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SMART CITY FINANSING: OPPORTUNITIES AND PROSPECTS

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Abstract
The development of smart cities is a global trend. However, the implementation of smart projects requires significant resources. In global practice, cities are searching for and developing new mechanisms to attract funds. The purpose of this article is to study and systematize the financial opportunities for implementing the concept of successful smart city functioning. The article uses the method of systemic-structural analysis to systematize the entire set of financial opportunities for the implementation of smart city projects. A comparative analysis of the implementation of various projects has made it possible to illustrate the successful experience of smart cities. The main result of the article is the proposed system of financial resources for a smart city. This system is important both in a theoretical and practical context. It can be useful both in the practice of individual cities and for further research in this area.

Keywords: *Smart City, Funding, Smart Projects, Crowdfunding, Green Bonds.*
JEL Codes: *G28, H54, H72, O16, O18, P25, P34.*

Introduction

A global development trend is the desire of cities and countries to become more sustainable, smarter, and more friendly to nature. The growth of the urban population poses new challenges for governments, such as the organization of urban life, traffic complications, problems with energy supply, environmental pollution, security, etc. Smart technologies can help solve these problems. The development of technologies such as the Internet of Things (IoT), Big Data, Artificial Intelligence, and sensors allows cities to manage infrastructure and services more efficiently. Moreover, smart technologies are helping modern cities to be more environmentally friendly, as they make it possible to monitor and reduce pollutant emissions, manage waste, and reduce resource consumption. People are becoming increasingly demanding of the quality of services and convenience of life, and the latest technologies facilitate access to various services, increase comfort and safety. This is becoming an integral part of modern urban life. Local authorities are increasingly trying to implement policies aimed at implementing smart solutions in cities, which requires funding and support for relevant projects. Thus, smart cities are the result of the spread of technology to create more efficient, environmentally friendly and livable urban environments.

The number of smart cities in the world is growing rapidly. Each city is building its own path to a smart city, defining goals, prioritizing them, prioritizing them, and setting up tools to achieve them. Investments in smart technologies can bring economic benefits, in particular by increasing the efficiency of municipal services, reducing energy costs, and improving the quality of life of citizens.

At the same time, a certain challenge for the city is the need to find and attract additional financial resources needed to smarten its operations. The city's current revenues may not be enough to finance the installation of sensors, the introduction of platforms for digital solutions, the implementation of green projects, etc. Therefore, innovations are coming to the field of finance. New mechanisms are being developed that allow cities to raise funds for smart projects.

Literature Review

Various aspects of smart cities are extremely relevant in modern scientific research. The emergence of the phenomenon of smart cities, their main characteristics have been the subject of research by J. Bruneckiene, J. Sinikienė (Bruneckiene, 2014); V. Kumar (Kumar, 2017), L. Galperina (Galperina, 2016); R. Giffinger (Giffinger, 2019) and others. The problems of success of smart cities and key factors of their success are studied by M. Angelidou (Angelidou, 2017); P. Lombardi, et al. D. Orejon-Sanchez, et al. Carboni (Carboni, 2024); H. Tekin & I. Dikmen (Tekin, 2024), S.M. Sureshchandra, et al. The issue of applying the latest digital technologies in the implementation of the smart city concept (artificial intelligence and its capabilities, volumes and dynamics of costs, development of various areas of their use, etc.) These problems are studied in the works of A. Greenfield (Greenfield, 2019), R. Novotny, R. Kuchta, J. Kadlec (Novotny, 2014). S. Roche et al. (Roche, 2024), R. Giffinger (Benchmarking, 2021), P. Lombardi (Lombardi, 2012), T. Nam and T. A. Pardo (Nam, 2011), I. Kalenyuk (Kalenyuk, 2022), A. Pleshkanovska (Pleshkanovska, 2021), A. Pozdniakova (Pozdniakova, 2017; Pozdniakova, 2019).

