38

Мшвідобадзе Т. ПРЯМИЙ ВПЛИВ ІСТ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ МІСТ ШЛЯХОМ ДЕМОНСТРАЦІЇ ...

Tinatin Mshvidobadze
PhD (Technical Sciences), Associate Professor
Gori State University,
53, Chavchavadze Avenue, Gori, 1400, Georgia
tinikomshvidobadze@gmail.com
https://orcid.org/0000-0003-3721-9252

DIRECT IMPACT OF ICT ON URBAN ECONOMIC GROWTH BY DEMONSTRATING AGENT-BASED MODELING FOR SMART CITIES

Abstract. A smart city is considered a city in which the infrastructure is coordinated and integrated using new digital technologies. We consider scenarios, based on the transition from old cities to new emerging smart cities, with the development of urban services using modern ICT. Several project areas are proposed: integrated databases, sensor networks and the impact of new social media, mobility and travel behavior, urban land use modeling, transport and economic interactions and planning structures for smart cities. The FuturICT project discussed in the paper was implemented within the framework of the European Union's Seventh Framework Program under grant agreement No. 284709. We consider a stylized agent-based model where heterogeneous decision-making agents interact under the following scenarios: improved urban. The paper assesses the positive impact of transport by using the example of the Baltic Sea countries' economies against the background of an analysis of key indicators measuring the success of the transport sector. It is noteworthy that any combination of these scenarios leads to higher population density and allows for the spread of creativity, which is a prerequisite for smart city transformation and economic growth. The results show clear correlations between rapid economic progress and socio-economic equality.

Keywords: *Smart cities, Urban, Transport Services, ICT, FuturICT, Agent-Based Modeling.*
JEL Classification: O1; R1; D8; A13.

In cites: Mshvidobadze, T. (2025). Direct impact of ICT on urban economic growth by demonstrating agent-based modeling for smart cities. *Social Economics, 69*, 38-44. doi: https://doi.org/10.26565/2524-2547-2025-69-03

Introduction. The concept of the smart city has emerged over the past decade as a convergence of ideas about how information and communication technologies can improve the functioning of cities, providing new ways to address problems of social deprivation (Harison, 2015).

Some of the most prosperous cities in the world, such as London and New York, are also leading centers of human creativity and innovation. They provide opportunities for economic and social integration and universal access to basic urban services[1] (UN-Habitat, 2020).

The task of the paper is to show smart cities, using the example of the FuturICT project, not only from their instrumental perspective, which is the domain of ICT companies, but also from the perspective of how this tool opens up radically different forms of social organization.

The aim of the paper is to demonstrate the effectiveness of implementing a tool for studying dynamic socio-economic processes in urban environments.

The objective of this paper is to demonstrate an intelligent platform based on a modeling approach and highlight the main advantages offered by ABMs for improving the understanding of dynamic socio-economic processes in cities. A series of different experiments are considered to better understand the relationship between model parameters. The results demonstrate the effectiveness of the model.

The FuturICT project focuses on

---

1 World Cities Report 2020. The Value of Sustainable Urbanization. 2020. URL: https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf (дата звернення: 12.01.2025).

Mshvidobadze T. DIRECT IMPACT OF ICT ON URBAN ECONOMIC GROWTH BY DEMONSTRATING....

39

identifying critical problems that arise rapidly and unexpectedly in society, some of which expose critical infrastructure.

The task of the paper is to describe urban simulation portfolios that reflect future design. As real-time city sensing and perception become increasingly capable of providing information about long-term

costs and with minimal transport processes. (Jiang, 2012).

According to Nielsen, new models of scientific discovery are emerging from the development of highly focused crowdsourcing, and they are being used to explore how we can design good cities for efficient cities. (Nielsen, 2019).

```
import jpype
import pkg_resources
import logging
_logger = logging.getLogger(__name__)
def start_jvm(jvm_path=jpype.get_default_jvm_path(),
        *additional_classpath):
  if not pkg_resources.resource_exists('javaresources', 'python-matsim-instance-1.0-
SNAPSHOT-jar-with-dependencies.jar'):
      raise RuntimeError('could not find jar file')
  if jpype.isJVMStarted():
      # TODO: check that classpath etc. are the ones we want
      _logger.info("JVM is already live, do nothing.")
      return
  python_matsim_jar = pkg_resources.resource_filename('javaresources', 'python-matsim-
instance-1.0-SNAPSHOT-jar-with-dependencies.jar')
  jpype.addClassPath(python_matsim_jar)
  for jar in additional_classpath:
    jpype.addClassPath(jar)
  _logger.info('start jvm with classpath {}'.format(jpype.getClassPath()))
  jpype.startJVM(jvm_path, "-Djava.class.path=%s" % jpype.getClassPath(),
convertStrings=False)
```

