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SUSTAINABLE SOCIAL DEVELOPMENT IN THE URBAN DIMENSION BASED ON BIG DATA. HOW DIGITAL TWIN CITIES CAN BE USED TO RESPOND TO SOCIAL PROBLEMS AND INEQUALITIES?

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Abstract

The Thesis investigates, from a Legal Informatics point of view, the concept of "Digital Twin Cities" (DTCs) and their potential to address social challenges within urban environments. Starting from a robust interdisciplinary approach, it integrates legal informatics and computer science to form the methodological foundation for analysing DTCs. It examines the implications, opportunities, and challenges of DTCs in the specific context of European cities, characterised not just by historical architecture and population density but also by socio-political structures emphasising spatial justice, privacy, and citizen engagement. The research includes non-EU cities (notably Zurich and the UK's Gemini Principles), which, like EU cities, strive to balance innovation with inclusivity.

A substantial portion of the Thesis addresses the legal considerations linked to DTCs, particularly focusing on challenges such as increased surveillance and ethical dilemmas posed by data ownership and algorithmic biases. Initially developed in industrial settings, DTCs enable cities to simulate and manage diverse aspects of urban life, from traffic flow and energy consumption to public safety and emergency response. However, deploying DTCs in European cities entails navigating a complex regulatory environment, balancing innovation with protecting citizens' rights, such as privacy and autonomy, while avoiding surveillance and social exclusion.

DTCs can reshape not only urban management but also the ontology and epistemology of the city, effectively creating a newer form of "documentality" (Professor Ferraris) —a continuous digital record influencing the identity and functioning of cities. To balance innovation with inclusivity, fundamental steps are necessary. The Thesis aims to offer an adaptive framework to balance "attractiveness through formality" and "inclusivity through informality", bridging the gap between the opposing visions of "cities as computers" and "cities as organisms" through the integration of new digital technologies.

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Peter Halley's exhibition in Luxembourg City, spring 2023, presented on his first floor a studio for a painting that got my attention. I was visiting the Mudam - Museum of Modern Art with my girlfriend and colleague Malwina, who became my wife later that year, and immediately she said: *this could be the cover of your PhD thesis.*
It was the studio "Untitled" (1981), which contained a draft of the, later expanded, "Ideal City" (1984). The simple drawing reminded me that cities are more than physical spaces; they are grids of power, imagination, and contradictions. In fact, the "Ideal City" by Halley is as-close-as-possible to my idea of explaining the digital twin city to a child, and as-close-as-possible to the representation of the conclusion of this thesis: cities are made by a part mechanical - formal, visible in a painting-like the Halley's- and one organic -informal, that is much more difficult to see, and then to regulate.

Approaching the emerging trend of Digital twin cities, a complex system of Big data and problems, I couldn't avoid carrying the memories of my learning journey. I have to thank my family for making this possible, from my parents to my parents-in-law, my grandparents and my brother. But it's not only that.
My mother introduced me early in her studies on the Council Vatican II, making it possible for me to inform my education with figures like Don Giovanni Nicolini, and discover the prominent figure of Giuseppe Dossetti. Some reflections, like the "precise diseducation plan" that is at the base of the current disinformation and post-truth, have already entered my research in "Pulire l'infosfera". Other things, like the "Libro Bianco su Bologna", took more time to come back into my life. But came back in my reflections on our reality.
Those initial steps made possible my contact with ACLI, during my University years. I formed *there* a perspective, a unique lens connecting my interest in writing with the broader, geopolitical dimension of the world. If my early trip to the exotic and dearest soil of Albania started a journey, attending the Course of Geopolitics and International Relationship organised by Silvio Ziliotto opened up another chapter in my life, being present all the time and widening my eyes on the tormented land of the western Balkans (I later tributed to them, and particularly to Kosovo's potentials as an info-State, the final thesis of the Geopolitics and Global Security Master in Rome).
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To no one else, during this thesis, I denied more time than my wife Malwina. Despite the early classes in Bologna, all the sunsets in Belval, and even this moment in which we are both writing and concluding our manuscripts, I would have loved to spend more time for you. So many things we still have to do. So many galleries and exhibitions.
It was spring 2024 when she brought me to Enzo Mari's exposition in London -*her London.* I discovered a man (*from Milan!*) who, in all his lifework, advocated for the social responsibility of design and designers. Again, I was finding pieces of my thesis. With Mari, I think that the design of a Digital Twin City has to restore autonomy and creativity in citizens. It has to be a way to practice equality, raise collective consciousness, and ultimately transform society to be more equitable.

Introduction

The Conceptual and Technological Emergence of Digital Twins in Urban Environments

The rise of "digital twins" in urban environments may mark one of the most compelling -yet not concluded and difficult to judge- frontiers in the digital transformation of cities. While this concept was largely unexplored until recently, its rapid advancement has transformed it from a theoretical possibility to a practical reality in just a few years, now within reach of cities of all sizes, including small and medium-sized municipalities. The concept of a "digital twin" is borrowed from industry and represents a dynamic, digital replica of a physical entity, in this case the city itself. This digital model is continuously updated with real-time data (*Big data*), reflecting the changing conditions of its physical counterpart. The increasing feasibility of digital twins in urban planning and administration reflects not only the acceleration of digital innovation, but also the potential for cities to exploit complex data systems to improve governance, operational efficiency and public services. However, this leaves open questions on the efficacy of the intervention and doubts over the true costs of it.

The digital twin offers an advanced framework for the aggregation and analysis of huge amounts of data generated by urban activities. By combining sensors, IoT devices, machine learning algorithms, and artificial intelligence (AI)[1], this technology empowers city administrators to observe, simulate, and address urban dynamics in a way never seen before. The ongoing advancement of digital twin technology presents both benefits and obstacles: as data accuracy improves, decision-making is enhanced, but it also brings about intricate challenges in data management, privacy, and security. These difficulties are especially clear in legal and regulatory settings, where safeguarding citizens' rights must be weighed against the aim of utilising data efficiently. The successful use of digital twins in cities must consider more than just technology, including ethical, legal, and social issues due to the specific vulnerabilities in urban data flows such as surveillance and cyber

[1] While many of the footnotes necessary for this introduction will be left to the following chapters, for a general understanding of AI it is worth referring to S. J. Russell, Stuart, P. Norvig, *Artificial Intelligence: A Modern Approach*. Fourth edition, Global edition. Prentice Hall Series in Artificial Intelligence. Boston: Pearson, 2022.

threats.

Historically, cities were built on systems of documentation. The advent of writing allowed early urban societies to record vital information such as food supplies, labour resources and economic transactions, thus enabling structured urban life. Writing, in this sense, was instrumental in the very formation of cities. The ability to document and manage information supported the stability and growth of early urban centres, creating a model of organised society.

The concept of documentality, which has its roots in the philosophical work of Maurizio Ferraris, emphasises the symbiotic relationship between documentation and social structure. Just as ancient cities relied on written documents to organise social life, contemporary digital cities rely on a vast interconnected system of digital documentation to maintain urban functions. The nature of documentation has shifted from predominantly human-generated documents to vast networks of mostly machine-generated data, encompassing everything from traffic patterns to environmental conditions to social media interactions. Today we find ourselves in the "infosphere", a term coined by Luciano Floridi to describe the global digital environment in which the balance between human-generated and machine-generated is terribly skewed in favour of the latter. Is it also so from a qualitative point of view? Certainly the proliferation of digital devices capable of continuously collecting, storing and analysing data has transformed the urban landscape into a dense network of information flows, where every movement, transaction and interaction potentially leaves a traceable digital footprint.

In this context, the digital twin serves as an integrated, multi-layered framework that organises, synchronises and visualises these data flows. By superimposing different data sources - from environmental sensors to transport networks and social media feeds - on a digital replica of the city, digital twins enable a better understanding of urban processes in real time. These digital replicas are not static, but (necessarily) they are continuously updated to reflect the changing conditions of the physical city. They offer a valuable tool for administrators, planners and researchers, facilitating everything from traffic management to environmental monitoring. For example, by simulating various scenarios - such as emergency response procedures, infrastructure maintenance needs or energy consumption patterns - the digital twin enables decision-makers to optimise resources and address potential problems in advance.

However, in a city governed by a digital twin, where data is continuously generated and interpreted by algorithms, who controls the city's narrative? Who decides what data is recorded, how it is processed and for what purpose? How controls what to ask to data?

The implementation of digital twins also raises an even deeper epistemological question: what does it mean to truly "know" a city or society? This question is not merely philosophical, but has direct implications for the deployment and governance of digital twin technologies. Urban knowledge, constructed through digital twins, is largely derived from quantifiable data models, but this form of knowledge can be limited by its reliance on metrics that privilege observable, machine-readable phenomena. This form of knowledge, often rooted in statistical correlations, may lack depth in understanding qualitative aspects of urban life, such as social cohesion, cultural identity and individual agency. As cities adopt digital twins, it becomes crucial to critically evaluate the extent to which these technologies capture the lived realities of urban residents, instead of merely rendering an abstract, data-centric model of urban space.

This shift towards automated, data-driven knowledge systems marks a profound departure from previous urban epistemologies. In the past, cities were seen as aggregates of "masses" - collections of individuals whose behaviour and preferences could be generalised and understood on a collective level. Today, however, the digital age has seen the dissolution of these traditional "masses" in favour of individualised experiences and behaviours, sometimes observable even at the micro level. Contemporary urban analysis therefore operates on the principle of capturing the actions and preferences of discrete "data vectors": each individual, each device, each interaction produces a separate data point that feeds its digital twin. Emerging patterns in these data vectors allow cities to identify trends, predict outcomes and customise services at an unprecedented level of granularity. However, this raises complex issues of privacy and autonomy as individual citizens become "vectors" whose behaviour is tracked and analysed without their direct involvement or awareness.

The behaviour of a single data vector may appear random or unpredictable, and it is. However, the aggregation of thousands or millions of such vectors makes it possible to identify patterns and trends that would otherwise remain hidden. This capability is in line with the principles of "big data" analysis, in which the analysis of vast data sets reveals emerging insights that transcend individual cases. However, the effectiveness and ethical implications of these insights require critical examination.

In the digital age, individuals act as "vectors" within complex networks, generating streams of data that contribute to the broader information fabric of the city. Each "vector" represents a unique data point within the urban data ecosystem, contributing to a detailed and continuously updated portrait of city life. Digital twins, in effect, represent a new form of documentation, relying on the automated generation of real-time data to create a continuously evolving "living document" of the city.

In the context of urban life, documentality emphasises -once again- the relationship between documentation processes and the organisation of city space.