The advanced technologies are also coming to the field of finance, which has led to the emergence of the fintech phenomenon and, accordingly, has led to an increase in interest in it in the scientific community: C. Haddad (Haddad, 2019), R. Hasan (Hasan, 2023), Z. Jourdan (Jourdan, 2023), R. Teeluck (Teeluck, 2021) and many others. The following different aspects of fintech are also being studied: the relationship between fintech and sustainable development (E. Battisti (Battisti, 2023), F. Campanella (Campanella, 2023), X. Deng (Deng, 2019), C. Vergara (Vergara, 2021), D. Wang (Wang, 2022)); the emergence of green finance is studied by V. Bruhl (Brühl, 2022), M. Dell'Ebra (Dell'Erba, 2021), P. Ozili (Ozili, 2022); features of Fintech application in the field of lending, investments, crowdfunding - A. Böckel (Böckel, 2021), S. Claessens (Claessens, 2018), G. Cornelly (Cornelly, 2021), V. Kaartemo (Kaartemo, 2017), Y. Sybirianska (Sybirianska, 2018).

Modern financial technologies bring certain advantages, allowing to accumulate significant funds for the implementation of infrastructure projects, including sustainable or green projects, and reduce risks for investors. That is why they are also used in the practice of smart cities, which is studied by A. Banerjee (Banerjee, 2020). The opportunities and threats of using digital twins in the practice of smart cities are studied by I. Vasiliu-Feltes (Vasiliu-Feltes, 2023), the possibilities of blockchain technologies are explored in the article by R. Teeluck (Teeluck, 2021). At the same time, the issues of a comprehensive study of the peculiarities of smart city finance: opportunities to attract financial resources, their capitalization, features of use, and successful implementation of various projects require further in-depth study. In fact, this article is devoted to these issues.

The purpose of the article is to systematize and identify the most effective financial opportunities for implementing the concept of smart cities.

Methodology

The article uses the method of system-structural analysis to systematize the practice of global smart cities in financing smart projects. The modern forms of attracting financial resources through crowdfunding platforms, issuing green bonds, etc. are investigated and disclosed. The prevalence of green and climate goals in bond issuance is proved using graphical visualization. A comparative analysis of the implementation of various projects allowed us to visualize the successful experience of smart city development.

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The entire set of financial opportunities for implementing smart city projects is systematized into four main groups.

Research Results

Implementation of the smart city concept requires more resources to finance both traditional sectors (technological infrastructure, transport, environment, social services, security, etc.) and smart solutions and projects in these areas. In today's environment, the possibilities of attracting financial resources are significantly expanding and diversifying. The city's financial basket can be formed according to the following formula:

$$F = \sum (F_l + F_g + F_{int} + F_{inn}), \quad (1)$$

were

F_l – local budget funds,

F_g – central government funds (targeted programs, subsidies, etc.),

F_{int} – funds from international funds and programs,

F_{inn} – funds raised through financial innovations.

The first component of Fl is the local budget's own funds. The resource capacities of cities are very different, as they vary in size, income, population, etc. The location of the city is important, as it can either provide certain competitive advantages or, conversely, be in an unfavorable or depressed region. Nevertheless, any city has its own specific opportunities for implementing smart city projects. Sources of local budget revenues can include a variety of taxes and fees: income, real estate, entertainment, advertising, tourist fees, etc.

Cities can start their journey in this direction with different projects, but the key aspects of a smart city are necessarily the following: communication infrastructure; transportation management systems; energy efficiency; security and monitoring systems; and electronic service management. Local authorities can also apply to banking institutions for loans for specific projects, which can be short-, medium-, and long-term.

The second source of funding for smart projects is the central government's resources - F_g. They can be in the form of targeted grants, subsidies for specific purposes. It can also be funding under large national programs. For example, digital transformation or digitalization programs, smart city programs, greening programs, and many others. For example, the U.S. Department of Energy is implementing a strategy to ensure equal access to energy-saving technologies and promote the achievement of national climate goals, in particular, the Energy Efficiency and Conservation Block Grant (EECBG) program, under which in August 2024 it announced the allocation of $12.62 million for 32 local governments in two states and one tribe. These funds are intended to improve energy efficiency, reduce greenhouse gas emissions, and reduce overall energy consumption in low-income communities (Biden).

Another example is the US Department of Transportation's Charging Station and Fueling Infrastructure Grant Program. Through this program, New York City intends to build the largest municipal roadside charging program for electric vehicles (EVs) in the United States, thanks to a $15 million federal grant. The initiative will install an additional 600 Level 2 chargers across the city, with a special focus on disadvantaged and low-income neighborhoods. The city also plans to install 32 solar-powered charging ports in New York City parks (NYC).

International resources can also help cities in their quest for smartization - F_{int}. Many international foundations and institutions also implement programs in the context of sustainable and smart development. They can also provide targeted grants to cities. Quite often, these resources become an important impetus not only to support cities, but also to further advance them in the implementation of large-scale smart projects.