Fig. 1. Structure of MATSim's input population Python file

changes, new immediacy will emerge in the construction of urban simulation models. (Meijer et al., 2015).

Literature Review. Transportation plays a crucial role in the economy in delivering goods and services to consumers, as well as in transporting passengers to work or for pleasure.

A modern society can only function effectively with an efficient transport and logistics system (Baublys, 2019). Therefore, every year larger and larger investments are spent on maintaining and improving the transport system in the European Union for the benefit of passengers and freight.

With the internal market, the volume of freight has increased significantly over the last few decades and continues to grow throughout Europe. The main task of transport decision-makers is to ensure further efficient transport services in order to maximize the contribution to economic development.

According to Jiang, it is important to implement certain transport policy instruments, the main of which is the mobility of goods and people, ensured at minimal

We present much more effective models and simulations that address problems of efficiency, equity and quality of life. Where broad groups of citizens can engage in the construction of smart cities, through new ways of participating in the future design of their cities and neighborhoods. (Aurigi, 2016).

Agent-based models (ABMs) offer an alternative to conventional urban and regional modeling tools. They allow us to shift the focus from static macro models to dynamic micro-scales (Batty, 2015). According to Grimm et al, a stylized virtual abstraction of a theoretical city is created, containing autonomous interacting agents in different scenarios, to gain insight into the functioning of dynamic urban systems. (Grimm et al., 2020).

Research Methodology. Over the past 50 years, various simulation models have been developed at different spatial scales.

These models have been mainly focused on simulating the location of physical activities, although there is an economic and demographic lens that allows for the prediction of material transport and use using various types of computer models.

40

Мшвідобадзе Т. ПРЯМИЙ ВПЛИВ ІСТ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ МІСТ ШЛЯХОМ ДЕМОНСТРАЦІЇ ...

According to Braille, such models are used in a somewhat intuitive dialogue with policymakers in the context of what are now called planning support systems (Braille, 2020).

According to Pagliara, this type of model structure, such as MATSim and Simulacra, already exists in many agent-based models for city sectors and in new approaches to transport modelling (Pagliara, 2023).

The main focus of smart cities will be on developing new models of the city with its various sectors operating primarily on digital networks, while at the same time connecting them to traditional movements and location-based activities (Kummitha et al., 2017).

There are now hundreds of examples of ICT implementation in cities, providing new insights into key urban problems.

We will examine a few examples and their salient points to provide some insight into how ICT is being used successfully and how it could be used in the short and medium term. (Meijer & Bolivar, 2015).

Innovation Approach. Technological innovation is underpinned by the cultural context in which it takes place. The agglomeration economy, with cities increasingly growing in terms of their population and knowledge base, lies at the heart of the smart city (Liu et al., 2024).

Cities that embrace ICT in different forms are changing the nature of the adoption process using the same ICT. In real cities, land use regulation reforms in the direction of mixed land use in places like Arlington, Virginia, have created clusters of creative professionals (Evans, 2020).

We will highlight different projects that will inevitably overlap with other domains of FuturICT. One of the main themes is the development of new forms of simulation models that encompass the new forms of complexity developed in smart cities. (Helbing, 2013).

The models developed within the project have the potential to encompass very different ideas about how a city can function.(Epstein, 2022). Model frameworks such as MATSim and Simulacra are used for the FuturICT project.

Theoretical background. In FuturICT, the work on various land use and transport models, ranging from conventional socio-physical-urban economic-style models to cellular automata models of urban development and the behavior of spatial agent-based models, has used the agent-based microsimulation MATSim, which provides the basis for implementing a comprehensive model that links travel behavior, land use, mobility issues, and social networks[1].

