two cities of the sample (Perm and Volgograd) are significantly behind the other objects under study. Among the reasons affecting the availability of facilities for city residents are the following: the size of the occupied territory, population density, the saturation with points of attraction and the specificity of their localization, as well as the unique features of urban planning and the quality of the urban environment (mainly in terms of ease of movement).

In general, it is worth noting that despite the great dependence of urban space on aspects that can hardly be influenced (the city area, terrain, previous urban policy, etc.), an effective spatial development policy can influence the peculiarities of its organization (for example, by creating conditions for convenient movement from one point to another), thereby ensuring a qualitative transformation of the urban environment, creating the most comfortable conditions for residents, and increasing the sustainability of the city's development. Conclusively, it can be pointed out that the sustainable development of contemporary cities is directly determined by a wide spectrum of factors, including:

− Socio-economic, political, and environmental challenges that play a dynamic role of the life, especially among, marginal areas of the urban setting, enabling the mitigation of the effects of climate-related events and urban marginality and amplifying marginal voices to change social policies for the good of all citizens [31].

− Urban climate change justice in a development context, showing that migrants experience extreme forms of climate injustice as they are often invisible to the official state apparatus, or worse, are actively erased from cities through force or discriminatory development policies. Therefore, today policies must engage more seriously with issues of recognition to enable more radical climate justice in cities [32].

− While valuing mobility as a service (MaaS) in alignment with household composition, it can be provided evidence for a high degree of heterogeneity. Therefore, the quantification of the value of mobility can interpret the functionality of transportation in marginalized cities of high heterogeneity [33].

− Primary health care in marginal urban areas, as that of rural health programs and community health programs can be designed to extend health services coverage into underserved rural and marginal urban areas. These types of programs can be proven useful not only so that novel ideas and information may be shared, but also so that constructive criticism capable of yielding future improvements can be generated [34].

− A simplified and feasible approach of simulating the cooling effect provided by green roofs can be handled as a mitigation option to combat urban heat island effects in high-density urban areas, such as that of China. Not all proposed strategies would moderate the thermal environment, therefore urban planners should pay special attention in the future construction sector and buildings' design [35].

− The classification of the urban marginal land into "vacant land" and "land between buildings" can support the disclosure of landscape patterns, thus, support urban planners to reclaim unused urban land and develop distributed bioenergy projects at a city scale [36, 37].

− Especially among densely populated cities it cannot undermined the utility of nonparametric linear programming to calculate key-aspects of urban sustainable development, as that of the shadow price of carbon dioxide (CO_2) emissions, which can be used to measure the marginal abatement cost (MAC) and to estimate the marginal abatement cost curve (MACC). Subsequently, it can be denoted that the technology spillover and the scale effect of the agglomeration economy should be explored fully to lower the costs of emissions reduction and to promote the low-carbon development of urban agglomerations [38].

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