The EU provides significant support to cities from its funds. For example, the European Commission is currently implementing several key initiatives to support cities through joint international resources. However, despite these

opportunities, it is far from easy for cities (especially small ones) to receive such funding. The main obstacle is the overly opaque and complex regime of EU financial instruments (Towards).

In the EU, much attention is paid to cities and urban development, urban air quality, circular economy, climate change adaptation, digital, green and energy transition in cities, housing, sustainable land use and nature-based solutions in cities, and many others.

In 2016, the UN adopted The New Urban Agenda, a paradigm shift based on urban science. The document sets out standards and principles for the planning, construction, development, management and improvement of urban areas in five main areas of implementation: national urban policy, urban legislation and regulations, urban planning and design, local economy and municipal finance, and local implementation (New Urban). On this basis, The Urban Agenda for the EU works in the EU, which aims to provide: better regulation, better financing and better knowledge for cities (The Urban Agenda). The use of technology to improve urban governance can help achieve three EU priorities: "Green Deal, focusing on digital technologies and a people-centered economy (the Green Deal, a focus on digital technology, and an economy that benefits people).

Important initiatives are underway and opportunities for funding have been created. Thus, the Smart Cities Marketplace platform was created (by merging two previous platforms: "The European Innovation Partnership for Smart Cities and Communities Marketplace (EIP-SCC Marketplace) and the Smart Cities Information System (SCIS)). This large project aims to bring together cities, industries, small and medium-sized enterprises, investors, banks, researchers, and many other smart city market participants. In total, about 130 projects with financing opportunities worth more than EUR 615 million in private investment have been identified (Smart cities).

Since 2008, the Covenant of Mayors on Climate and Energy has been operating to unite local and regional authorities in implementing the EU's climate and energy goals on their territory. It is a bottom-up initiative that unites local governments in their efforts to meet and exceed the EU's climate and energy targets (City initiatives).

The European Horizon program also attaches great importance to urban development. By 2020, the total amount of Horizon 2020 funding allocated to Lighthouse projects amounted to 381 million euros. The cost of the supported projects, including co-financing, is 446 million euros. Forty-eight beacon cities, 72 twin cities, and 515 other partners have participated or continue to participate in 18 Lighthouse projects. Participating cities are located in 24 EU member states, except for Cyprus, Lithuania and Luxembourg. In the period 2014-2020, the Commission led or supported more than 50 initiatives, including funding instruments and support measures, directly or indirectly related to urban development (Smart cities Tangible).

Beyond 2020, the flagship initiative is the Horizon Europe Mission on Climate-Neutral and Smart Cities (the "Mission"), which aims to create 100 climate-neutral cities by 2030 and ensure that all EU cities follow suit by 2050. In April 2022, the Commission selected 100 cities from EU Member States and 12 cities from countries associated with the Horizon Europe program to participate in the Mission ("Mission Cities"). Of these, 51 cities are participating in Lighthouse projects.

In total, the European Regional Development Fund will allocate 15 billion euros over the period from 2014 to 2020 directly to comprehensive sustainable urban development strategies. About 900 cities across the EU will be able to implement these strategies (City initiatives).

Public and research organizations can be involved in attracting international funds. One such example is the creation of the FinEst Smart Cities Center, an international research and development center based on researchers and developers from Tallinn University of Technology (Estonia) and Aalto University (Finland). FinEst Center is an independent organization at Tallinn University of Technology (TalTech), founded in 2019 by TalTech, Aalto University, Forum Virium Helsinki and the Estonian Ministry of Economic Affairs and Communications. During this time and until 2027, 17 projects on security, circular economy, urban air mobility and urban biodiversity will be

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implemented, with an investment of more than EUR 15+ million, mainly funded by the European Commission (FinEst). Examples of such projects are: METACITIES Connecting cities across the Baltic Sea (500 000 EUR); MAPIT project (Mobilizing Advanced Partnerships for Digital Innovation and Transformation) (1 159 062.50 EUR); FINEX (999 995,32 EUR); FINEST SCALEUP project (999 968,76 EUR EUR); PLIADES (9.8M EUR) and others (17 projects).