New models of movement and location: MATSim and Simulacra. Open source agent-based microsimulation such as MATSim has an excellent track record in terms of computational speed and size (Ficara, 2024).

Like most microsimulations MATSim typically includes data from real environments, and creates agents with attributes and activities taken from data. The easiest way to create a road network is to use OpenStreetMap and then convert to MATSim representation using the MATSim utility class OsmNetworkReader. (Hoyer et al., 2017).

To define the population of agents, we developed an input file in Python format, as shown below.

Unlike other creativity ABMs (Doboli, 2022), each agent also has several socio-economic attributes that influence their behavior during simulation runs. These mechanisms allow us to perform a reconstruction of the traffic situation across the entire urban network, as shown in the Roadmap to a Safer City within the framework of the FuturICT project.

Benefits of Transportation. Investments into transport infrastructure are aimed at additional transport capacity, increased reliability and a better quality of transport services. This in turn leads to lower transport costs as well as to shorter transit times. Besides, better transport infrastructure is the core element for business expansion.

The transport sector is an important component of economy impacting on the development and welfare of populations. When transport systems are efficient, they provide economic and social opportunities and benefit that impact throughout economy. When transport systems are deficient, they can have an economic cost in terms of reduced or missed opportunities.

More specifically, it has been recognized that the provision of a high quality transport system is a necessary precondition for the full participation of remote communities in the benefits of national development (ST/ESCAP/2019)[2].

The impact of transport activities on the economies of the Baltic Sea countries. The transport sector in the EU contributes to 7% of the EU GDP and 5% of total employed persons are employed in the transport sector.

---

1 MATSim – The Multi-Agent Transport Simulation. URL: https://www.matsim.org (дата звернення: 12.01.2025).

2 Economic and Social Commission for Asia and the Pacific (ESCAP).

Mshvidobadze T. DIRECT IMPACT OF ICT ON URBAN ECONOMIC GROWTH BY DEMONSTRATING....

41

Transport remains a rapidly developing industry, ensuring the effective functioning of the internal market, the provision of foreign trade and transit services, passenger services and the development of tourism.

Analyzing the situation in the entire Baltic Sea region, the constantly growing volumes of export of transport services demonstrate the role of the transport sector in the economic growth of these countries.

Main results. Improved transport brings obvious benefits to the economy, including improved logistics and improved mobility, which leads to improved business profitability. This in turn leads to higher demand for transport and requires larger measures for investment. Under conditions of good functioning of this cycle, the country's economy becomes stable and conditions are created for long-term planning and creation of businesses.

When comparing the situation in the Baltic Sea Region (BSR) between 2019 and 2023, all countries increased the efficiency of transport services (Table 1). The lowest increase was 36% (Sweden) and the highest – 107% (Lithuania).

remains the same: the lowest is observed in Germany (less than 2%) and the highest – in Denmark (more than 12% in 2023).

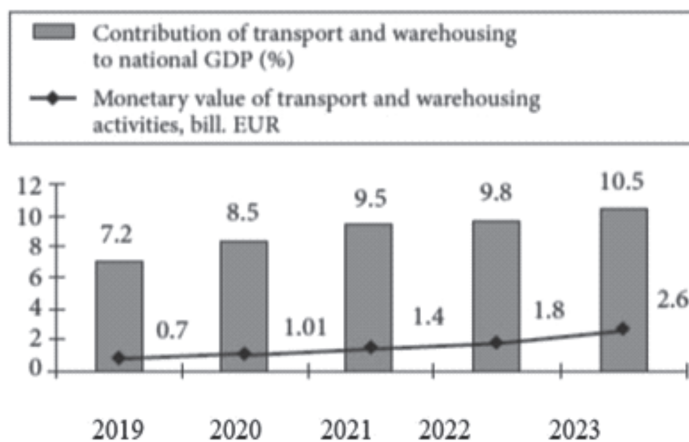In the transition period, in the knowledge

Fig. 2. The share of the transport sector to GDP

Source: built by the author based on data ⁽Statista. URL: https://statista.com (дата звернення: 12.01.2025)⁾

economy, this share may slow down, however, the experience of Western European countries shows that the export of transport services can be much higher, even with its lower share in national GDP (Fernandez-Aneza, 2018).

