

P / REFERENCES OF DESIGN



DIGITAL TWINS IN THE PUBLIC SECTOR AND THE ROLE OF THE SERVICE DESIGNER.

Mariia Ershova^{*a}

a Sapienza University of Rome, Italy

* mariia.ershova@uniroma1.it

DOI: 10.63442/NDVB4983

KEYWORDS | DIGITAL TWIN APPLICATIONS, DIGITAL TRANSFORMATION, PUBLIC SERVICES, PUBLIC ADMINISTRATION, HUMAN-CENTERED DESIGN

ABSTRACT | Digital Twins are increasingly being discussed in the literature of industrial, smart cities, and smart healthcare fields, but what if this technology was also applied to the Public Sector? This research aims to identify possible uses of the Digital Twin approach in public services and understand what role the Service Designer can play in the process of integrating this solution. The Digital Twin is already actively used in the industrial context, healthcare, or smart cities thanks to its capabilities for real-time prediction, optimization, monitoring, controlling, and improved decision-making. At the same time, digital transformation has become one of the needs in the Public Sector, and even if many countries are taking significant steps to implement it, many opportunities remain unrealized. The Digital Twin solution can be considered one of the technologies that improve public services, but so far, research on this topic is limited. From a few studies on this topic, one can highlight the Digital Twin Bureaucracy, which is a digital replica of the bureaucracy in the physical world. Simultaneously, there is currently no Service Design literature on this topic, although it can be useful in integrating such technologies due to the design's ability to deal with complexity and the Human-centered approach.

To explore technology applications and design capacity in this topic, this study uses a Literature review and Case studies analysis based on articles and cases that touch on concepts of Digital transformation, Human-centered design, Public services, and Public administration. The study presents a list of possible applications of the Digital Twin in the Public Sector and the role of the designer in this process. Possible uses of this technology in the public services identified in the research are accelerated prototyping and redesigning systems, optimization of organizational resources, forecasting problems, systems planning, and Public Engagement. The Service Designer's role in Digital Twin integration may be characterized as an expert who thinks through the experience of stakeholders based on their needs and improves the interactions between them and technologies.

Future studies will address the following questions: What other uses can a Digital Twin have in the Public Sector? How can Service Design adapt this approach to meet stakeholder needs in public services? How can design make information from this technology accessible and personalized to stakeholders in this context? To answer these questions, the PhD research aims to identify trends and cases of using Digital Twin in the Public Sector, understand the dynamics of one Italian public service that can be improved by applying this technology, develop a prototype of its interfaces, and create guidelines for Service Designers.

1. Introduction

Digital Twin solutions help to effectively plan and optimize processes in various areas of industry, smart cities, and smart healthcare. Could it also be useful for improving the quality of public services from the point of view of the citizens and state employees? This PhD research explores how the Digital Twin can be integrated into public services to improve the efficiency and stakeholders' satisfaction with these services and what is the role of Service Design in this process.

2. Digital Twin: Definition, History, and Benefits

The Digital Twin, according to Rasheed et al. (2020), is defined as a virtual representation of a physical asset that can be used for better decision-making, real-time prediction, optimization, monitoring, and controlling via data and simulators. The idea of a Digital Twin appeared before it gained popularity, namely in 2002 by Grieves, who came up with the “Mirrored Spaces Model” associated with Product Lifecycle Management and consisting of real space, virtual space, and a mechanism for connecting the data flow between them. A decade before this, there was a similar idea called “Mirror Worlds” by David Gelernter, in which software models simulate reality based on information from the physical world. The name Digital Twin itself originated from NASA in 2010 and was designed for flying vehicles (Singh et al., 2021). Singh et al. (2021) also pointed out the benefits of using Digital Twin in different areas.