Although the aggregation of data from millions of vectors enables the identification of behavioural patterns, it challenges the notion of authentic social understanding. Does the data-driven knowledge generated by digital twins really encapsulate the essence of urban society or does it merely construct a quantified approximation lacking the nuances that define human experience?
Furthermore, the use of predictive algorithms within digital twins raises ethical concerns regarding surveillance, bias and accountability, as they introduce complex issues of free will and determinism in urban settings. If a city's digital twin is able to anticipate collective behaviour with a high degree of accuracy, this could lead to preventive interventions that limit the autonomy of entire social groups and even personal autonomy, disproportionately affecting vulnerable populations or reinforcing existing social inequalities.
Such preventive measures, while ostensibly aimed at improving the safety, health or functionality of services, risk violating individual rights and freedoms, raising legal questions about the acceptable limits of predictive governance.

The integration of digital twins into urban governance frameworks represents a paradigm shift in the way cities are understood, managed and experienced. The digital twin not only reproduces physical urban spaces, but reconstructs (re-ontologises and re-epistemologises) the city as a network of data flows and algorithmic insights. This transformation offers significant advantages in some areas, including greater efficiency, but also poses profound challenges, both technical and ethical, that must be addressed to ensure that digital twins serve the public good rather than undermine democratic principles.

City management will be more efficient. Will it also be more effective? This question is mostly evaded and not explored in the current context of digitisation.
As we move into the era of smart cities and digital governance, the deployment of digital twin technologies requires a careful examination of the values, assumptions and consequences inherent in these systems. Can digital twins offer a truly holistic understanding of urban life, or do they represent a new form of surveillance and control, in which the identity of the city is shaped not by its residents, but by the algorithms that monitor and regulate them?

This thesis seeks to explore these questions by examining the legal, ethical and technical dimensions of twin digital technologies in urban contexts, with the aim of providing a comprehensive framework for understanding both their potential and limitations. Through a multidisciplinary analysis,

the following chapters will address the critical issues of data governance, privacy and the social implications of algorithm-driven urban management, contributing to the ongoing debate on the future of digital cities.

Chapter One provides an overview of the development and challenges associated with digital twin cities in Europe. As the urban population grows, cities face an increasing demand for efficient infrastructure and sustainable solutions. Such progress encounters a legal framework, especially in the European context, where overlapping national and EU regulations introduce complexity.

Two key questions are presented: (1) the minimum legal requirements for UDTs operations in the European city context and (2) the feasibility of using digital twins to address social problems, such as inequality, through predictive analysis and scenario simulation.

Focusing mainly on Europe, the study recognises the unique historical and regulatory aspects of digital twin implementations. By segmenting the digital twin lifecycle into design, management and evaluation phases, this research aims to establish a fundamental framework for digital twin applications in European cities, with implications for sustainable and law-compliant urban development.

Chapter Two outlines the methodology of the research, within the disciplinary framework of legal informatics, but open to an interdisciplinary approach. Focusing on secondary sources, the methodology is structured around a literature review of relevant laws, a legal analysis -especially international and supranational, identified as mag- areas- of the European legal framework, and scenario testing to explore how digital twinning frameworks can address urban challenges such as health crises, climate change and crime prevention.

Chapter Three offers a brief examination of the historical development and conceptual foundations of Digital Twin Cities (DTC) as a response to the complexities of the digital society. The "knowledge hypothesis", based on data analysis with predictive modelling to manage urban infrastructures and anticipate societal needs, is evaluated with an interdisciplinary approach that integrates philosophical, sociological, legal and computer science insights.

The Fourth Chapter deals with the reconstruction of the legal framework, starting from the international and supranational dimension of human rights, and then turns to the problem of social scoring and the assessments with which - in a sectoral and non-generalised way - regulation responds to the challenges of the digital.

Chapter Five, before the Conclusions, discusses the findings of the previous

chapters, proposing an adaptive framework to systematically reorganise the issue and better respond to the problem of growing inequalities in urban areas. Since the focus on the designing phase of a Digital Twin City, remain out of the scope of the present work to discuss the possible or actual use of the digital tool.

The advent of digital twins in urban environments, in fact, on the one hand reflects a deep-rooted and persistent need for decision-makers - be they political leaders or municipal administrators - to understand the complexities of the societies they govern. This need has remained constant over the centuries, as cities have always required accurate and up-to-date information to effectively manage resources, infrastructure and social dynamics. On the other hand, however, while the goal of understanding society may be timeless, the means and forms of such understanding have undergone significant transformations and are today not neutral with respect to the underlying idea of society.

A key issue running throughout this thesis is the possibility that digital twins create a new form of epistemic opacity, in which the mechanisms underlying urban knowledge become increasingly abstract and inaccessible. As cities increasingly rely on algorithmic analysis to inform policy and operational decisions, there is a risk that decision-makers place unwarranted trust in data-derived insights without fully understanding the assumptions or limitations of the algorithms involved. The opacity is increased because the data sources for digital twins are often biased or incomplete, potentially distorting urban reality. For instance, social media information can offer understanding of public opinion, yet it may also favor certain demographic groups over others. Likewise, predictive algorithms that learn from (past) data could inadvertently perpetuate current social disparities by relying on historical patterns influenced by systemic biases.

In light of these concerns, there is a need to critically assess the limitations and potential risks associated with the knowledge of digital twins. One of the main questions is whether the knowledge generated by digital twins constitutes a form of "hardening" society. Data formalism, far from being a liberating tool, becomes not only a form of monitoring that easily slips into both an "Orwellian" and a "Kafkaesque" control paradigm, to use Professor Giovanni Ziccardi's definitions in reference to the dystopian visions of total surveillance and bureaucratic dehumanisation described by George Orwell and Franz Kafka respectively, but also becomes a hetero-directed management of urban populations.
In this scenario, the digital twin could transform from a tool for improving urban life into a constant, pervasive surveillance-direction mechanism in which individuals are reduced to data points, monitored and regulated according to predefined criteria by opaque algorithms.

The ethical consequences of this possible alteration are significant. The extensive use of digital twins could lead to a scenario where city residents are constantly under surveillance, with their actions, likes, and movements being monitored and examined in real time. Despite proponents' belief that this data can enhance public safety, enhance service delivery, and reduce inefficiencies, they also express major worries about privacy, autonomy, and agency. Citizens could become users of algorithmic interventions without giving consent or fully grasping the process. Furthermore, using algorithmic decision-making could diminish the importance of democratic discussions in urban governance as intricate societal choices are more and more being handed over to data-driven systems that exist beyond customary political responsibility structures.

To sum up, digital twins are a groundbreaking development for cities to understand and react to urban changes, yet they also question conventional ideas of understanding, authority, and action. As urban governance decision-makers rely more on digital twins, it is crucial to carefully analyze the assumptions, biases, and ethical implications of these systems. Using digital twins in urban areas should be approached cautiously, balancing the advantages of data analysis with safeguarding individual rights. This dissertation will investigate the legal, ethical, and technological aspects related to the design of a Digital Twin City used for highly impacting intervention like managing inequalities. Terms like "Urban Digital Twins", or "Local Digital Twins", will be considered synonyms of "Digital Twin City" because of the novelty of the topic and because of early phase of the designing stage.
Through examining the philosophical and practical consequences of designing a Digital Twin City, this study seeks to add to the wider discussion on the impact of digital technologies on urban governance, exploring how digital twins can support a genuinely democratic and inclusive urban knowledge system.

Chapter 1

1.1. Urban Digitisation. Opportunities and Problems

Summary: 1.1.1. Urban Digitisation in Europe - 1.1.2. Urban Challenges - 1.1.3. European Cities and the Era of Globalisation - 1.1.4. Planning Cities in Uncertain or Absent Legal Frameworks - 1.1.5. Conclusions: Initial Research Questions

1.1.1. Urban Digitisation in Europe

Over the past century, the global population has increased enormously. This remarkable surge has not been uniform across rural and urban areas, as a significant demographic shift has occurred. The 8-billion world population[2] is, since 2018[3], an urban population of approximately its 55% (the exact percentage is debated, but all the indicators show a number above 50%)[4].
Some researchers, based at the European Commission, suggest that far more people live in urban areas than the numbers tell (although this does not seem to refer to Europe, for which the data is quite accurate)[5].
The numbers of this growth are cold and it is not easy to figure out their meaning. The urban population growth in Western Europe moved from 61.5% in 1950 to 75% in 2000; in Central Europe, from 34,6% to 60% (in these data the European Continent is divided only in Western and Central Europe - see more in note[6]. This division will be kept and used through all the thesis). The overall average percentage of the world passed from 29,1% to 46,8 the same time considered.

[2]See https://www.worldometers.info/world-population/ (link consulted on 10.01.2024)

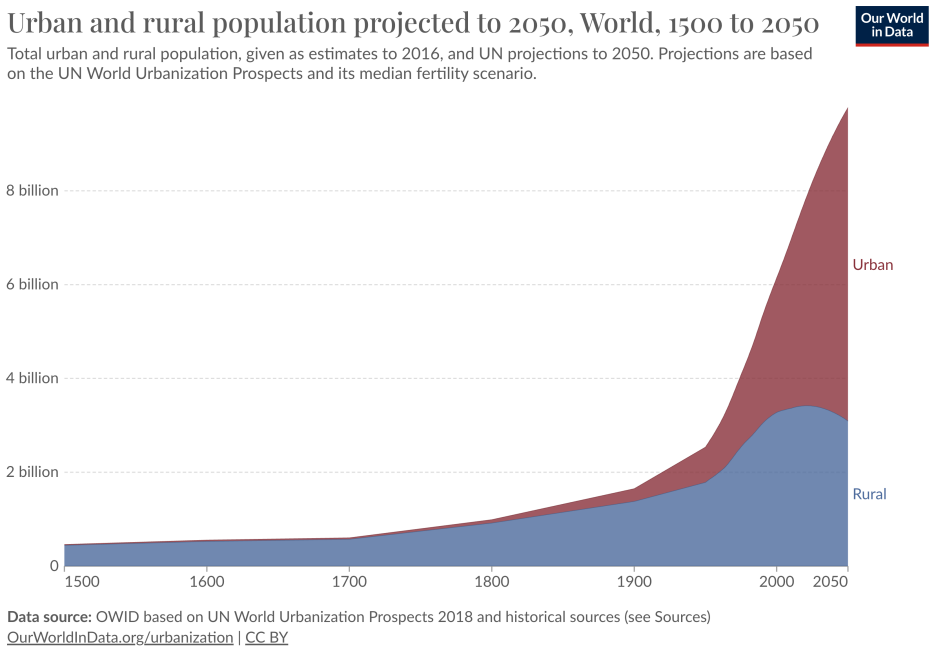
[3]See https://ourworldindata.org/population-growth (link consulted on 10.01.2024)

[4]For data and for the debate on why there are problems and disparities in calculating the exact percentage of the urban population, see https://ourworldindata.org/urbanization (link consulted on 10.01.2024).