Thus, high-quality transport infrastructure has a significant impact on the

Table 1. The dynamics of the export of transport services in BSR, mln EUR

BSR countries	2019	2020	2021	2022	2023	Change 2023/2019 (%)
Denmark	15.8	17.2	21.7	26.4	29.0	83.91
Germany	23.9	27.0	30.9	33.5	37.5	56.88
Estonia	0.8	0.9	1.0	1.1	1.3	52.56
Latvia	0.8	0.8	9.8	1.1	1.3	69.42
Lithuania	0.8	1.0	1.2	1.5	1.7	107.02
Poland	3.5	3.3	4.3	5.5	6.7	91.43
Finland	1.7	1.9	1.9	2.1	2.3	34.45
Sweden	5.9	6.5	7.0	7.3	8.1	35.95

Source: built by the author based on data (Eurostat. URL: https://ec.europa.eu/eurostat (дата звернення: 12.01.2025).⁾

The BSR is becoming a hub for transcontinental trade, and this is explained by the rapid growth of the role of logistics. Outside the EU's neighbours, external transport policy is different and focused on the EU's main trading partners.

The BSR is well connected to TRACECA and the trade routes of the Central and Far East Asian regions (Mačiulis, 2023).

If we take the same BSR countries as a comparative element, we see that the share of transport services exports in national GDP

development and well-being of the population, which is one of the factors facilitating the transformation of smart cities and a key element for business expansion.

Conclusion. The paper presents various literature studies on the dynamic socio-economic processes that underlie urban economic growth through computer technology simulation.

This paper is a basis for arguing that new technologies have synergistic effects, especially on the forms of social organization

that are needed for future forms of governance and social action, as well as for business.

The main emphasis is on efficiency, balanced against capital. Web-based interactive systems, a form of citizen science, should be the norm for smart cities, allowing for the development of equity and balancing it against competition.

The Smart Cities project aims to develop infrastructure that is accessible to a wide range of groups.

The results of this study are available on the FuturICT website[1]. The Smart Cities project aims to develop infrastructure that is accessible to a wide range of groups. The main emphasis is on efficiency, balanced against capital. Web-based interactive systems, a form of citizen science, should be the norm in

a smart city, allowing for the development of equity and balancing it against competition.

Given the positive balance of export-import of transport services, this means that the transport sector is very competitive in the international arena and, therefore, should be developed.

By distributing state investments, the policy of developing the national economy strives for maximum economic growth in the short term. Improving transport infrastructure is one of the main priorities of such investment. Ultimately, high-quality transport infrastructure has a significant impact on the development and well-being of the population, which is one of the factors contributing to the construction of smart cities and economic efficiency.

Список використаної літератури

1. Aurigi, A. (2016). Making the Digital City: The Early Shaping of Urban Internet Space. Farnborough, UK: Ashgate Publishing Company. doi: https://doi.org/10.4324/9781315249964

2. Batty, M. (2015). Intelligent Cities: Using Information Networks to Gain Competitive Advantage. MIT Press, Cambridge, doi: https://doi.org/10.1068/b170247

3. Baublys, A. (2019). Principles for modelling technological processes in transport terminal. Transport, 24(1), 5–13. doi: https://doi.org/10.3846/1648-4142.2009.24.5-13

4. Brail, R. (Ed.). (2020). Planning Support Systems for Cities and Regions. Cambridge, MA: Lincoln Institute of Land Policy.

5. Doboli, A., & Doboli, S. (2022). A novel agent-based, evolutionary model for expressing the dynamics of creative open-problem solving in small groups. Springer Science and Business Media LLC. doi: https://doi.org/10.1007/s10489-020-01919-6

6. Evans, G. (2019). Creative Cities, Creative Spaces and Urban Policy. Urban Studies, 46(5-6), 1003–1040. doi: https://doi.org/10.1177/0042098009103853

7. Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2015). Foundations for Smarter Cities. IBM J. Res. Develop, 54. doi: https://doi.org/10.1147/JRD.2010.2048257

8. Epstein, J. M. (2022). Why Model? Journal of Artificial Societies and Social Simulation, 11(4), 12. doi: https://doi.org/10.4236/ce.2022.133069