1. Acceleration of prototyping and product redesign as the Digital Twin allows exploration of a range of scenarios.
2. Economic benefit, since mostly virtual resources are used to create a Digital Twin.
3. Forecasting problems and planning the system in future states of the physical twin.
4. Optimization of solutions through several scenario options proposed by virtual twins.
5. Accessibility is due to the ability to manage and monitor a physical device remotely.
6. Consolidating documentation and communication around the Digital Twin in one place, such as data scattered across different software applications, databases, etc.

3. Digital Twin in the Public Sector and Other Fields

These benefits have already been proven in fields where the Digital Twin is actively used, namely, industry, smart cities, and smart healthcare. On these topics in recent years, numerous articles can be found in the literature. In the industrial sphere, Digital Twins are most popular in the field of Prognostics and Health Management, in smart cities in agriculture, urban transport, urban health management, and security, while in healthcare in personal health management and precision medicine (Yang et al., 2021).

At the same time, digital transformation is a necessity for public organisations, and although some government functions have made significant progress, the full potential of digital transformation remains untapped (Alvarenga et al., 2020). This is why the use of a Digital Twin approach in the Public Sector can be considered, and there are even concepts of using it to deal with bureaucracy, public policy, and optimization of financial data. Eom (2022) speaks about a Digital Twin bureaucracy, which is defined as a digital replica of a bureaucracy in the physical world that will control the physical bureaucracy through autonomous decision-making on matters of government affairs. Another article explores the integration of Digital Twin technologies into public policy-making, looking at a scenario for a public bike-sharing system. Its result highlights the benefits of the implication of Digital Twin simulation modeling to make intelligent public policy decisions (Hwang and Choi, 2023). It is important to emphasize that these two studies above were done for Sejong City in South Korea. Lynch, Issa, and Anumba 2023 discuss how a Financial Digital Twin (Figure 1) can be applied to Public Sector Capital Projects, integrating fund allocation, project execution, and rules-based knowledge management in real-time. This automation ensures compliance and optimizes the use of financial data throughout the asset lifecycle.