[5]See https://www.reuters.com/article/us-global-cities/everything-weve-heard-about-global-urbanization-turns-out-to-be-wrong-researchers-idUSKBN1K21UU, as reported in https://ourworldindata.org/urbanization (both link consulted on 10.01.2024).

[6]Disclaimer: in the present work Europe, Western and Central Europe will be merged to indicate in a broader sense the European Continent, in its geographical integrity. It will include the European Union (used as a base reference for most of the legislation) and other countries geographically and historically European. See more on this at Paragraph 1.3.

A chart, available at the website ourworldindata.org/urbanization, can better describe the phenomenon.



- Figure 1[7]. Urban and rural population projected to 2050, World, 1500 to 2050.

This demographic milestone underscored a fact: cities are, more than before, the central hubs for economic, social, and political activities. Consequently, cities are the crossroads for problems and opportunities in what is referred to, by many sources, as "The Century of Cities"[8].
Cities serve as focal points for both difficulties and potential progress, because of their concentration of people and socioeconomic activities. They produce (or offer the changes for) inventive solutions, cultural interactions, and economic growth, while causing (or having to counter) challenges like sustainability concerns, strains on infrastructure, and inequalities in society. The complexity of the problem is shown by the fact that multiple narrations are allowed and can be found (even in the academic literature of different

[7]Data: OWID based on UN World Urbanization Prospects 2018 and others – processed by Our World in Data. Source: https://ourworldindata.org/grapher/urban-and-rural-population-2050 (link consulted on 10.01.2024).

[8]See, above all, Cities: The century of the city. *Nature* 467, 900–901 (2010). https://doi.org/10.1038/467900a.

disciplines) about the city. The topic is also interconnected with political debates, political measures and day-by-day management of the "constant" flow of life.

For the matter of the present research, an image is suggested as a preliminary point-of-view on the city: the city (and the territory[9]) as the "archive" of all the policies and projects for the society[10]. The idea of an "archive" is strictly connected with the idea of "documents", a fundamental (not fully studied) part of the creation of cities, especially in the European context (on the limitation of the present analysis to the European context see later in Paragraph 1.3.).

An important *caveat* seems necessary before continuing. There are at least two main topics whose importance is recognised, but which cannot be sufficiently developed in the present discussion for reasons of space, focus and argumentative coherence.

Firstly, the paradigm in which cities are "central hubs for economic, social, and political activities" causes the attraction of significant funds by cities. This often leaves rural regions, or even smaller cities, with insufficient resources. This exacerbates the problem of inequalities between citizens living inside and outside the cities. A major concern arises when funds are directed to cities to pursue "marginal gains" in attractiveness, or even sustainability, and more "substantial gains" are under-pursued outside the cities.

Secondly, the uncontrolled request for funding by the cities can"t be without implications. Digitisation sustained itself thanks to the possibility[11] of attracting enormous resources, both from the civil and the military sectors[12].

[9]For a definition of territory, will be allowed the reference to G. Suffia, *Geografia delle cyberwars*, Giuffrè Francis Lefebvre, Milano, 2018.

[10]The image is borrowed (adapted) from B. Secchi, *La Città Dei Ricchi e La Città Dei Poveri*. 1. ed. Anticorpi 36. Roma: Laterza, 2013.

[11]For example, the last years can be defined as a "spring of AI". See J. Maclure, "The new AI spring: a deflationary view". *AI & Soc* 35, 747–750, 2020, https://doi.org/10.1007/s00146-019-00912-z; Y. Shin, "The Spring of Artificial Intelligence in Its Global Winter," in *IEEE Annals of the History of Computing*, vol. 41, no. 4, pp. 71-82, 1 Oct.-Dec. 2019, doi: 10.1109/MAHC.2019.2922909; S. Olhede, and P. Wolfe, "The AI spring of 2018", *Significance* 15, no. 3 (2018): 6-7. See also the intervention by Elena Esposito at the "festivalfilosofia 2020" at linK https://www.festivalfilosofia.it/edizione-2020. Other refers to "AI summers" and "AI winters", as in the "Preface" of S. Abbady, *The EU Artificial Intelligence (AI) Act: A Commentary*, edited by Ceyhun Necati Pehlivan, Nikolaus Forgó, and Peggy Valcke. Alphen aan den Rijn: Wolters Kluwer, 2025.

[12]For the military involvement in the AI supply chain, see the research by Brookings al link: https://www.brookings.edu/articles/the-evolution-of-artificial-intelligence-ai-spending-by-the-u-s-government/, as reported by many news like https://www.gzeromedia.com/gzero-ai/the-ai-military-industrial-complex-is-here#toggle-gdpr (referring the famous farewell address of U.S. President Dwight D. Eisenhower on January 17, 1961). For other news, see https://time.com/6961317/ai-artificial-intelligence-us-military-spending/ or https://www.defenseone.com/technology/2024/03/military-funding-new-chip-designs-ai-era/394749/It (all link consulted on 04.02.2025). It sis worth

However, this "stream" can"t be assumed as a constant in the upcoming years and some form of spending management must be set for the cities' spending. This aspect requires recognising the correct priorities and setting the necessary measures, especially in an era of "Anthropocene"[13] and climate change.
These two issues, like others strictly connected to the relationship between cities and rural areas, will not be directly tackled within the present study (again, more on limitations of the present analysis in Paragraph 1.3.), despite helping us in introducing the topic of the connection between city and documents.
The concepts of "inside" and "outside" themselves, for example, are developed in our societies starting as the description of the spatial relationships of human settlements[14], then transferred in languages and then in documents, to come back in the city description and city's policies.
All this considered, in addressing the multifaceted challenges cities face, digital and communication technologies are often posited as key solutions. These technologies have the potential to enhance efficiency, promote sustainability, and improve the quality of urban life through what are commonly referred to as "smart city initiatives". However, solutions are not as simple as they seem in visual renderings and presentations.
European cities share some specificities and common characteristics that differentiate them from the rest of the world[15]. In addition, European urban digitisation has to deal with a complex regulatory landscape, made of:

- existing and proposed laws at a European supranational level (with different technical forms, even if recently often referred to as "Acts");
- existing and proposed laws at each national level, in diverse technical forms;
- a plethora of independent authorities[16] created both at the national and the supranational level, with various competences.

The regulatory landscape is further complicated by principles such as federalism, regionalism, decentralisation, subsidiarity and local autonomies,

remembering that even in Europe the military sector is excluded by the application of the EU's AI Act - Regulation (EU) 2024/1689.

[13]For "Anthropocene" see W. Steffen, J. Grinevald, P. Crutzen and J. McNeill, *The Anthropocene: conceptual and historical perspectives*, Phil. Trans. R. Soc. A.369842–867, 2011, available at link: http://doi.org/10.1098/rsta.2010.0327; S. Lewis, M. Maslin, "Defining the Anthropocene". *Nature* 519, 171–180, 2015. https://doi.org/10.1038/nature14258.

[14]See the intervention of Francisco Jarauta at the "festivalfilosofia 2017" (https://www.festivalfilosofia.it/edizione-2017).

[15]See later in par. 1.3.2.

[16]See G. Gitti (a cura di), *L'autonomia privata e le autorità indipendenti*, Il Mulino, 2006.

each term describing a different legal concept according to different and various legal experiences.
Additional layers of complexity come considering, for example, the roles of standardisation bodies. The matrix of this scenario, as it is just sketched but not detailed described, is luckily rich and multi-faced, due to a vibrant, yet painful, history of the European continent.
This complex regulatory landscape, experienced by scholars and legal practitioners every day, can be instrumental in covering most of the aspects of nowadays life, like setting a box of various tools to face every existing and upcoming situation, even unpredictable ones.
It is designed to (or it aims to be designed to) potentially address a broad spectrum of contemporary life aspects.
It is designed to (or it aims to be designed to) potentially adapt to ongoing and unforeseen changes, especially in the face of rapid technological advancements.
It answers (or it aims to answer) the regulative struggle of chasing technology and fast technological development[17].
However, the intricate nature of this regulatory landscape can lead to gaps and overlaps in legal provisions, as long as maintaining harmful, unregulated areas. These issues might not only cause confusion and uncertainty but could also create regulatory loopholes. Both the loopholes and the overlapping parts can result in a lack of protection for people, uncertainty, and even vulnerabilities that can be exploited by malicious actors[18]. This poses significant risks to both individuals, cities and States.
The present dissertation thesis will reflect critically on this complex regulatory landscape applied to cities in Europe. This analysis will be conducted from the vantage point of Legal Informatics, within the broader context of the Philosophy of Law. More on the interdisciplinarity of the problem, and the methodology, will be expressed below (see Chapter 2).
A key aspect of the thesis will be the exploration of regulatory approaches to the concept of a Digital Twin City in Europe. This emerging trend in urban digitisation represents a confluence of physical and digital urban environments, necessitating regulatory considerations.
While the study initially focuses on urban regulation, its implications are far-reaching. The findings and discussions could extend beyond the scope of city-specific regulations, potentially influencing broader domains.
This Chapter offers the background of the study and the context of the research.

[17] More considerations on this point will be expressed in the Chapter 4.

[18] These vulnerabilities can be described as "hybrid threats". More on this can be found in the work of the Hybrid CoE - European Centre of Excellence for Countering Hybrid Threats. See https://www.hybridcoe.fi/ (link consulted on 10.01.2024).

1.1.2. Urban Challenges

Digital Twin Cities can be a valuable tool to deal with various problems that are affecting cities. These problems can span from the traditional management of flows (traffic, energy, waste) to more complex societal problems.
However, concerns and criticalities are already recognisable, as for any "smart city project". In addition, these concerns are noticeable even though the technical framework for fully realised Digital Twin Cities is still in the developmental stages and the actual implementation of such sophisticated urban models is, at the moment of writing, in an early phase.
A critical reflection can be made through the lens of Legal Informatics precisely for the complexity involving the philosophical, legal, and technical conceptualisations of Digital Twin Cities. There is a notable interplay among these dimensions, and the resulting synthesis among these components crucially affects how Digital Twin Cities should be structured and governed.
In the context of this work, it is crucial to acknowledge and explore at least two key dimensions (among others). These sides for cities are:

- the relationship between "Cities and Inequalities";
- the relationship between "Cities and Digital Technology" (including particularly AI, but not limited to).