And finally, the fourth source of financing for smart cities is increasingly becoming the attraction of funds through financial innovations - F_{inn}. The following instruments can be considered as financial innovations:

- Partnerships with the private sector, academic and research institutions, and civil society organizations; formation of municipal pools of financing (Municipal Pooled Financing), usually used for large infrastructure projects;
- Crowdfunding, i.e. raising money from a wide range of entities through crowdfunding platforms;
- Investment instruments (green bonds, etc.).

Various projects are being implemented by city governments and private companies, creating new forms of financing. For example, a public-private partnership model without the use of budgetary funds is being implemented in Astana (Kazakhstan), where a hardware and software package for photo and video recording and video analytics through the use of video surveillance has been introduced. The project is provided by a private company and is aimed at improving the safety of living and creating a safe community (Akildi).

Another model is used through collaborative innovation by representatives of the public, business structures, and active involvement of citizens. This can be implemented to shape the direction of regulatory changes, technological solutions, and the provision of administrative services. Financing smart projects is often complex and involves a large number of players or investors, each of whom may be interested in implementing their part of the project. For example, in Colombia, representatives of all sectors are involved in the formation of the green bond market, including the development of smart city projects: the real economy, the financial sector, government representatives of various levels, from national to local (Road map).

Innovative forms of financing include digital platforms for crowdfunding and crowdinvesting. Fintech platforms such as Kickstarter, GoFundMe, and others allow cities to raise funds from citizens for local smart projects, such as creating green areas, installing smart lights, or developing infrastructure for electric transport. Through digital platforms such as Fundrise, citizens can invest small amounts in large-scale urban projects and receive a share of their revenues. This makes it possible to raise funds for the development of smart city infrastructure without resorting to traditional sources of funding.

One of the successful examples of crowdfunding is the Peckham Coal Line project in London, which raised 75 thousand pounds to transform an old railroad line into a public park (The Peckham). A separate crowdfunding platform, Spacehive, is used to finance a number of urban initiatives, including the creation of public spaces, green areas, cultural facilities, energy efficiency, etc. In total, this platform has raised more than 30 million pounds (The home). In New York City, the crowdfunding platform Kickstarter has raised more than $150 thousand for the formation of an underground park in the Lower East Side neighborhood (LowLine). In addition, crowdfunding has been used to finance the installation of public bicycle stations and the development or expansion of green areas.

Innovative financial instruments include green bonds, which are actively used in many cities (Toronto, Cape Town, San Francisco, etc.) to finance climate goals (What). The practice of using municipal green bonds (MGBs) allows a municipal government to raise certain funds from investors. These bonds provide for interest payments at an agreed fixed rate with a fixed maturity. The

peculiarity of their use is the formation of a package of financial resources aimed at environmental or "green" projects, such as energy efficiency, renewable energy sources, carbon emission reduction, etc. (Suzuki, 2020).

A study of the structure of different types of bonds issued by different issuers shows that this instrument is popular (Figure 1).

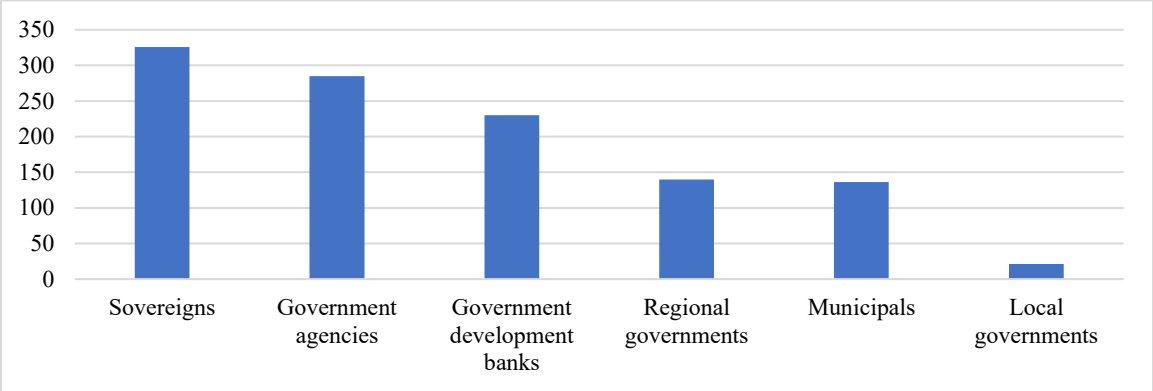

Figure 1. Public sector issuance by type of institution, USD Bn 2022 (Green, Social, 2023)

It is worth noting that the structure of such bonds indicates the predominance of green bonds in municipal issuance. At the same time, green bonds and sustainability bonds have approximately equal shares in the structure of regional level issuance. Government agencies focus on social bonds. In general, according to the World Bank, these institutions account for about 30% of the total green bond market, which is USD 1.1 trillion. The public sector issues 61% of green bonds from the total number of bonds (Green, Social, 2023).