9. Ficara, A., Fazio, M., Celesti, A., & Villari, M. (2024). Design and Analysis of a MATSim Scenario From Open Data: The Messina City Use Case. IEEE Transactions on Systems Man and Cybernetics Systems, 99, 1-12, doi: https://doi.org/10.1109/TSMC.2024.3490854

10. Grimm, V., et al. (2020). A Standard Protocol for Describing Individual-Based and Agent-Based Models. Ecological Modelling, 198(1–2), 115–126. doi: https://doi.org/10.1016/j.ecolmodel.2006.04.023

11. Helbing, D. (2013). Introduction: The FuturICT Knowledge Accelerator Towards a More Resilient and Sustainable Future. doi: https://doi.org/10.48550/arXiv.1304.0788

References

1. Aurigi, A. (2016). Making the Digital City: The Early Shaping of Urban Internet Space. Farnborough, UK: Ashgate Publishing Company. doi: https://doi.org/10.4324/9781315249964

2. Batty, M. (2015). Intelligent Cities: Using Information Networks to Gain Competitive Advantage. MIT Press, Cambridge, doi: https://doi.org/10.1068/b170247

3. Baublys, A. (2019). Principles for modelling technological processes in transport terminal. Transport, 24(1), 5–13. doi: https://doi.org/10.3846/1648-4142.2009.24.5-13

4. Brail, R. (Ed.). (2020). Planning Support Systems for Cities and Regions. Cambridge, MA: Lincoln Institute of Land Policy.

5. Doboli, A., & Doboli, S. (2022). A novel agent-based, evolutionary model for expressing the dynamics of creative open-problem solving in small groups. Springer Science and Business Media LLC. doi: https://doi.org/10.1007/s10489-020-01919-6

6. Evans, G. (2019). Creative Cities, Creative Spaces and Urban Policy. Urban Studies, 46(5-6), 1003–1040. doi: https://doi.org/10.1177/0042098009103853

7. Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2015). Foundations for Smarter Cities. IBM J. Res. Develop, 54. doi: https://doi.org/10.1147/JRD.2010.2048257

8. Epstein, J. M. (2022). Why Model? Journal of Artificial Societies and Social Simulation, 11(4), 12. doi: https://doi.org/10.4236/ce.2022.133069

9. Ficara, A., Fazio, M., Celesti, A., & Villari, M. (2024). Design and Analysis of a MATSim Scenario From Open Data: The Messina City Use Case. IEEE Transactions on Systems Man and Cybernetics Systems, 99, 1-12, doi: https://doi.org/10.1109/TSMC.2024.3490854

10. Grimm, V., et al. (2020). A Standard Protocol for Describing Individual-Based and Agent-Based Models. Ecological Modelling, 198(1–2), 115–126. doi: https://doi.org/10.1016/j.ecolmodel.2006.04.023

11. Helbing, D. (2013). Introduction: The FuturICT Knowledge Accelerator Towards a More Resilient and Sustainable Future. doi: https://doi.org/10.48550/arXiv.1304.0788

1　The FuturICT Knowledge Accelerator – Exploring and Managing our Future. URL: https://www.futurictch.ethz.ch/ (дата звернення: 12.01.2025).

Mshvidobadze T. DIRECT IMPACT OF ICT ON URBAN ECONOMIC GROWTH BY DEMONSTRATING....

43

12. Hoyer, S., & Hamman, J. (2017). Xarray: N-D labeled Arrays and Datasets in Python. Journal of Open Research Software, 5(1), 1–6. doi: https://doi.org/10.5334/jors.148

13. Jiang, S., Ferreira J., & Gonzalez, M.-C. (2012). Clustering daily patterns of human activities in the city. Data Mining and Knowledge Discovery, 25. doi: https://doi.org/10.1007/s10618-012-0264-z

14. Kummitha, R. K. R., & Crutzen, N. (2017). How do we understand smart cities? An evolutionary perspective. Cities, 67(July 2016), 43–52. doi: https://doi.org/10.1016/j.cities.2017.04.010

15. Liu, Y., Yang M., & Cui, J. (2024). Urbanization, economic agglomeration and economic growth. Heliyon, 10(1), e23772. doi: https://doi.org/10.1016/j.heliyon.2023.e23772

16. Meijer, A., & Bolivar, M. P. R. (2015). Governing the Smart City: A review of the literature on smart urban governance. International Review of Administrative Sciences, 82(2). doi: https://doi.org/10.1177/0020852314564308

17. Mačiulis, A., & Jakubauskas, G. (2023). Challenges and opportunities for Lithuanian transport sector to become an integrated part of Trans-Asian connections. in Proceedings of the 11th International Conference 'Transport means' (pp. 95–98). doi: https://doi.org/10.3846/1648-4142.2009.24.93-99

18. Nielsen, M. (2019). Reinventing Discovery: The New Era of Networked Science. Princeton, NJ: Princeton University Press.