The first relationship will be considered first, as this work aims to offer a critical contribution on "if today technologies can solve cities" problems", and not on "what cities" problems can be solved with technologies". The answer is formulated, in fact, in a manner that presumes designing technologies according to the problems (in this case, inequalities), and not vice-versa. The matter of inequalities is pressing and urgent[19].
In fact, a significant trend in European cities, particularly those in Western and Central Europe, is the problem of inequalities in the perimeter of the city (so, "urban inequalities"), and among different cities. A proxy factor to visualise these inequalities is generally considered the "cost of living".
Data from sources such as the Cost-of-living Index[20] show that the "cost of living" is escalating, revealing a stark increase in the expenses associated with urban living. This develops into an increase in poverty and into a progressive expulsion of people from the cities to suburban, "gated"[21] or marginalised areas. Both the increase in poverty and the progressive expulsion from the city are detrimental to the quality of life in a city and

[19] see T. Vitale, ed. "City Divide. Fighting Urban Inequalities", Fondazione Giangiacomo Feltrinelli, 2024.

[20] See in "Cost of Living Index by City 2025" at https://www.numbeo.com/cost-of-living/rankings.jsp, and previous years (link consulted on 04.02.2025).

[21] See more later in 3.2.2.

to the rights of people.
This increasing unaffordability has profound causes that involve the general scenario in which cities are immersed today in Western Countries. Cities are pivotal players in shaping our era, with all the struggles we are experiencing in defining what our era is. Described as an era of transition, it is certainly an era of global interconnectedness[22] (on the point, see below at Par. 1.1.3.).
Cities are navigating the transition from industrial to post-industrial economies[23], often under conditions of austerity or, at least, with constraints in resources. Cities are increasingly burdened with limited resources while being tasked with addressing a growing range of responsibilities[24].
Ongoing challenges involving cities are on how to effectively carry out urban renewal without triggering gentrification[25], or how to address major transitions, such as responding to climate change, that see cities at the forefront of them.
This role involves balancing developmental needs with sustainability goals, but it could lead to the displacement of long-standing communities or exacerbate social divides. The theme of the inequalities poses democratic implications to cities, as it raises important questions about democratic access and representation[26], or on the purpose of efficiency in urban management.
This initial Chapter involves assessing whether the pursuit of efficiency serves the broader interests of urban communities and aligns with democratic principles, keeping in mind the diverse needs of all residents.
The second relationship is between "Cities and Digital Technology". As mentioned, the expression includes particularly the so-called Artificial Intelligence (or AI), but it's not limited to[27]. The incorporation of advanced

[22] See, among others, P. Khanna, *Connectography*, Roma: Fazi Editore, 2017.

[23] See R. Cucca, C. Ranci, "(Un)Equal Cities in Europe? The Challenge of Post-Industrial Transition in Times of Austerity", 2015.

[24] This is also the starting point of S. Weß, *Wie können digitale Zwillinge die Aufgabenerledigung deutscher Kommunen verändern? eine Analyse von Einsatzbereichen, Veränderungspotenzialen und Rahmenbedingungen* (How can digital twins change the way German municipalities perform their tasks?), edited by Jörn von Lucke. TOGI Schriftenreihe (The Open Government Institute), Vol. 24. Berlin: epubli, 2023.

[25] According to N. Finio, "Measurement and Definition of Gentrification in Urban Studies and Planning", in *Journal of Planning Literature*, *37*(2), 2022, p. 249-264. https://doi.org/10.1177/08854122211051603, the rediscover of the term started with British sociologist Ruth Glass in 1964. The term was popularised in more recent years by scholars like Richard Florida, not without merit and critics, for example in R. Florida, *The Rise of the Creative Class: And How It's Transforming Work, Leisure, Community and Everyday Life*, Basic Books, 2003, later edited in R. Florida, *Rise of the Creative Class–Revisited: 10th Anniversary Edition–Revised and Expanded*, Basic Books, 2012.

[26] see T. Vitale, ed. "City Divide. Fighting Urban Inequalities", Fondazione Giangiacomo Feltrinelli, 2024.

[27] Also depending on the imprecise definition of AI in doctrine and legislation. The definition of AI is not fully discussed in the present work, as the concept of Digital Twin

technologies, particularly AI, into urban environments raises a spectrum of concerns, alongside the immense possibilities. These apprehensions stem from the potential impacts on society, individual rights, and the democratic nature of cities. Some of these concerns are primarily debated among scholars, while others are more under-represented.

Among all, one of the primary is on Privacy and Data Protection. The extensive collection and processing of personal data in smart cities, often through sensors, IoT, and wearable devices, bring to the fore issues regarding privacy and the safeguarding of personal information. The risk that the use of AI will widespread[28] into massive surveillance poses a threat to fundamental democratic values. The more and more blurred border between personal and non-personal data[29], in the light of the inherent right to not be subject to decisions made solely based on automated processing, having significant legal effects (or similar) on the legal sphere of the individual[30], ask for specific policies and a deep reflection on the existing laws and their enforcement.

Less discussed, yet crucial concerns are the data quality and the accuracy of the data we use. This is particularly relevant because the trend is not only to inform decisions on data, but also to have automatic decisions taken autonomously on them (see, among all the possible examples, the case of highly automated flood barriers. In reality, most of the decision taken by human operators can rely solely on algorithms).

Another debated trend is the notion of "trading personal data for services". The topic is sometimes presented among scholars as a new frontier of possibilities, despite strong positions not in favour of this configuration[31]. It needs critical examination because of the connection with some digitisation projects, keeping in mind that personal data represent more than mere commodities and exercising a right generally should not entail costs other than administrative ones.

City already includes the state-of-the-art technology, AI or not.

[28] And it will happen, if unregulated, if accepted the premise posed by S. Zuboff, *Il capitalismo della sorveglianza il futuro dell'umanità nell'era dei nuovi poteri*. Roma: LUISS University Press, 2019.

[29] See I. Graef, R. Gellert, and M. Husovec. "Towards a Holistic Regulatory Approach for the European Data Economy: Why the Illusive Notion of Non-Personal Data Is Counterproductive to Data Innovation", SSRN Electronic Journal, 2018. https://doi.org/10.2139/ssrn.3256189. For other doctrinal analysis see M. Finck, F. Pallas, "They who must not be identified—distinguishing personal from non-personal data under the GDPR", *International Data Privacy Law* 10.1 (2020): 11-36.; D. Supriyadi, "The Regulation of Personal and Non-Personal Data in the Context of Big Data", *Journal of Human Rights, Culture and Legal System* 3, no. 1, 2023, p. 33–69. https://doi.org/10.53955/jhcls.v3i1.71.

[30] See GDPR Art. 22 par. 1.

[31] See the EDPB-EDPS Joint Opinion 2/2022 on the Proposal of the European Parliament and of the Council on harmonised rules on fair access to and use of data (Data Act), adopted on 4 May 2022.

The accuracy, integrity and updating of data are critical both when they are collected, shared, or sold, and when they are subsequently used in decision-making processes. The use of data as a proxy for other variables (e.g., using an address to infer creditworthiness[32]) can not only be problematic and lead to inaccurate or unjust conclusions, but it is also in violation of the often overlooked principle that personal data collected for a specific purpose should not be repurposed for other uses without explicit consent or explicit norms.

The theme of the use of proxies is particularly sensible when it comes to cities and inequalities, as is evident by the complexity of the human sphere and human life (the use of the temperature of a liquid as a proxy of the risk of inflammation is more close and reliable than, as mentioned, the use of the address as a proxy of creditworthiness). More consideration on the relationship between governing and causation and correlation will be spent in Chapter 3.

The increasing reliance on sensors for city management poses risks[33], as it could turn into a dependency on technologies that are (necessarily[34]) vulnerable to attacks and often even structurally fragile. A precise evaluation of alternatives, and their costs, is what is needed to balance vulnerabilities and solutions[35].

The focus only on technological solutions might divert attention and resources from other relevant problems, or from different solutions to address problems.

Last but not least, the trend of attributing *de facto* law enforcement roles to tech firms and private companies raises critical issues. Private companies may prioritise efficiency and profitability over effectiveness, leading to potential conflicts of interest and concerns over the privatisation of public functions. This could be particularly relevant considering the management of a Digital Twin City (DTC)[36].

Given these premises, urban digitisation and integration of AI in European cities is fraught with challenges but also abundant with opportunities. More words must be spent on researching the causes of cities" struggles. It seems

[32]See G. Halegoua, *Smart Cities*. Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

[33]As exemplified by incidents like the robotaxi traffic jam in San Francisco 2023, at link: https://www.theguardian.com/us-news/2023/aug/14/san-francisco-robotaxi-waymo-cruise-breakdown (link consulted on 02.02.2025).

[34]See for example L. Floridi, "The Unsustainable Fragility of the Digital, and What to Do About It", *Philosophy & Technology* 30, no. 3, 2017, p. 259–61. https://doi.org/10.1007/s13347-017-0280-4.

[35]Solutions could appear worse than the problem they tend to solve, as in the case of the electronic vote, which doesn't solve the problem of participation, as in W. Linder, S. Mueller, *Swiss Democracy: Possible Solutions to Conflict in Multicultural Societies*, Cham: Springer International Publishing, 2021. https://doi.org/10.1007/978-3-030-63266-3.

[36]See e.g. the Rio de Janeiro / IBM case, in G. Halegoua, *Smart Cities*. Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

primarily due to the context in which cities are demanded to operate and the lack of definition of a precise legal framework for digital technologies in cities.

1.1.3. European Cities and the Era of Globalisation

Over the last thirty years, the world has become increasingly fluid. This upheaval in the international context has many causes, spanning from the retirement of the State[37] to the emergence of the digital world[38].
In this scenario, cities emerged as a leading role for innovation and government, since the pressure for social demands didn"t decrease with the retirement of the State from intervention in the major societal debates, and new tools of governance made it possible to achieve practical results in very effective ways.
In this work, the causes of this situation will not be discussed in depth. The focus will be on the interplay between cities and digital technologies (in particular digital twin cities) as a way to deal with societal problems like inequalities. As it will be clarified better in the following parts, the reflection comes - but is not limited by - in the shadow of the UN Agenda 2030 Goal 11 ("Make cities and human settlements inclusive, safe, resilient and sustainable")[39].
Given this premise, it seems useful to continue the description of the scenario of the World, and Europe in particular, as a way to extract and analyse fundamental characteristics of this era. Underlining them will help in a better identification of the problems and it will help in presenting and questioning the proposed solutions.
The doctrine is divided when it comes to offering reconstructions and providing definitions of the present era. However, for the purpose of this work, the uncertainty can be reduced by following the efforts made by Contemporary History, accepting the state-of-the-art definition of "the era of globalisation"[40] for the present era.
Historians are debating about when to set a proper start for it, but they tend to agree on four main pillars. Globalisation, as it is understood also in

[37]The retirement of the State is a debated topic. See the program of the conference ICON-S 2022 at link: https://www.icons-italia.it/bologna-2022/ (link consulted on 04.02.2025).

