DIGITALIZATION AND KNOWLEDGE-BASED ECONOMY OF SMART CITIES: DEVELOPMENT SCENARIOS

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ABSTRACT

This study aims to assess potential changes in the existing approaches to urban development within the national scale. The paper focuses on the development of such an approach that would encourage digital transformation in cities with the maximum number of benefits for their residents. Cluster analysis of the Russian regions allowed articulating various development scenarios for each cluster in terms of digitalization and improvements in the knowledge-based economy. Apart from changing the urban environment as it is, information technologies alter the very notion of how the regions can be integrated into the social and economic space. This fact makes even more sense regarding the emergence of digital inequality and disproportions in the development and distribution of new knowledge. Thereby, decent living standards in the regions end up undermined. Global changes of early 2020 will certainly lead to transformations in consumer behavior and thinking behind business processes, which will change the needs for the urban environment to meet. The core requirements include infrastructure security, state regulation, social security, localization of production and consumption, as well as changes in the consumption patterns. It should be noted that improvements in the public policy of the Russian Federation can be implemented only when guided by the identified scenarios and factors influencing urban transformation. In this regard, all the incorporated digital solutions are expected to enhance comfort, which does not necessarily mean an overwhelming set of tools, but high quality and an idea behind their use. The introduction of digital technologies is no longer a matter that can be neglected or prioritized by the authorities. It has been immersed in the system of public administration to such an extent that there is now no other way but to use its effectiveness as a competitive advantage of the region. At the regional level, the

competition for investors is so harsh at the moment that the ability to embrace the full potential of digitalization turns out to be the key to success, determining the speed for an investor to access the required infrastructure and start their commercial activities

CCS CONCEPTS

• **Applied computing** → Law, social and behavioral sciences; Economics.

KEYWORDS

digitalization, regional development, infrastructure potential, digital economy, smart cities

1 INTRODUCTION

Building original "smart" cities is an effective strategy to alleviate potential problems related to the growing population and rapid urbanization. However, a perfect picture was spoiled when the Covid pandemic hit and took over to control the global trends of modern society. For instance, the range of essentials has been broadened by sanitary means, such as masks and gloves, which used to be widely used only by the medical staff. Whereas now, the enterprises that strove to operate at the time of the pandemic, became active consumers of the given means. Another pandemic-born trend that has left all the city streets empty, is self-isolation and the prohibition of mass events. Nonetheless, the ongoing crisis encourages people to adapt to new conditions and adopt new realities, thus contributing to the establishment of a new type of stability.

At the same time, such relative stability raises new questions and challenges for the country's economy to transform urban space. Shopping centers, among other things, in large and major cities, were closed, which led to overstocking in the consumer sphere (clothing, household goods, building materials, etc.). However, the

greatest sufferer of preventive measures against Covid was the services industry with the reduction of 37.2% in the volume of services in April-June, compared to the same period last year (data provided by Rosstat). And in general, such complications as bankruptcies and wage saving regimes associated with the transition to online work, have resulted in significant changes in the level of income and well-being of citizens. Fairly enough, fluctuations in aggregate supply and demand have affected the overall price parameters.

This problem has not been deeply investigated yet, due to the recent character of the triggering events. This is why this study aims to fill the existing gap in the research of smart cities. In addition to that, in response to the increasing use of the "smart cities" concept, this paper suggests considering the hypothesis on a possibility to boost the efficiency of smart cities through infrastructure development, and, what's more, to assess its subsequent effects.

2 LITERATURE REVIEW

Practitioners and scientists are still struggling to derive a single definition for the "smart city" concept. Thereby, an unambiguous variety of interpretations allows applying the term to a vast number of cities [1]. Some sources tend to consider the concept only through the lens of urban economy, which means that "smart cities" are to be characterized by the presence of the "smart" industry, for instance by a range of information and communication technologies. Whereas in other sources, the term "smart city" describes relations between the government, city administration, and residents [2]. These vague definitions can be used in an abstract discussion, but they are not sufficient in terms of strategic decision-making or in-practice implementation, not to mention the comprehensive scientific discourse. Research in the area provides a number of concepts, including "smart energy", "smart transport", "smart urban environment", "smart home", etc. However, the given set of "smart" facilities is incapable of fully reflecting the meaning of "smart city" in a way that would distinguish it from other territorial entities. The term itself has not yet settled down, which results in its common use in irrelevant contexts.