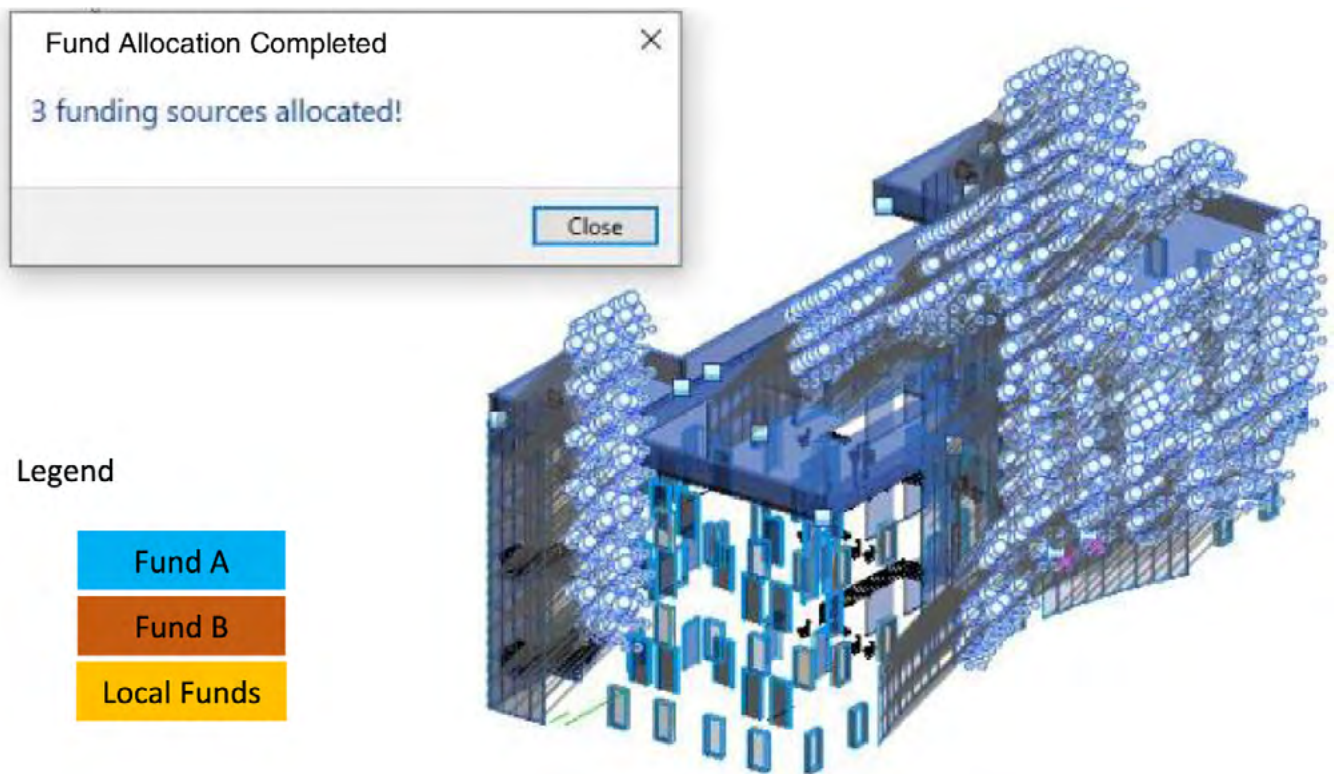


Figure 1. Sample output of prototype plug-in that is used to support funding distribution on an integrated BIM model.

Since there is still little practice on the use of Digital Twin in the Public Sector, we can identify numerous case studies from other fields that may be adapted for the Public Sector.

Kroger Co. and NVIDIA envision using the Store Digital Twin (figure 2) to optimize store efficiency and processes, such as simulating changes and their impacts, for example, removing cashiers and adding self-service lines (NVIDIA Newsroom, 2024).



Figure 2. Simulation of self-checkout and cashier-assisted checkout lines in Store Digital Twin.

Azure Digital Twins (Figure 3) offers the ability to optimize supply chain efficiency by providing real-time tracking, actionable insights, and flexible modeling (Eightify, 2023).