[38]See, *ex multis*, L. Floridi, *La quarta rivoluzione*. Milano: Raffaello Cortina Editore, 2017.

[39]UN Agenda 2023 goal 11, at link: https://sdgs.un.org/goals/goal11 (link consulted on 02.02.2025).

[40]See https://www.treccani.it/enciclopedia/globalizzazione_(Dizionario-di-Storia)/ (last accessed 20.12.2024). The qualification of "globalisation" is debated, but more analysis remain outside from the scope of the present work. Some considerations reported in this work are drawn from the undergraduate course of "Contemporary history" (Corso di Storia contemporanea) from the University of Milan, a.y. 2019/2020.

the present work, is characterised[41] for:

1. Contamination
2. Complexity
3. Conflict
4. Cooperation

These elements seem self-explanatory. In brief, a better look will give more insights into what is at the core of what they mean also for the present work.

"Contamination" is the proper way in which things happen. The causality link is much more under stress nowadays when our knowledge touches the inner boundaries of things, and causality explanations in smaller systems seem not sufficient to enlighten bigger systems. The nature itself of the ecosystems calls into question the idea of a permanent contamination between things and their systems, in which each movement influences others in predictable and unpredictable ways. Some of them are explainable through causality, while others are included in the idea of an "ecosystem"[42]. Furthermore, more than ever in recent human history, a new way of explaining and connecting things is emerging, despite causality: the correlation, proper of some types of Artificial Intelligence[43].

"Complexity" is an intrinsic feature of a globalised world. It comes from the difficulties in describing and explaining a a-polar order, which resulted from the collapse of the ideologies and the end of the bipolar order at the end of the Cold War. It comes from our knowledge, which is expanding and we are exploring more and more complex branches of it. However, complexity is also what we find inter-disciplinary aspects of our research, and we have to deal with them. More comments on that are left to the methodological section of the thesis.

"Conflict" is, again, an inner state of globalisation. Sometimes not manifest, or not expressed in a traditional way (or "hybrid", as part of the doctrine tends to rely on this flexible adjective to propose a definition), is the

[41] Many frameworks present different elements. The "Cs" of globalization can vary depending on the framework being discussed, but the most common models highlight three or four key components, like "Communication", "Collaboration" and "Cooperation". Expanded frameworks, especially in critical studies, present very different components.

[42] See "ecosystem": in Biology, A biological system composed of all the organisms found in a particular physical environment, interacting with it and with each other. Also in extended use: a complex system resembling this (Oxford English Dictionary, at link: https://www.oed.com/dictionary/ecosystem_n).

[43] See also later at 3.2.4.

result of the conflicting movements moving in complexity. The sum of all the conflicts can result in a peaceful state, not through immobility, but through a balance of forces. It can result in a more dynamic environment in which the forces play harder to achieve stability. Conflict is, also, the conflict between norms and reality, or between principles and laws, or between different norms. Partially, the leading (and supplying) role played nowadays by Jurisprudence or Independent Authorities, especially in the Western World, is a way to find balances of forces in a state permanently characterised by the conflict.

"Cooperation", lastly, is an emerging characteristic of globalisation. It can be found in nature when multiple factors cooperate in producing an effect, but it is also, and more importantly, a recurrent mechanism of dealing with the fluid world. For the purpose of this work, cooperation is what is needed when different fields of knowledge come to a common effort to solve a problem, or it is the way cities developed to deal with challenges. In other words, to deal with the era of globalisation.

Given this lens, a series of factors led to recognising that nowadays cities are an exceptional vantage point for studying transformations of power and technological trends: they are what emerges from the problematic and chaotic image of an a-polar order, as an attempt to give a new perspective. They constitute, for some, the most dynamic long-term players in the attempt to reconstruct a multipolar world after the decade 1989-2001[44].
A possible multipolarity of the world is expressed, above all, in the multipolarity of cities, which are today the main vectors of transformation and the main vectors of change in their leading role within their respective States[45].

[44]The reconstruction of the transition after "The 1989" ("L'Ottantanove", in the definition and use of Prof. Luigi Bonanate in the book L. Bonanate, *Anarchia o Democrazia. La Teoria Politica Internazionale Del XXI Secolo*, 1a edizione. Quality Paperbacks 464. Roma: Carocci editore, 2015), even if interesting, it is not the topic of the present work. Most scholars and analysts agree on describing the decade after the collapse of the Cold War's bipolar order as a failed attempt by the US to create a "unipolar order". This transition was described in many ways, more or less involving a horizon of homologated peace (F. Fukuyama) or a prospect of clashes (S. P. Huntington), but received also a political imprimatur from the "Wolfowitz Doctrine" ("Defense Planning Guidance for the 1994-99", dated to February 18, 1992), named after the Secretary of Defence Paul Wolfowitz. According to this "doctrine", the international order post-1989 would have been dominated by the United Nations Organisation, with the "operational direction" of the United States of America, the only hegemonic power capable of intervening to pacify any conflict situation and even of being able to foresee them thanks to a capillary and global information collection. It is widely recognised that the attacks to the United States of America on September 11, 2001, declared the unipolar order as a failed attempt. For a summary reconstruction of the debate and its implications, please refer to G. Suffia, *Geografia delle cyberwars*, Giuffrè Francis Lefebvre, Milano, 2018.

[45]See P. Khanna, *La rinascita delle città-Stato*, Fazi Editore, 2018, and P. Khanna,

Generally, norms or documents don"t attribute to cities this role. However, it is possible to recognise how many opportunities and problems of the world in the Era of Globalisation find in cities a first point of intersection. A fertile ground to build on this intersection can so seen in helping cities to take this opportunity.
From this perspective, then, dealing with the digitisation of the city means not only reasoning from the perspective of the opportunities that technological innovation offers, but also reasoning about how innovation can itself be a problem creator for the city. Maintaining an approach solely to innovation as an opportunity, in fact, could result in an exacerbation of the city's problems.

1.1.4. Planning Cities in Uncertain or Absent Legal Frameworks

Today, cities are studied and analysed under multiple disciplines, many of which reflect critically with respect to city problems, and how solutions are now proposed in the sense of innovation and success. However, even with the numerous relevant voices in most of the scholars" communities, issues of cities are still read as an "absence of innovation". Precisely, a lack of innovation and success, to be filled through greater innovation and success[46]. The definition of this vision is the first obstacle. The umbrella term often used to describe it was for decades, and it is still very popular, the idea of a "Smart City". As Breuer and Pierson (2021) write:

Over the past couple of decades, the concept of a "smart" city has become central in various domains and the application of associated ICT within urbanisation has become inevitable. In 2011, IBM officially registered the term as its trademark (Söderström et al., 2014). Previously, scholars had been discussing concepts of wired (Dutton, 1987), digital (Ishido, 2002), telecommunications (Graham & Marvin, 1996), informational (Castells, 1996), or intelligent (Komninos, 2002) cities and urban informatics (Foth, 2009) with similar connotations; announcing changes to urbanisation based on ICT for better or worse.[47]

In years, the term "Smart city" emerged as a paradigm of efficiency and innovation, even reaching a mainstream debate.

Connectography, Fazi Editore, 2017.

[46] See, *ex multis*, P. Allmendinger, *The Forgotten City. Rethinking Digital Living for Our People and the Planet.* Bristol: Policy Press, 2021; A. Courmont, P. Le Galès. *Gouverner la ville numérique. La vie des idées.* Paris: la Vie des idées.fr PUF, 2019; G. Halegoua, *Smart Cities.* Cambridge, MA: The MIT Press Essential Knowledge series, 2020; E. Granata, *Placemaker: Gli Inventori Dei Luoghi Che Abiteremo.* Passaggi Einaudi. Torino: Einaudi, 2021.

[47] See J. Breuer, J. Pierson, "The Right to the City and Data Protection for Developing Citizen-Centric Digital Cities". *Information, Communication & Society* 24, no. 6, 2021, p. 797–812. https://doi.org/10.1080/1369118X.2021.1909095, pag 798.

For the purposes of this work, it is important to consider the implication of the term "smart city" in the Law.
In the European Digital Strategy, smart cities projects are linked with *well-being of its inhabitants, businesses, visitors, organisations and administrators by offering digitally enabled services that contribute to a better quality of life*[48]. The tautology is explained with examples, like: better management of resources, like energy or water; monitoring and reducing local traffic and pollution; more interaction and responsiveness by the city administration; more engagement of citizens in decision and policy-making; more ability to address problems like safety or the ageing population.
This "vision" clearly indicates a bottom-up approach that requires first to identify the problem, and later design the solution. This approach is not always respected in practice[49].
The "smart city paradigm" is also not free of problems and contradictions in a broader analysis. it is part of the literature the fact that the smart city vision leaves some criticalities on the table:

- While the indicator of the "hours saved" is one of the emerging one[50] to measure the impact of smart cities projects, it is measured a gap in life expectancy even among cities in the same State, due to inequalities[51].
- These problems are often imagined to be answered by better organisation or better management of resources. It seems, however, that these "problems caused by success" are being sought to be answered with "greater success"[52].

Critical smart city studies point out that "for every San Francisco, Berlin or New York there is a Baltimore, Sunderland or Leipzig, scrambling for investment and growth and facing severe social and economic problems"[53].
The digital society has evolved, in fact, within what are now the most advanced countries on the planet in terms of economy and development, increasing conditions within them that are still unknown elsewhere. In "smart cities", conditions are experienced those other types of society do not allow,

[48]See https://digital-strategy.ec.europa.eu/en/policies/smart-cities-and-communities (consulted on August 24, 2023).

[49]See *ex multis*, G. Halegoua, *Smart Cities*. Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

[50]See, as example, Kalasatama (Helsinki)'s "One more hour a day", https://fiksukalasatama.fi/en/building-blocks/one-more-hour-a-day/; or "How do Estonians save annually 820 years of work without much effort?", https://e-estonia.com/how-save-annually-820-years-of-work/ (both link consulted on 04.02.2025).