For instance, marketing tends to apply a more user-friendly word "smart", instead of "intelligent", aiming to establish a quicker customer reaction and gain feedback. Another approach suggests that "smart" is a much broader concept that implies "intelligence", since the smart functions can be realized only when an intelligent system adapts to the user's needs [3]. If the "intelligent" component remains indifferent to requests, neither feedback processing nor adaptation occurs, leaving the "smart" systems totally unused. Fairly enough, O'Grady and O'Hara point out that there are no single guidelines for creating a "smart" city, or its universal definition [4].

The term "smart city" was coined in the 1990s when information and communication technologies (hereinafter ICT or IT) gained popularity and entered the era of active growth in terms of a more modern urban infrastructure [5]. One of the first papers about the concept of "smart cities" was presented by the California Institute of Smart Communities. Back then, the concept assumed that societies could go "smart" if the city was designed via a tech-savvy approach [6]. Technologically speaking, a "smart" city is one that has a large number of information and communication technologies implemented in vital infrastructure services and systems [7].

Throughout its evolution, the "smart" city concept has significantly expanded its boundaries, from being restricted to ICT and management to actually prioritizing human and social needs [8]. What is more, this focus on the "human" factor is immersed in management to such an extent, that human relations and social capital are currently becoming critical for the systems of urban development [9]. In its turn, this shift has contributed to the perception of management as a fragmented and decentralized process.

While the urban planning system considers the term "smart" city as an institutional aspect, where the "smart approach" entails establishing a city development strategy. Governments and state bodies at all levels use the term "smart" to emphasize their eagerness to ensure the principles of sustainable development, integrated economic growth, rising living standards, and the overall happiness of their citizens [10]. While state programs that are not given the "smart" label are commonly more narrowly focused and imply obtaining limited effects of the same type. Another noteworthy fact is that theoretical papers on the development of "smart" cities highlight the need to address residents directly with an aim to obtain their feedback and ideas on the changes that should alter the city. According to the proponents of this approach, analysis of public opinion stands to improve the living standards [11].

The observed variety of interpretations allows introducing a certain number of generalizations. "Smart" city is a concept that is scientifically considered regarding technologies (advanced methods and services); human capital (people are able to create and use services and technologies); management and collaboration (people are able to create and use services and technologies to manage for their own benefit).

The Russian scientist Eremeev S.G. has identified a range of deep-rooted disagreements on the concept and shaped them into four types of dichotomies [12]. The first type is associated with the contradictions between the overall technological focus of cities and the holistic strategy of their development. Since this contradiction is based exclusively on the implementation of the ICT, the main beneficiaries (stakeholders) of "smart cities" are represented only by the IT companies, thereby shaping closed models of cooperation. In this regard, it makes more sense to interpret the "smart city" as a complex social and technological system, where technological development is consistent with human, social, cultural, economic, and environmental improvements. Such an approach to the concept turns out to be more holistic due to its focus on ordinary people and expanding their opportunities to participate in smart urban development and management [13].

But that is where the second deeply-entrenched contradiction becomes visible - how many key actors should be there? Apparently, business ranks first among the most active stakeholders, followed by the government and authorities. A number of approaches concentrate only on these interactions, considering them the basis of the "smart" concept. Some other studies additionally include scientific organizations to the system (triple helix) [14]. And yet again, in most cases, the civil organizations and residents are the least active actors in the implementation of "smart city" principles. However, this fact should not be attributed to the passive attitude, but to their insufficient integration into the shared ecosystem. While a comprehensive vision of smart cities involves efforts to include citizens in the processes of regulating the city.