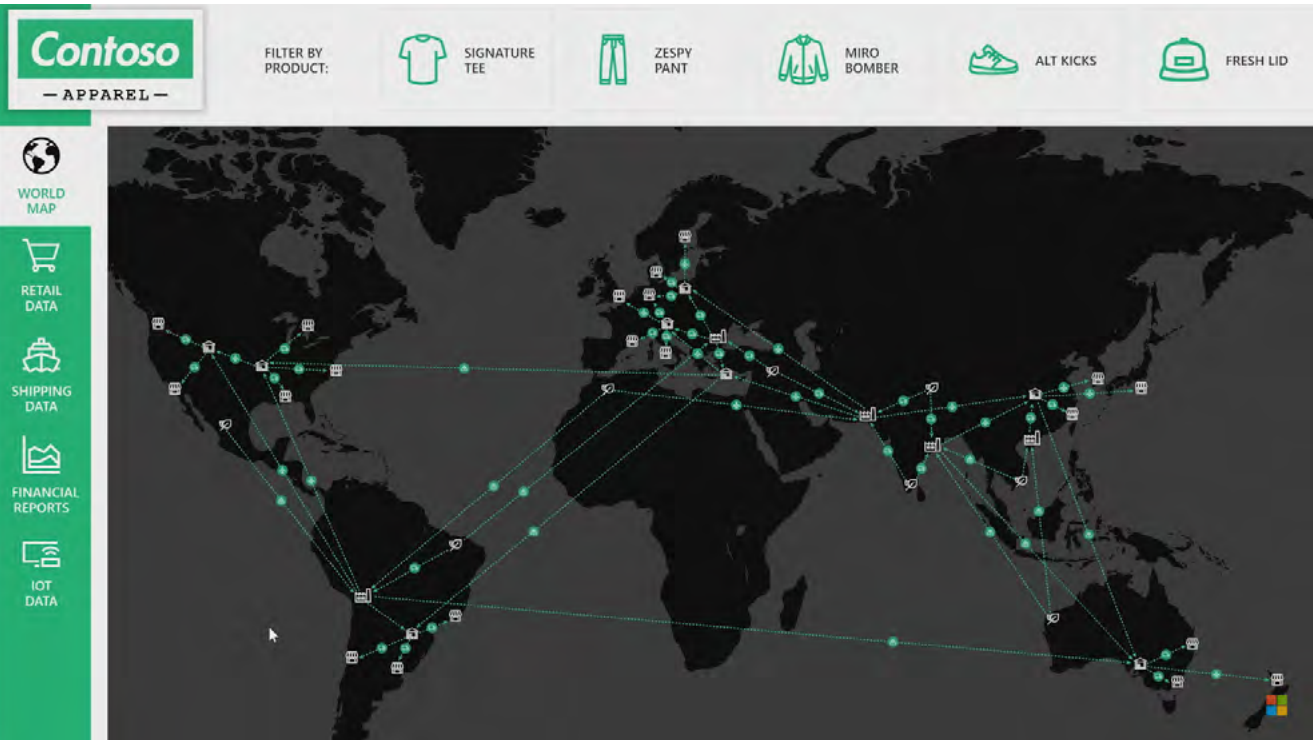


Figure 3. Global map of suppliers, manufacturers, transportation, warehouses, and retailers in Azure Digital Twin.

Twinzo launched a Digital Twin of smart offices (Figure 4) in buildings in London, Bratislava, and Budapest, which allows the client to monitor the movements of employees and visualize the occupancy of desks and rooms and data from the environment. In addition, security workers, in dangerous situations, such as during a fire alarm, can understand where workers are in the office for their evacuation (Twinzo, 2023).



Figure 4. A view of a floor of the smart offices Digital Twin demonstrating the reservation of a workspace in a specific room.

The Docklands area in Dublin, Ireland, has a Digital Twin smart city for citizen feedback, the 3D model of which can be published online for citizens, where they can provide feedback on planned changes in the city and can also interact with components to mark problems in their area. Such a Digital Twin will facilitate the dissemination of information and provide transparency to the public before decisions are put into practice (White et al., 2021).

As shown in Figure 5, features from each of these four case studies may be easily transferred into solutions of Digital Twin for the Public Sector.