[51]See P. Allmendinger, *The Forgotten City. Rethinking Digital Living for Our People and the Planet*. Bristol: Policy Press, 2021, p. 7.

[52]See "optimistic view" in P. Allmendinger, *The Forgotten City. Rethinking Digital Living for Our People and the Planet*. Bristol: Policy Press, 2021, p.7.

[53]see P. Allmendinger, *The Forgotten City. Rethinking Digital Living for Our People and the Planet*. Bristol: Policy Press, 2021, p. 8.

even though they use ICT technologies in various forms. Outside "smart cities", there are important limits to development, bordering on exclusion from it[54].

However, areas of exclusion exist even within the advanced countries themselves, in the form of "inequalities" (increasingly growing), and in the form of un-sustainability. These facts ask questions about the "smart city concept" and how it is applied to cities. Studies suggest the necessity to evaluate the current model of development and rethink some of its most recognisable forms, such as the digitisation applied to cities.

One proposed solution could come from Big Data. Described as one of the biggest disruptions of the 2010s, Big Data is at the base of the so-called "data-driven society"[55]. The possibilities offered by the use of data are numerous, but they are not limited to numbers. The technological advancement brought about by information technology, in fact, is accompanied by increasing automation in all areas of human life and an extraordinary production of documents[56].

In this point of view, the technological paradigm of "big data" is not only a matter of historical logs that we recorded, but the core of the "centrality of information"[57] in our era. In this scenario, for example referred as the infosphere[58]), there are not only a large amount of data available, no longer analysable by humans without the help of machines, but data mainly produced by algorithms and sensors.

This paradigm presents a major challenge for social sustainability, understood here as economic development with protection of fundamental human rights[59], as it cannot be achieved without digital technology.

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[54]See L. Bozzo, "I dilemmi della sicurezza nell'era digitale", in S. Marchisio, U. Montuoro (eds.), *Lo spazio cyber e cosmico*. Dual use resources for the Italian system in Europe, Giappichelli, 2019.

[55]See V. Mayer-Schönberger, K. Cukier. *Big Data: A Revolution That Will Transform How We Live, Work, and Think*. First Mariner Books edition. Boston: Mariner Books, Houghton Mifflin Harcourt, 2014.

[56]See M. Ferraris, *Documentalità: Perché è necessario lasciar tracce*, Laterza, 2014; M. Ferraris, *Postverità e altri enigmi*, Il Mulino, 2018; M. Ferraris, *Documanità: filosofia del mondo nuovo*. I Robinson. Bari: GLF editori Laterza, 2021.

[57]See Development, Concepts And Doctrine Centre - Ministry Of Defence UK, "Global Strategic Trends: The future starts today", 2018. Available at: https://www.gov.uk/government/publications/global-strategic-trends.

[58]See L. Floridi, *Il verde e il blu*. Idee ingenue per migliorare la politica, Raffaello Cortina, 2020 and L. Floridi, *La quarta rivoluzione*, Raffaello Cortina Editore, 2017, formerly *The Fourth Revolution*: How the Infosphere is Reshaping Human Reality, Oxford University Press, 2014.

[59]For a more precise definition, reference can be made to "sustainable development", initially introduced in the so-called Brundtland Report published in 1987 by the World Commission on Environment and Development (WCED). Broadly speaking, sustainable development is defined as "development that meets the needs of the present without compromising the needs of future generations to meet their own needs" (WCED, 1987). Following, the UN Conference on Environment and

The study of the legal and regulatory context of social sustainability can greatly benefit from the study of "big data" and its use. To deal with these difficulties, cities are looking at new paradigms of development. In this sense, projects are manifold and sometimes open to all-encompassing scenarios of city management, such as in the case of the so-called "digital city twins" (despite not all advanced and omni-comprehensive smart cities projects being explicitly called "digital twins", like in the case of the Milan "Digital Urban Ecosystem"[60]).
For the purpose of this work, *Digital Twin Cities* are highlighted as the new frontier in smart cities studies and considered -as they are at the time of this writing- one of the most advanced stages in cities" development. Any urban system characterized by a close connection between physical and digital dimensions, an exchange of data through systems such as APIs, an integration of digital services and technologies, will be considered for the purposes of this research. The term "digital twin city" will be used generally, while specifying where possible in what meaning and with what level of maturity. Where the system analyzed cannot be properly defined as a "digital twin" this will be indicated, although its analysis will continue in the interest of this work. But what is the legal framework behind a smart city, or more precisely a Digital Twin City in Europe?
The debate around smart cities today is conditioned:

- by the design nature of most applications.
- by the questions on the clarity and the coherency of the legal framework around innovation and digitisation.

Smart cities today thrive on projects that are implemented in circumscribed realities (often in the size of neighborhoods, if not even in the size of individual buildings or services). Often such projects do not seem to be able to be replicable outside the context in which they are piloted. The very

Development in 1992 stressed the importance of the integration of environmental and social concerns into all development processes to achieve socially inclusive and environmentally sustainable economic growth (Sachs, 2015). For the present research project, "social sustainability" is seen here for its implications in "equity", "accessibility" and "participation", three elements at the base of the "institutional stability". See Policy Department for Economic, Scientific and Quality of Life Policies, "Social Sustainability. Concepts and Benchmarks", April 2020 (document requested by the European Parliament's Committee on Employment and Social Affairs), available at link: https://www.europarl.europa.eu/RegData/etudes/STUD/2020/648782/IPOL_STU(2020)648782_EN.pdf (link consulted on 03.06.2021).

[60] See the early 2025 update by the Municipality of Milan, titled "Smart City e sviluppo del Gemello Digitale esteso", https://www.comune.milano.it/aree-tematiche/pnrr-fondi-europei-e-nazionali/pn-metro-plus-2021-2027/le-priorita/smart-city-e-sviluppo-del-gemello-digitale-esteso, in the PN Metro Plus 2021-2027 plan; more details at "Ecosistema Digitale Urbano Gemello Digitale", update March 2023, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.comune.milano.it/documents/20126/464296132/2103230
fb64-4f16-27d0-fb09b5c05599?t=1685959992339 (both link consulted on 04.02.2025).

attributes that make these smart city projects thrive in their environments of origin often make them non-transferable to different urban landscapes. What thrives in one neighborhood may fail when transplanted to another city district, or even to a different building within the same city. This lack of replicability creates a state of fragmentation in the smart city ecosystem, which poses significant obstacles to its sustained evolution and the development of standards.

Fragmentation can be seen as an inevitable product of smart city projects. If this were the case, there would be a problem of inefficiency to consider for the concept itself, requiring the development of similar projects even for similar contexts, leading to redundant efforts and increasing resource consumption. Second, fragmentation would hinder interconnectivity, making it difficult for disparate projects to join into a cohesive citywide smart ecosystem. This fragmented landscape complicates urban management and hinders the realisation of smart city goals.

Perhaps most troubling is the financial toll imposed by this fragmentation. The inability to replicate successful projects across the city results in substantially increased costs. Initial investments in research, development, and implementation are duplicated, while ongoing maintenance becomes a maze of disparate systems, further driving up operating expenses. Ultimately, the promise of sustainable and cost-effective urban innovation remains elusive in the face of this replicability challenge.

When the various components of a smart city, such as infrastructure, data systems and services, are developed independently or without proper coordination, there is a general lack of integration and interoperability.

It often happens that different systems coexist within a single State, or within a coordinated system such as a European one. This makes it difficult to optimize the use of resources and share data.

Often this fragmentation requires additional investment to implement interchange and linking methods for different elements. These additional efforts are costly and can put a strain on the financial resources allocated to smart city projects, since they do not produce a new service, but are a revision (sometimes an almost *ex-novo* remake) of the same previous service.

It is as necessary as ever to establish the optimal legal frameworks, which allow technical standards not only to be developed but also actually used, with the aim of harmonisation and collaboration among various stakeholders.

Such measures can help mitigate the financial burdens associated with fragmented development and promote the efficient realisation of smart city goals.

At times, the fragmented implementation of smart city projects can result in "unintended effects"[61]. This highlights the importance of comprehensive

[61] See the Algorithm case in Italian schools, at link https://algorithmwatch.org/en/algorithm-school-system-italy/ (last accessed 20.09.2024).

planning and a holistic approach to smart city development. Careful consideration of the potential consequences and interdependencies between various aspects of a smart city is crucial to avoid such unintended and adverse outcomes, in the city and in the neighbouring areas.
Legal informatics can play a role in addressing these challenges by developing frameworks and regulations that account for the complex, interconnected nature of smart city projects, thereby helping to mitigate unintended effects and promote the positive impact of these initiatives. New resources can now come from comprehensive projects like "digital twin cities".
On the side of the Law, the underutilisation of digital technology, such as AI, often stems from the absence of a legal framework, particularly when it comes to public sector initiatives[62].
A significant distinction arises between the impact of a strong and clear legal framework and its absence. The presence of a robust legal framework not only impedes but also serves as a vital catalyst for the establishment of a robust digital infrastructure. Conversely, when such a framework is missing, a digital landscape takes shape that starkly contrasts the intended outcome.
This landscape consistently exhibits characteristics that include fragility, fragmentation, disorganisation, limited openness, a lack of transparency, and, most crucially, a glaring absence of interoperability[63]. These disparities underscore the profound effect of legal frameworks on the digital realm.
A clear legal framework is instrumental in defining the roles and responsibilities of all involved parties throughout the development of complex infrastructures. It ensures that the approach is meticulously structured, well-organised, and entails comprehensive planning methodologies, sound economic strategies, and deliberate design considerations right from the project's inception[64].
On a methodological perspective, Legal informatics can play a role addressing this "description problem", a term that has stayed on in Nordic legal informatics since the late "80s and and taken up by Seipel in his writings[65] (on the methodological aspects, see later in Paragraph 2.1.).

It is evident how in sensitive contexts a "simulation" can be a non-resolving, but certainly important element for an *ex ante* evaluation of the innovation to be introduced.

[62]See Luciano Floridi, lesson 2022.06.29, Bologna Seminars.

[63]See Giovanni Ziccardi on the relationship between infrastructure and legislation, in https://ziccardi.ghost.io/il-futuro-delle-professioni-e-le-professioni-del-futuro/amp/ (link consulted on 09.02.2024).

[64]See Giovanni Ziccardi on the relationship between infrastructure and legislation, in https://ziccardi.ghost.io/il-futuro-delle-professioni-e-le-professioni-del-futuro/amp/ see also at the same link what India has done (link consulted on 09.02.2024).