Social indicators	Economic indicators	System indicators
• Light vehicle budget • Availability of retail space • Proportion of Internet sales • Number of inhabitants per practitioner • Housing area per capita • Proportion of late shift students	• Storage space for wholesalers • Proportion of cutting-edge and knowledge-intensive industries in the national GDP • Share of companies using broadband Internet access	• Number of petrol stations per 1000km • Share of regulatory public roads • Level of digitalization in the local telephone network • Number of mobile devices per unit of telephone capacity

Figure 1: Indicators of social and economic development in the Russian Regions [designed by the authors according to the Rosstat data]

A tendency to include the city residents in the management processes forms an upward (decentralized) trend as opposed to a downward (centralized) one. The thought behind this tendency is for the authorities to encourage an open system of cooperation by attracting large groups of people; to provide these bigger communities with a strategic framework in order to direct their effort and to benefit from this collective intelligence and common interest in the development of smart cities [15, 16]. On the contrary, a centralized approach implies strict regulation of every single move or action to maximize the output for business communities via the "hidden agenda". Lobbying systems are a typical example of the centralized model.

3 RESEARCH METHODS

Regions of the Russian Federation differ greatly in terms of their infrastructural development. While large agglomerations exhibit higher levels of social infrastructure, cultural and leisure facilities, and transport accessibility - the situation is often drastically different outside, where the regions either experience a severe lack of social infrastructure, or their system is simply overloaded. Within the indicators considered in this study, the difference in the level of preschool education coverage is triple (30% in Rep. Dagestan and 90% in Rep. Komi), while the share of expenses for mandatory payments ranges from 4% in the Chechen Republic to 28% in the Novosibirsk Region (with the difference of more than 6 times).

Such diversity is the exact reason why this study identifies groups of regions that are more or less similar in the level of their development in the social sphere and digitalization. In order to efficiently manage the process of clustering, 13 indicators were selected to describe the level of infrastructural development in every region (Figure 1).

With the help of the correlation coefficients, the next stage of the research examines whether it is reasonable to apply all the selected indicators together. The correlation coefficient (r) of |0.7| was taken as a criterion to recognize two factors as related. As a result, we have distinguished 13 independent indicators, which do not show any mutual influence.

Further on, in order to bring all the values to a single dimension, the scaling was performed [17], with each value of a particular region divided by the maximum among all the regions selected. Thereby, we have managed to obtain the estimates of the maximum value in Russia represented by either region.

The level of trust (when clustering by the Ward method) determines the diversity of the regions within one group. When the trust level is low, the line moves closer to zero and, thus, more smaller groups of regions appear. Now, when the level of trust is close to zero, these groups break up into a set of 85 separate clusters, where each region makes up an individual cluster. On the other hand, if the level of trust proves to be high, the groups show a more significant inner diversity and internal homogeneity. In this case, quite a limited number of groups can be derived. Throughout this stage, we have identified five groups of regions - clusters.

Then, clustering via the k-means allowed clarifying the composition of clusters and evaluating all 13 variables in each one. What is more, clustering shows that the regions which are typically closer to the center of the cluster are indeed closer to the average variable within the taken cluster as well. This process sets certain benchmarks (reference regions for each type - Table 1) and clarifies the degree of approximation of other regions to this central reference benchmark.

4 RESULTS

It is necessary to consider different scenarios for each cluster when developing digitalization and the knowledge-based economy. Apart from changing the urban environment as it is, information technologies alter the very notion of how the regions can be integrated into the social and economic space. This fact makes even more sense regarding the emergence of digital inequality and disproportions in the development and distribution of new knowledge. Thereby, decent living standards in the regions end up undermined. The basic challenge here is to shape the meaning and purpose of the individual cities, since their lack results in the fact that the cities lose their economic and social potential. Based on these parameters, it is possible to describe each cluster (Figure 2). According to the typical features of each cluster, three development scenarios can be distinguished. It is important to note that each scenario is complementary and allows combining efforts and resources in the development of the cities and entire regions.