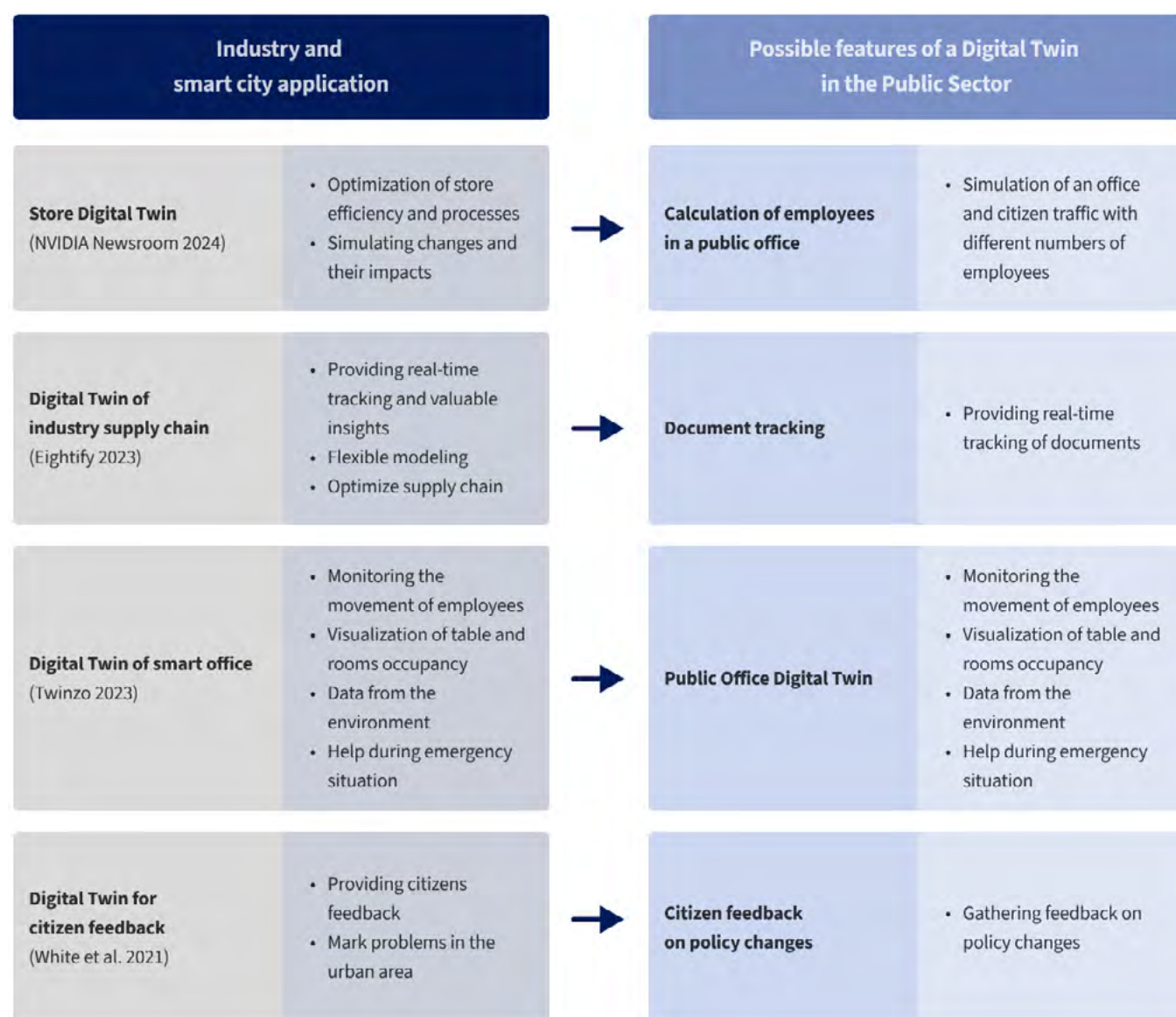


Figure 5. Possible features of the Digital Twin in the Public Sector by analogy with other areas.

As has been seen in several case studies, there are many opportunities that the Digital Twin can provide to the Public Sector, some of them are:

- accelerated prototyping and redesigning systems using the Digital Twin to explore several scenarios, for example, to create a new service in the Public Sector;
- optimization of Public Sector efficiency and processes in terms of all organizational resources: staffing (for example, monitoring the movement of employees); fiscal resources (for instance, controlling the movement and use of financial resources); facilities, equipment, and technology (such as the visualization of table and rooms occupancy or data from the environment, or even the help during an emergency); informational resources and materials (for example, consolidating documentation and communication in one place, providing real-time tracking of documents or even using of the Digital Twin bureaucracy concept);
- forecasting problems and system planning in future phases of the physical twin;
- Public Engagement, namely, gathering feedback on planned changes in the Public Sector, for example, to the policy.

4. The Role of Service Design for the Implementation of the Digital Twin in the Public Sector

The studies above confirm the possibility of using the Digital Twin in the Public Sector, but what is the role of the Service Designer in this process?

To answer this question, it is important to understand the context that the PhD research will focus on, namely the Italian Public Sector. Various studies highlight the inefficiency and dissatisfaction of citizens with public services. For example, one European study shows citizens' satisfaction with services such as electricity and postal services. The results show that satisfaction levels are lowest in Italy and highest in Denmark and Ireland (Ferrari and Manzi, 2014).

Another research demonstrates how many days were lost to bureaucracy in the G7 countries, and Italy has the highest average (Datta, Walker, and Amarilli, 2020). This study also shows that the complexity of the Italian population lies in the diversity of political views and traditions that exist in a democratic society. The authors emphasize that to make digital transformation effective, the Italian population must accept digital transformation.