[65]See in P. Seipel, "IT Law in the Framework of Legal Informatics", Scandinavian Studies in Law, 2004, p. 31–50. quoting Mads Bryde Andersen in Andersen, Mads B., EDB og ansvar. Studier i edb-erstatningssrettens beskrivelses-problematik, Jurist- og Økonomforbundets forlag, Copenhagen 1988, p. 38.

Following this part of the doctrine, Seipel highlights four tasks involved in the "description problem". Legal Informatics can pose those tasks and try to suggest answers, leading to a better understanding of the legal framework necessary to be adopted for an optimal result:

- Adjusting, developing and bringing close legal and technical concepts.
- Describing the IT environment in legally relevant ways.
- Investigation of overall frameworks and wholes.
- Shaping of legal regulation according to the principle of "viable steering models".

The task of adapting, developing, and approximating legal and technical concepts, Seipel writes, can mean many different activities, such as detailed investigations and critical assessments of all kinds of formal and legal requirements that can comfort, modify, or hinder the implementation of ICT (thus including AI) among public authorities and between them and citizens. Particularly the task of adapting and developing legal and technical concepts becomes crucial in cities development, as the city governance and regulation must adapt to the principle of "viable steering models"[66] capable of orchestrating harmonious urban development.
Only by reconciling the paradox of innovation in confined contexts with the need for replicable, interconnected solutions can smart cities truly fulfil their potential as models of urban excellence.
As mentioned, the analysis in the current dissertation has regard to finding relevant overlaps and loopholes in this complex interplay between supranational, national and local regulations, that can undermine safeguards and rights.

1.1.5. Conclusions: Initial Research Questions

It is debatable if smart city projects are successfully dealing with the problems they aim to solve. Moreover, can they (as they are) be used to deal with complex urban problems like inequalities? From these questions, many others arise in the context of smart cities and Digital Twin Cities:

- What are the essential characteristics that a robust legal framework should possess for the management of complex ICT adoption projects, such as digital twin cities?
- What principles must this legal framework adhere to in order to ensure

[66] See in P. Seipel, "IT Law in the Framework of Legal Informatics", Scandinavian Studies in Law, 2004, p. 39: *The notion of "viable steering models" is based on the proposition that legal norms may be viewed as steering models of reality.* See also P. Seipel, "Computing Law : Perspectives on a New Legal Discipline", 1977, p. 203-205.

the protection of the rights of citizens and the community at large within the context of smart city projects?

- What legal principles should guide the development of regulations and policies for managing data privacy and security in the context of smart city initiatives?
- How can legal frameworks be adapted to address the challenges of data ownership and control in smart cities, especially regarding the vast amount of data generated and collected?
- What are the key legal considerations when defining liability and accountability in the event of AI-driven decision-making impacting citizens within a smart city?
- In the context of smart cities, what are the legal implications of using AI for traffic management and public safety, and how can these technologies be ethically regulated?
- How can legal informatics assist in the development of legislation that promotes responsible AI and data usage in the public sector, while maintaining transparency and accountability?
- How can the adverse effects of smart city projects be minimized or simulated to reduce costs, facilitate anticipatory analysis, and make them more widely accessible to the public?
- What measures need to be implemented to establish a comprehensive GELSI (Governance, Ethics, Legal, Social, and Interoperability) analysis system for simulation projects in smart cities, ensuring transparency and accountability in their implementation?

The definition of the research question becomes, for the purpose of this dissertation, expressed as follows: How digital twin cities can be used to respond to social problems and inequalities?

1.2. Research Problem and Questions

Summary: 1.2.1. Research Problem and Questions: An Introduction - 1.2.2. LAST-jd: An Interdisciplinary Perspective - 1.2.3. Defining the Core Research Problems and Formulation of the Research Questions - 1.2.4. Significance of the Research Questions

1.2.1. Research Problem and Questions: An Introduction

This paragraph aims to clearly define the research problem, focusing on the legal complexities and challenges posed by the integration of Digital Twin Cities into urban planning.
It establishes the groundwork for the subsequent exploration of specific questions, as the problems highlighted in the previous Paragraph 1.1. requires a deeper analysis of a series of aspects here summarised:

- an examination of how cities integrate digital twin technologies into their existing urban frameworks. This includes a discussion on the technological requirements, data management, and the role of IoT (Internet of Things) in enriching the digital twin's capabilities.
- an exploration of how digital twins serve as virtual replicas of physical cities, allowing for detailed simulation and analysis.
- a discussion on how Digital Twin Cities can influence urban development, focusing on their potential to provide real-time data and predictive analytics. This encompasses the assessment of urban infrastructure, traffic management, environmental monitoring, and more.
- a highlight of the unique position of Digital Twin Cities in addressing urban social challenges. This involves analysing how these digital tools can identify, model, and potentially mitigate urban social problems and inequalities, such as poverty zones, unequal access to resources, and social unrest.

The lifecycle of a Digital Twin City project can be segmented into at least three phases: design and preparation; utilisation and management; evaluation and revision. Those phases can be performed in cycles, as some projects explain like the Bologna "Gemello Digitale"[67].
For the first phase (design and preparation), it is necessary to analyse the Interplay Between Digital Tools and City Development, in particular:

[67] Lifecycle Gemello Digitale di Bologna, in official presentation (https://www.comune.bologna.it/notizie/gemello-digitale) and Longo et al., "Gemello digitale urbano e modellazione energetica. Esperienze e analisi di casi d'uso | Urban Digital Twin and Energy Modeling. Experiences and case study analyses", *AGATHÓN 15*, 2024, 160–69. https://doi.org/10.19229/2464-9309/15122024.

- Identifying applicable norms in the phase of drafting a Digital Twin solution for a city. This is fundamental to correctly identify actors and stakeholders and to set a correct balance of powers. it is also fundamental to ensure accountability and compliance. it is necessary to address the legal and ethical implications of using digital twins in urban planning. This includes privacy concerns (*privacy by default and by design*[68]), data security, and the legal frameworks governing the collection and use of urban data.
- Identifying Social Inequalities. To use digital twins to address social problems like inequalities, it is preliminary necessary to identify areas of social inequality by analysing diverse data sets, ranging from economic indicators to healthcare access.

For the second phase (utilisation and management), it is necessary to analyse the practical usage of a DTC project, in:

- Dealing with real-time data ("hot data"): Exploring how digital twins can have access to and use real-time data for decision-making, providing city planners and policymakers with applicable predictions or taking direct decisions (but with the necessary limitations and safeguards).
- Simulating Solutions: Exploring how digital twins can simulate various interventions and policy changes, providing city planners and policymakers with insights into potential outcomes before implementing real-world changes.

For the third phase (evaluation and revision), it is necessary to discuss the challenges in implementing and maintaining Digital Twin Cities, such as technological limitations, funding, and public acceptance, as well as the opportunities they present for sustainable and inclusive urban development.

1.2.2. LAST-jd: An Interdisciplinary Perspective

The analysis of this dissertation will be conducted as a part of the PhD in "Law, Science and Technology" (LAST-jd programme), established in a consortium of universities in Europe with the University of Bologna at its centre. It involves an interdisciplinary approach.
Highlighting the interdisciplinary nature of legal issues in Digital Twin Cities intersects several domains and fields of knowledge, such as technology law, urban planning law, privacy law, and environmental law. The combination of the two approaches (law/legal informatics and computer science) is sup-

[68] See GDPR, art. 25, par. 1 and 2, and for example G. Bincoletto, *La privacy by design: un'analisi comparata nell'era digitale*, Università di Trento. Dipartimento di scienze giuridiche, 2017. https://doi.org/10.15168/11572_177733.

posed to give a deeper analysis to this present work and to help to have a better understanding of the problem.
More about the interdisciplinarity will be discussed in Chapter 2.

1.2.3. Defining the Core Research Problems and Formulation of the Research Questions

From the consideration expressed in the previous Paragraphs that Digital Twin Cities (or Smart Cities projects in general) are about to be used (and in many cases are used) to address social problems and inequalities, this thesis aims to analyse the Current Legal Frameworks Governing Digital Twin Cities to have a deeper understanding on how these tools work and might work complaint to our laws. To do so, it will be necessary to:

- Explore the existing Legislation: Have a comprehensive analysis of existing legislation at both the national and international levels that governs the implementation and operation of Digital Twin Cities. This includes data privacy laws, urban development regulations, and specific statutes related to digital infrastructure.
- Identify legal challenges in the Digital Twin Cities context: Identify legal challenges unique to Digital Twin Cities, such as data ownership, usage rights, and the applicability of existing laws to virtual simulations and predictive modelling in an urban setting.
- Conduct a comparative analysis: Drawn comparisons with other technological fields where legal frameworks have evolved or are in the process of evolution, to understand potential trajectories for legal development in the context of Digital Twin Cities.

The exploration appears to be vast and open to many directions. A drive in this analysis is the particular aim of highlighting gaps or ambiguities in these legal frameworks, characterised by particular choices in their socio-technical design[69]. Three more specific Research Questions emerge as:

- Question 1: What Constitutes the Minimum Legal Framework for Operating a Digital Twin City in the EU?

To answer this question it appears to be necessary to conduct an examination of EU directives, regulations, and standards that must be complied with for the legal operation of a Digital Twin City. It will conduct also an analysis of the intersection between urban planning laws, technology laws, data privacy regulations, and their implications for Digital Twin Cities.

[69] see G. Viale Pereira, M. A. Macadar, and M. Gregianin Testa. "A Framework for Understanding Smart City Governance as a Sociotechnical System". In *Proceedings of the 9th International Conference on Theory and Practice of Electronic Governance*, 384–85. Montevideo Uruguay: ACM, 2016. https://doi.org/10.1145/2910019.2910061.

- Question 2: Exploration of Existing Legal Norms and Regulations Affecting Digital Twin Cities.

To answer this question it appears to be necessary to identify and examine key legal norms and regulations that directly or indirectly impact the operation and development of Digital Twin Cities. Specifically, it will assess the adequacy of these norms in addressing the unique challenges posed by digital twin technology in urban settings.

- Question 3: How Do Digital Twin Cities Navigate the Complexities of Urban Planning While Adhering to Legal Standards?

To answer this question it appears to be necessary to explore the strategies employed by existing Digital Twin Cities to comply with legal standards while addressing complex urban planning challenges. The focus will be on Case study analysis on legal compliance, particularly in scenarios involving data privacy, public engagement, and infrastructure development.