Table 1: Main features of clusters with the typical region in the center [designed by the authors according to the Rosstat data]

Typical cluster region	Quantity ofregions	Principal characteristic
Vladimir Region (cluster 1)	22	Regions that proved to be unattractive. The resource base is no longer relevant, consequently, the key competencies are lost. A chance to update the space on the basis of a new technological structure becomes visible.
Chechen Republic and Republic of Ingushetia (cluster 2)	4	Deprived regions with a low level of social and economic development, lack of potential. The regions preserve traditional ways of life, which builds up stability when the whole world is being transformed.
Khabarovsk Krai (cluster 3)	37	Targeted development of the territory is typical of the region. A major part of the region's territory is left outside the social and economic activities.
Kemerovo Region (cluster 4)	20	Regions with a clear vision of the future. Represented by the industrial and resource-producing zones. Resource potential remains relevant at the moment. However, the system of actions for the transition to a new technological order is still not clear, given the chance that its relevance for the existing resource base can be potentially lost.
Moscow and St. Petersburg (cluster 5)	2	Regions-cities. The absence of territories outside agglomerations allows gaining the maximum benefit from the introduction of digital technologies and the knowledge economy itself. At the same time, the territory is usually overwhelmed, which imposes extra risks on the social and economic space. For example, the spreading rate of diseases might, unfortunately, increase.

Scenario conditions for the development of regions in terms of knowledge-based economy

☐ Ability to attract and retain population

☐ Implementation of digital technologies

☐ Ability to shape and develop "knowledge"

☐ Ability to maintain investment appeal

☐ Engagement with global and local agenda

☐ Infrastructure potential

☐ Pace of renovation and modernization at the infrastructure units

Figure 2: Scenario conditions for the development of regions in terms of knowledge-based economy [designed by the authors]

Scenario 1. Potential capacity building

The scenario implies defining an exact core for the development of territories. This so-called core can be represented by technology or even a cultural event, which is a matter of extreme importance because ongoing growth inevitably requires a solid foundation. Engagement with the public is carried out in accordance with cultural and historical background and is based on a set of patriotic and knowledge-related values, especially in education. In its turn, the investment potential relies on federal sources primarily with a long-term planning scheme. Subsequently, the combination of these factors shapes a clear request for infrastructural development, while preserving the limited resources.

Digital technologies serve as a tool for meeting urban challenges and detecting negative trends, thereby preventing numerous social and economic repercussions. To be precise, the main goal of the regions is to distinguish a rational meaning or sense of purpose among the population of each region to help the residents associate themselves with certain cities, therefore reducing their motivation to move. The scenario described above is represented by Cluster 1

and Cluster 2. Such regions should not be deeply integrated into the system of global trends until they develop an internal ecosystem.

Scenario 2. Support of development potential

Currently, these regions demonstrate high investment attractiveness due to the key technological resources they possess. However, during the transition to a new economic model, they are at risk to lose their stability and development potential. Today it is necessary to build up a stable social and economic foundation based on the principles of intensive development within the educational environment, especially in basic education. Another important aspect to consider here is a range of centralized educational tracks that must be formed in accordance with the strategic goals and state requests. Yet another goal is to preserve the existing technological competencies with their economic potential to be adapted to new challenges. A comprehensive transition to the new technological structure depends on the level of knowledge accumulation in the regions. The urban environment follows two key vectors, primarily focusing on the preservation of historical heritage. The second vector provides the basis for the infrastructural development and relies on shaping and meeting the needs of the population, and creating conditions of additional comfort and leisure. This scenario proves to be implementable in Cluster 4 and Cluster 3. The regions are already tightly integrated into the global agenda, which consequently boosts their ability to identify fluctuations in trends and quickly respond to change.

Scenario 3 Diversification of development potential

This scenario covers the regions that demonstrate a severe stratification in terms of social and economic development. First of all, they require the alignment of the existing imbalance, which is only possible on the basis of digital technologies and non-standard solutions. Although at a bigger scale the problems in the regions of this type seem similar, they may demonstrate different approaches on how to meet geographical and administrative challenges. It is important to find centers of activity outside the core region, where the advantages are not related to the existing center of investment attraction. The state support is largely aimed at the most vulnerable groups and is built on protectionist principles, which means the regions do interact with global markets, but still have their internal development preferences. At the same time, implementation of risky investment strategies with the possibility of applying special regimes, such as PSEDA, free trade area, or SEZ, attracts the local population [18].