In this context, Service Design, with its ability to face complexity and find a Human-centered approach, can be useful for creating flexible solutions. As Manzini affirms, a designer's role within social innovation initiatives might function as an expert, triggering and facilitating various design conversations (Manzini, 2015). Several governmental organizations are already interested in using Service Design methodologies for the Public Sector, such as Design Thinking and Co-design. For instance, the Design Thinking methodology has helped some public managers explore new policy development methods (Mortati, Schmidt, and Mullagh, 2022). The introduction of Design Thinking and Service Design methodologies into Italian public administration through digital services was done in the Italia Login project. The collaborative and open-source models present an opportunity to reconsider public service communication in a context that encourages sharing between public managers and designers for public benefit (Sinni, 2017).

Despite these few practices of using Service Design in the Public Sector, there is no Service Design literature yet on the integration of the Digital Twin in this area. Therefore, it is important to plan future research on this topic.

5. PhD Research

The PhD research (Figure 6) is devoted to the integration of the Digital Twin into the Italian Public Sector. In order to comprehend and face these challenges, the study will address the following questions.

1. What uses can a Digital Twin have in the Public Sector?
2. How can Service Design adapt Digital Twin technology to meet stakeholder (state employees and citizens) needs in the Public Sector?
3. How can Service Design make information from a Digital Twin accessible and personalized to stakeholders in this context?

Based on the identified applications and design opportunities, the research project aims to understand how to effectively integrate the Digital Twin into the Public Sector while taking into account the needs of stakeholders. The specific objectives of the research are to:

1. identify trends and cases of using Digital Twin in the Public sector;
2. understand the dynamics of one Italian public service that can be improved by applying Digital Twin; namely, determine the characteristics and problems of this service, taking into consideration different types of citizens and state employees involved in this service; develop a

prototype of interfaces for selected public service with the Digital Twin and create guidelines for Service Designers on applying Digital Twin in this context.

The research plan consists of three main phases, which will employ various tools and methods typical to Service Design.

1. Preliminary research through Literature review, Case studies, and Field research resulted in the mapping of case studies from Italy and from abroad.
2. Ethnographic research through the creation and application of an ethnographic toolkit, followed by a report of summarized findings with different Service design tools (Personas, Journey Map, etc).
3. The experiment phase with prototyping and testing Digital Twin interfaces leads to the creation of guidelines for Service Designers on applying Digital Twin in the Public Sector.

Research questions	Objectives	Methodology and phases	Expected results
What uses can a Digital Twin have in the Public Sector?	Identify trends and cases of using Digital Twin in Public sector.	Preliminary research • Literature review • Case studies • Field studies	Mapping of case studies according to trends found
How can Service Design adapt Digital Twin to meet stakeholder needs in the Italian Public Sector?	Understand dynamics of one chosen service	Ethnographic research • Creation of toolkit • Application of toolkit • Summarizing of findings	• Toolkit for ethnographic research • Report with findings
How can Service Design make information from a Digital Twin accessible and personalized to stakeholders in the Italian Public Sector?	Develop a prototype of interfaces of one chosen service with the Digital Twin and create guidelines for Service Designers	Experiment • Prototyping and testing • Creation of guidelines	• Guidelines for Service Designers • Prototypes of interfaces of one chosen service

Figure 6. PhD research.

6. Conclusion

This article, through an initial Literature review and Case studies, identified possible applications of the Digital Twin in the Public Sector. The role of the Service Designer in this process can be defined as an expert who thinks through the experience of stakeholders based on their needs and improves the interactions between them and technologies. The research has already shown that the Digital Twin approach in the Public Sector can bring economic benefits due to the use of mostly virtual resources, time benefits through faster prototyping or redesign, transparency, and quality thanks to Public Engagement.