In Toronto, for example, the city government is using green bonds with the ambitious goal of achieving zero net greenhouse gas emissions by 2040. The city uses the proceeds from green bonds to finance relevant projects, including increasing renewable energy generation capacity, energy efficiency projects, green building, green infrastructure, etc. Approximately USD 1 billion has been raised in this way.

This program began its development in 2018, when green bonds worth CAD 300 million were issued, with a fixed yield of 3.21% and maturity in 2048. The proceeds from this project were used to upgrade the subway and electric rail infrastructure, including the Scarborough subway, restore Union Station, and improve the energy efficiency of Leslie Barns (City of Toronto). In 2019, the City of Toronto issued CAD 200 million worth of green bonds with a price of 2.646% and maturity in 2039. The resources were used to finance energy efficiency projects, modernization of urban lighting, flood protection systems in port lands, bicycle infrastructure, electric railways, solar energy projects, photovoltaic projects, etc. Financing of these projects was continued with funds raised in 2020 - CAD 130 million at 2.14% maturing in 2039. In 2021, green bonds in the amount of CAD 150 million at 2.238% and maturing in 2031 raised funds that were used to develop the Dufferin organic processing plant and purchase electric buses for the TTC and upgrade the electric rail support infrastructure (City of Toronto). In 2022, the funds raised were used to develop bicycle infrastructure, bridges and tunnels, the electrical system, subways and traction power, and bonds were sold for CAD 300 million (4.419% until 2042) (City of Toronto).

Another city that actively uses green bonds to promote urban development and implement smart projects is Cape Town, South Africa. The bonds were issued in the second half of the 2010s and the funds raised were used for water management projects and the development of low-carbon transportation (City of Cape Town). In 2017, the city issued bonds worth USD 77.2 million. The purpose of the investment was to increase energy

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efficiency, reduce emissions by 13%, and increase the share of energy from renewable energy sources to 10% (CBI).

San Francisco actively uses green bonds, where they understand that the transition to a low-carbon economy will lead to a 4.5% increase in costs compared to business as usual. However, the implementation of this project will lead to more co-benefits that will have long-term positive effects (What). San Francisco has been using green bonds since 2015, which allowed it to raise funds to repair the Mountain Tunnel, which is part of the Hetch Hetchy regional water system (Green bond).

It is worth noting that green bonds for urban projects are issued not only by municipalities but also by private companies that offer solutions to various city problems, and the proceeds from such bonds are used to implement environmental projects in the city. For example, in Hong Kong, Mass Transit Railway (MTR) is quite active in the green bond market, which allowed the railway operator to raise funds for the construction of energy-efficient stations and subway lines, reduction of water consumption, etc. According to the company's report, these goals were partially achieved by 2023 (Keep). Thus, the company has reduced the level of harmful emissions since 2019, water consumption, and partially electricity consumption per kilometer (Performance).

Discussion And Conclusions

Digital technologies significantly expand the possibilities for organizing urban life on the basis of sustainability and environmental friendliness. The widespread introduction of ICTs allows for the creation of a comfortable, safe, and environmentally friendly city. Although different cities use them with different intensity and dynamics, this trend is undeniable around the world and in all cities.

When starting its journey to a smart city, each city can choose a different strategy. A city can choose an ambitious breakthrough strategy based on breakthrough innovations. Or it can take small steps, gradually implementing various smart city projects. In any case, each city needs to clearly understand its financial capabilities and have calculations of the possible use of other, newer forms of raising funds. The system of smart city financial resources presented in this article can be useful both in the practice of individual cities and for further research in this area. The advantages of the latest forms of attracting financial resources are undoubted. At the same time, it is also important to study different experiences, possible negative results, failures, and their causes. A major challenge for the functioning of smart cities and the spread of ICT is the regulation of cybersecurity issues and their combination with privacy rights.

Nevertheless, despite possible threats and negative phenomena, the phenomenon of smart cities is developing and spreading. It is these smart forms of organizing urban life that will continue to develop in the future. And it is only in our power to do this consistently and with the least losses.

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