19. Özbay, E.,& Özbay, F. (2020). Modeling and Simulation of Urban Growth in the Use of Industry 4.0. International Journal of Computer Science and Mobile Computing, 9(11), 28-37. doi: https://doi.org/10.47760/ijcsmc.2020.v09i11.003

20. Pagliara, F., de Bok, M., Simmonds, D., &Wilson, A. (Eds.). (2023). Employment Location in Cities and Regions: Models and Applications. Heidelberg, DE: Springer. doi: https://doi.org/10.1007/978-3-642-31779-8_1

21. Spencer, G. M. (2022). Creative Economies of Scale: An Agent-based Model of Creativity and Agglomeration. Journal of Economic Geography, 10(1), 247–271. doi: https://doi.org/10.1093/jeg/lbr002

22. Fernandez-Aneza, V., Fernández-Güellb, J. M., & Giffingerc, R. (2018). Smart City implementation and discourses: An integrated conceptual model. The case of Vienna. Cities, 78, 4-16. doi: https://doi.org/10.1016/j.cities.2017.12.004

Тінатін Мшвідобадзе,
кандидат технічних наук, доцент, Горійський державний університет, проспект Чавчавадзе, 53, Горі, 1400, Грузія
tinikomshvidobadze@gmail.com
https://orcid.org/0000-0003-3721-9252

ПРЯМИЙ ВПЛИВ ІСТ НА ЕКОНОМІЧНЕ ЗРОСТАННЯ МІСТ ШЛЯХОМ ДЕМОНСТРАЦІЇ АГЕНТНОГО МОДЕЛЮВАННЯ ДЛЯ РОЗУМНИХ МІСТ

Розумним містом вважається місто, в якому інфраструктура скоординована та інтегрована за допомогою нових цифрових технологій. Ми розглядаємо сценарії, засновані на переході від старих міст до нових розумних міст, що розвиваються, з розвитком міських послуг з використанням сучасних ІКТ. Запропоновано кілька напрямків проекту: інтегровані бази даних, сенсорні мережі та вплив нових соціальних медіа, мобільність і поведінка під час подорожей, моделювання міського землекористування, транспортні та економічні взаємодії та планувальні структури для розумних міст. Проект FuturICT, який обговорюється в статті, було реалізовано в рамках Сьомої рамкової програми Європейського Союзу згідно з грантовою угодою № 284709. Ми розглядаємо стилізовану

модель на основі агентів, де гетерогенні агенти, що приймають рішення, взаємодіють за такими сценаріями: покращення інвестицій у міський транспорт, регулювання змішаного землекористування та зменшення сегрегації серед мешканців. У статті оцінюється позитивний вплив транспорту на економіку країн Балтійського моря на тлі аналізу ключових показників, що вимірюють успішність транспортного сектору: частки транспортного та складського секторів у національному ВВП (%) та частки експорту транспортних послуг у ВВП (%). Варто зазначити, що будь-яка комбінація цих сценаріїв призводить до більшої щільності населення та дозволяє поширюватися творчості, що призводить до економічного зростання. Результати показують чітку кореляцію між швидким економічним прогресом і соціально-економічною рівністю. Транспорт завжди був і залишається однією з головних рушійних сил економічного розвитку. Широко визнано, що транспорт відіграватиме вирішальну роль в економічному розвитку в майбутньому, особливо в транзитних перевезеннях, як у країнах Балтії. У роботі проаналізовано позитивний вплив транспорту на економіку та оцінено можливі шляхи розвитку сталої транспортної системи.

Ключові слова: *розумні міста, урбаністика, транспортні послуги, ІКТ, FuturICT, агентне моделювання.*

JEL Classification: O1; R1; D8; A13.