The future research and the PhD research proposal can cover the following questions. How can the Digital Twin be integrated in the context of the Italian Public Sector? What challenges could there be in integrating the Digital Twin into the Public Sector, including ethical, legal, social, and technological challenges?

References

- Alvarenga, A., Matos, F., Godina, R., & Matias, J. C. O. (2020). Digital transformation and knowledge management in the public sector. *Sustainability*, 12(14), 5824. <https://doi.org/10.3390/su12145824>
- Datta, P., Walker, L., & Amarilli, F. (2020). Digital transformation: Learning from Italy's public administration. *Journal of Information Technology Teaching Cases*, 10(2), 54-71. <https://doi.org/10.1177/2043886920910437>
- Eom, S. J. (2022). The emerging digital twin bureaucracy in the 21st century. *Perspectives on Public Management and Governance*, 5(2), 174-186. <https://doi.org/10.1093/ppmgov/gvac005>
- Ferrari, P. A., & Manzi, G. (2014). Citizens evaluate public services: A critical overview of statistical methods for analysing user satisfaction. *Journal of Economic Policy Reform*, 17(3), 236-252. <https://doi.org/10.1080/17487870.2014.909313>
- Hwang, H., & Choi, H. (2023). Intelligent decision-making in public policy through digital twin technology: Digital twin simulation modelling based on evidence-based scenarios. *Korean Public Administration Review*, 57(1), 39-71. <https://doi.org/10.18333/kpar.57.1.39>
- Lynch, K. M., Issa, R. R., & Anumba, C. J. (2023). Financial digital twin for public sector capital projects. *Journal of Computing in Civil Engineering*, 37(3), 04023003. <https://doi.org/10.1061/jccee5.cpeng-4961>
- Manzini, E. (2015). *Design, when everybody designs: An introduction to design for social innovation*. MIT Press. <https://doi.org/10.7551/mitpress/9873.001.0001>
- Mortati, M., Schmidt, S., & Mullagh, L. (2022). Design for policy and governance: New technologies, new methodologies.
- NVIDIA Newsroom. (2024, January 31). Kroger and Nvidia to reinvent the shopping experience through state-of-the-art, AI-enabled applications and services. <https://nvidianews.nvidia.com/news/kroger-and-nvidia-to-reinvent-the-shopping-experience-through-state-of-the-art-ai-enabled-applications-and-services>
- Rasheed, A., San, O., & Kvamsdal, T. (2020). Digital twin: Values, challenges, and enablers from a modeling perspective. *IEEE Access*, 8, 21980-22012. <https://doi.org/10.1109/access.2020.2970143>
- Singh, M., Fuenmayor, E., Hinchy, E. P., Qiao, Y., Murray, N., & Devine, D. (2021). Digital twin: Origin to future. *Applied System Innovation*, 4(2), 36. <https://doi.org/10.3390/asi4020036>
- Sinni, G. (2017). Participatory design for public services: Innovation in public administration. *The Design Journal*, 20(sup1), S3368-S3379. <https://doi.org/10.1080/14606925.2017.1352841>
- Twino. (2023, December 5). Digital twin for smart office. *5.0 Technologies j.s.a* <https://www.twino.eu/blog/solutions-2/digital-twin-for-smart-office-6>
- White, G., Zink, A., Codecá, L., & Clarke, S. (2021). A digital twin smart city for citizen feedback. *Cities*, 110, 103064. <https://doi.org/10.1016/j.cities.2020.103064>

Yang, D., Karimi, H. R., Kaynak, O., & Yin, S. (2021). Developments of digital twin technologies in industrial, smart city and healthcare sectors: A survey. *Complex Engineering Systems*, 1(1), 3.
<https://doi.org/10.20517/ces.2021.06>

About the Authors:

Mariia Ershova is a PhD student in Service Design for Public Sector at the Sapienza University of Rome. My main research interests are Service Design and Technology-Driven Design. Before PhD, two research scholarships were won in the field of Service Design and Interaction Design.