5   DISCUSSION

Global changes of early 2020 will certainly lead to the transformation of consumer behavior and the thinking behind building business processes, thus altering the requirement for the urban environment. It is necessary to identify the main factors influencing this transformation in the regions of Russia. The core requirements include infrastructure security, state regulation, social security, localization of production and consumption; changes in the consumption patterns. These factors are examined in more detail below.

Infrastructure security. The presence or absence of infrastructure facilities allows regions and cities to build various models of the urban transformation and the behavior of residents. Clearly enough, the infrastructure facilities are rather diverse. Social and

economic infrastructure are the types that are commonly distinguished. Provision of the first is based on the need to meet the state interests [19].

Nonetheless, hospitals, kindergartens, social agencies, etc. are mostly not able to generate sufficient profit to benefit the business community. While in their absence, the expenses turn out to be many times higher than the cost of creating and operating such facilities. This is why the state actively encourages businesses to cooperate and create social infrastructure within the public-private partnership mechanisms (PPP). Thereby, the efficiency of such facilities increases, together with their ability to attract private investment. At the same time, the state is still responsible for the main financial burden in terms of ensuring that the system functions properly [21, 22].

Among other things, the economic infrastructure is required to meet the needs of businesses, due to the fact that it is the main factor in building business models and reducing costs for consumers. Development of such infrastructure cannot completely shift to the private sector, since all the involved agents also have their own social effects [23, 24]. For instance, the state can encourage business communities to work in less favorable conditions in order to increase comfort for citizens (e.g. opening shops or providing household services in small settlements).

In addition, the economic infrastructure can generate income, and, therefore, presents interest for investments from the business. In order to contribute the state can stimulate private initiative by creating favorable conditions for doing business in the infrastructure industries.

State regulation. In times of crisis, the role of the state increases significantly, primarily due to the necessity to control the budget expenditures. By determining directions for the allocation of funds, the state not only forms the development paths for individual industries, but also creates effective demand in cities. Another important aspect is the income of citizens employed in the public sector since the state represents the largest employer in the country. Responsibility of the state in terms of salary increases, benefits packages, etc. can become the basis for maintaining the existing consumer demand or increasing it in certain industries.

However, the new reality will require a more flexible and adaptive management system from the country's leadership. The present day dictates the need to revise the measures of state control in many industries (e.g. reduction or complete abolition of outdated standards and regulations), to switch to the individual tracks of entrepreneurial control and develop additional business support measures, etc.

The state authorities take on great responsibility by offering ready-made solutions to cities.

Social security. In turbulent times state support becomes indispensable. Implementation of the social security measures not only addresses support of the population to preserve their wellbeing but also focuses on the targeted stimulation of consumption, including preferential mortgage lending, maternity capital, Far East mortgage, etc.).

By increasing the number of social guarantees, the state creates a minimum consumer demand and thereby regulates the entire markets of goods and services. Gender and age composition becomes

essential in terms of building consumer models in the regions. Different age groups are entitled to different amounts of state support. Thus, the elderly population receives pensions based on the parameters of their work activity, while the child benefits are less dependent on the previous income of parents [25, 26].

Nonetheless, the latter tend to demonstrate higher consumer activity, due to their constantly growing needs, while the retired people have a more limited, yet stable consumer basket.

Localization of production and consumption. The international division of labor as an opportunity to obtain additional profit by reducing production costs has proved to be rather a flawed system in the pandemic.

Closed borders partially stopped the transfer of goods between the countries, especially during the sharp increase in morbidity. As a result, it has led to the need to restore production chains within individual countries, regions, and even cities. First of all, this is relevant for the essentials that are consistently demanded.

Reducing the marginalization of some businesses will require the large players to build vertically integrated business processes that will imply working directly with the consumer of products or services. Thereby, a number of intermediaries will be eliminated and the existing marketing strategies and retail sales concepts will be revised for mutual benefit.

Consumer behavior has also undergone changes, with the local goods gaining consumer loyalty, due to the greater transparency of their quality and the production process itself. Thanks to this system, small local manufacturers have a chance to compete with the network brands.

Changing consumption patterns. The existing consumption patterns are largely based on trends typical of the world community, including globalization, digitalization, and the transition to goods with a limited period of preferred consumption.

It is worth noting that the growth of consumption in such a model is triggered by availability (the consumer's ability to purchase a particular product), which means there is a need for constant cost reduction, especially for transactions. Consequently, the manufacturers need to organize retail outlets using the models of shopping malls. That implies high traffic, which enables manufacturers to sell goods and services with the maximum profit.

Another room for improvement is digital commerce, and, consequently, the entire delivery system. Growing comfort, transparency (security), verifiability, and speed of receiving goods and services result in more people using online shopping to meet most of their needs. What is more, the pandemic will certainly introduce a number of changes in the current system, primarily due to the measures of social distance. Currently, mass gatherings are becoming unacceptable both for the state, and individuals due to the risks of disease outbreaks and social fears of falling ill.

As a result, the established behavioral patterns of the population transform, and now most people tend to limit contact with strangers, switching either to online shopping (still a fairly large sector of goods and services is not adapted to be sold remotely), or to offline shopping in the smaller local shops and outlets.

The above-mentioned fears and risks increase the costs of verifying goods and services, which means that generally, consumers tend to show more loyalty to manufacturers and service providers they are already familiar with.

6 CONCLUSION

The introduction of digital technologies is no longer a matter that can be neglected or prioritized by the authorities. It has immersed in the system of public administration to such an extent that there is no other way but to use its effectiveness as a competitive advantage of the region. In the struggle for investors at the regional level, success is defined by the ability to apply the potential of digitalization, which determines the speed for investors to access the required infrastructure and start their commercial activities [20].

The Ministry of Digital Development, Communications, and Mass Communications of the Russian Federation recognizes the problem of a rather weak elaboration of the legislative framework. The most urgent challenge they face in this regard is bringing the interests of society, business, and state together. For example, in order to introduce the system of digital signatures full-scale, certification centers need to be rehabilitated. Thereby, the population and business will be safe from unscrupulous service providers, still keeping the market competitive and protecting it from monopolization.

Leaving the regions to make their own decisions, the government provokes digital inequality and the emergence of duplicate solutions, with no unified approach to manage unique regional activities. For instance, services that are incompatible in terms of their quality and functions may be implemented in healthcare, when one clinic uses a set of software tools that are not used by another. This results in a range of daunting steps a person needs to take in order to have their medical record transferred in case of relocation.

Such a simple example brings the whole system to the necessity to alter the existing digital strategies towards greater centralization. In order to do that, it is necessary to develop a common federal understanding of the ways to develop specific spheres of life, including the definition of technologies, forms of the service provision, and even a list of supplier companies.

The scrutinized approach of that kind can create an incentive for the development of most regions in the country, especially at the start of the whole-scale digitalization. Undoubtedly, it does not mean that the technologically successful regions of today will have to adopt unified solutions. An individual approach may be tailored if the region possesses free resources and is in line with the principles of digitalization accepted in the Russian Federation.

Overall, the need for more active participation of the state in the digital development of the country proves to be apparent. All measures taken by the relevant Ministry and, generally, the implementation of the "Digital Economy" project depends on the development of a conceptual block. Here comes the question yet to be answered: what does the government aim to achieve in terms of digital development?

The disadvantages of digitalization, though accompanied by a vast set of benefits, are still available. For instance, it is essential to prioritize such issues as job cuts and the professional training of state workers. Otherwise, the government officials are bound to express their concerns over the comprehensive nature of the conducted work.

Another important area for improvement is represented by a unified digital environment. Unlike such platforms as Gosuslugi (Public Services) or Nalogi (Taxes Control Service) which have already been implemented, there are still more than two thousand

websites of city administrations, hospitals, schools, kindergartens, and other state institutions that are yet to develop and update their digital services. When improved, the wider digital coverage will ensure equal quality of services throughout the country. Fortunately, in 2019 the Ministry of Digital Development, Communications and Mass Media of the Russian Federation launched a pilot project in five regions to implement the state web system and develop website standards within four categories: local governments, schools, hospitals, and kindergartens.

In this regard, all the incorporated digital solutions are expected to enhance comfort, which does not necessarily mean an overwhelming set of tools, but high quality and an idea behind their use.

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