1.2.4. Significance of the Research Questions

The result of this work is expected in the identification of gaps or ambiguities in current legal frameworks that may not fully address the specificities of Digital Twin Cities. This includes areas such as liability for inaccurate simulations, the legal status of virtual representations, and the enforcement of regulations in a digital context. This result is at the base of a discussion to explore potential evolution in regulation. The legal frameworks need to evolve alongside technological advancements, ensuring that they are adequately equipped to handle the complexities of Digital Twin Cities.
These questions are particularly relevant to the field of urban development and legal studies because they can offer an important occasion for understanding how the regulation of the Digital Sector is impacting not only individuals but also societies. In the form of cities, it is possible to explore the balances between the protection of individuals and the protection of collectivities and collective values; between the freedom to conduct business and the protection of people, especially of those who are part of vulnerable categories.
The findings could contribute to sustainable and equitable city planning, bridging the gap between rapid technological advancements in urban development, specifically Digital Twin Cities, and the evolving legal frameworks. Linking Technology and Urban Legal Frameworks, in fact, can offer a different point-of-view and useful insight on how to ensure that technological growth aligns with legal, ethical, and social norms. By addressing legal issues related to Digital Twin Cities, the research contributes to creating more resilient, efficient, and equitable urban spaces.
Potential contributions consist in advance knowledge in the legal and urban

planning fields, especially in the context of rapidly evolving digital technologies. This is relevant for the Policy and Legal Discourse in areas like data governance, privacy, and urban planning.
The existing body of knowledge in both legal and technological domains might be insufficient to address future challenges when technological solutions are impacting society in unexplored ways. It might be argued that not every new technology requires new legislation. it is certainly true that every new harm requires proper legislation to deal with. This research could inform future legislation and policy-making, particularly in the European context, understanding and explaining the legal landscape of Digital Twin Cities. This includes the development of guidelines and standards for the implementation and management of Digital Twin Cities.
Stating the potential impact of this research across various disciplines, including law, urban planning, data science, and public administration, it could also contribute to a better understanding of how to develop (or not) studies in these fields.
This dissertation believes that the adoption and integration of digital technologies in city planning cannot be done fully without consideration on wide-ranging implications. Those considerations can be brought to the discussion by the Law, and designing the Law on Digital Twin Cities is as necessary as engineering the technical elements of hardware and software to run the DTC itself.
Discussing the potential for this research to drive the evolution of legal frameworks could ensure that they remain relevant and effective in the face of technological innovations. Considering the broader implications of the research, exploring how the findings could be applied or adapted in different European contexts could contribute to a global discourse on the legal and ethical aspects of Digital Twin Cities.
This paragraph has shown how this thesis aims to identify and define the core legal and regulatory challenges associated with the implementation and operation of Digital Twin Cities. It set the foundation for exploring how these challenges can be addressed to facilitate sustainable and socially equitable urban development through digital innovation.
It underscored the broader significance of the research questions, positioning them within the larger framework of sustainable urban development, legal evolution, and interdisciplinary impact.

1.3. Implications and Limitations of the Study

Summary: 1.3.1. Implications of the Study - 1.3.2. Limitations of the Study

1.3.1. Implications of the Study

The considerations expressed in the previous paragraphs serve as a way to draft some initial implications.
Smart city studies rarely investigate the legal frameworks behind the creation of a smart city, while law studies tend to consider the smart city as a whole an autonomous concept. The purpose of linking the "smartification" with a series of precise legal provisions and obligations, at least on a certain level, could suggest new pathways and perspectives on the studies.
The study aims to broaden the perspective beyond national borders, underscoring the significance of international and supranational legislation in shaping smart city governance. By not limiting the analysis to a single country's legal framework, this study addresses the transnational dynamics of digital city regulation and governance, incorporating elements of international law, EU law, and other supranational frameworks that increasingly influence national policies. This approach is in line with the theorisation of the so-called 'Brussels effect', a phenomenon whereby EU regulatory standards - particularly in the areas of data protection, privacy and digital infrastructures - actually set global standards due to the EU's role and global interest in accessing its market.
Consequently, national legislation within and beyond the EU often mirrors these standards, embedding European legal principles into the governance structures of smart cities worldwide.
Moreover, given the global reach of major technology providers that supply essential infrastructure and services for smart cities, the regulatory landscape cannot be confined within national borders. These companies, which often operate across jurisdictions, must navigate an intricate matrix of legal requirements that include data protection laws, cybersecurity mandates, and public procurement regulations on an international scale. By considering the global dimension of tech providers, the study emphasizes that smart city legal frameworks are not solely products of local or national policymaking but are instead influenced by the operational demands and regulatory compliance obligations of international actors. This perspective, in line with for example Delmas-Marty's work[70](see Par. 2.1.2. and Par. 4.4.), suggests that the "smartification" of cities will increasingly be shaped by a hybrid of local, national, and supranational legal norms, creating a complex but inter-

[70]See M. Delmas-Marty, *Una bussola dei possibili*. Edited by Emanuele Fronza and Carlo Sotis, 1088press Alma Mater Studiorum – Università di Bologna, 2021. https://doi.org/10.12878/1088pressbyte2021_1.

connected regulatory environment that calls for an integrative approach in future research.

1.3.2. Limitations of the Study

One of the main limitations of the study is geographical. The analysis will be limited only to European legal background, for the necessity of space and thematic deepness.
However, the study is not only strictly limited to the European Union, but also other European countries will be considered. If it is true that the European Union play a pivotal role in this study, especially considering the efforts in regulating the Digital Sector, it is certainly true that valuable experiences can be found also in European, non-EU cities.
When it comes to cities, in fact, Countries like Switzerland and the UK[71] are particularly interesting. Some of their cities are what are so-called "global cities", but they also have small and medium urban areas with vivid traditions and social life. It was considered also to explicitly refer to the European Backbone called "Blue Banana", as described in 1989 by RECLUS, a group of French geographers managed by Roger Brunet[72]) and revisited later[73].
The "Blue Banana" represents a wonderful example of how European cities can be connected together and can share similar features in terms of structure and society, even in terms of law. However, the analysis doesn"t want to exclude European cities not part of the European Backbone, recognising how the "Blue Banana" itself was relevant and appropriate to, at least, pursue the goal of recommending a polycentric development[74].
In this way the reference to European cities is not intended as vagueness, but as an attempt to find insights and considerations valid for the whole varied and rich articulation of the urban phenomenon on the European continent. Indeed if a European nation is not a member of the European Union (EU), it can still share a common history and common experiences that characterise "the European city"[75]. For the matter of the present work, it can still share common laws and controls by joining different European organisations and

[71]See the whole evolution (2018-2022)of the Gemini Principles at link: https://www.cdbb.cam.ac.uk/DFTG/GeminiPrinciples (link consulted on 06.02.2025).

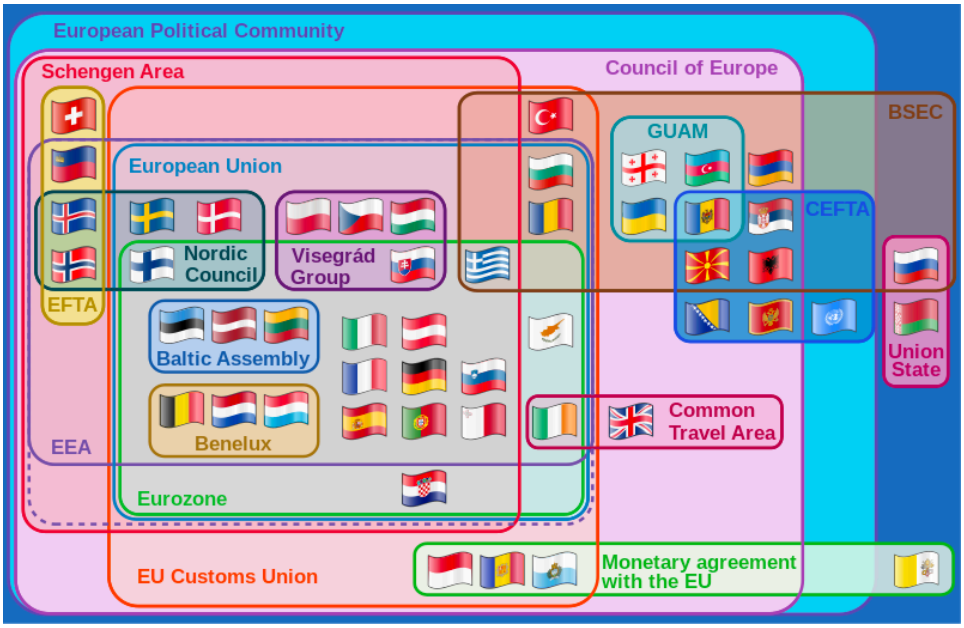
[72]See R. Brunet, J-C Boyer, "Les villes européennes: rapport pour la DATAR, Délégation à l' Aménagement du Territoire et à l' Action Régionale". Paris: La Documentation Française, 1989.

[73]See L. Capoani, C. Lakócai, C. Imbesi, and V. Van Veen, "Blue Banana Dynamics and the Perspective of Its Edges", European Spatial Research and Policy, 18 December 2024. https://doi.org/10.18778/1231-1952.31.2.02.

[74]This conclusion in the opinion of Andreas Faludi, Guest Researcher and Professor Emeritus of Spatial Policy Systems in Europe, Delft University of Technology, Delft, the Netherlands. In A. Faludi, "The"Blue Banana", Revisited", No. 56, European Journal of Spatial Development, 2015.

[75]See B. Secchi, *La Città Dei Ricchi e La Città Dei Poveri*. 1. ed. Anticorpi 36. Roma: Laterza, 2013.

treaties. These incorporate the Council of Europe, the European Economic Area (EEA), and the Schengen Area, all of which help align legal and regulatory standards among their members.
As discussed more later, the Council of Europe, which incorporates almost every European nation, promotes human rights, democracy, and the rule of law through agreements like the European Convention on Human Rights (ECHR). The EEA permits non-EU nations like Norway and Iceland to be part of the EU's internal market by adopting many EU regulations. Similarly, the Schengen Agreement enables free movement by eliminating border controls between member countries, including non-EU members like Switzerland.
This interconnecting, which can be visualized through an Euler graph of these supranational entities, shows how these countries are part of a complex web of legal cooperation. This creates a shared legal framework that extends beyond the EU itself.



- Figure 2: Euler diagram showing the relationships between various multinational European organisations and agreements (https://en.wikipedia.org/wiki/Council_of_Europe)

Moreover, experiences outside Europe may vary significantly due to differences in geography, geopolitical conditions, ethnic composition, place of origin, and historical development of cities.
Thus, China's urban landscape is undergoing dramatic changes that differ from the European pattern. China was initially characterised by rapid ur-

ban growth, accelerated by economic reform and industrialisation. This was followed by large-scale rural-urban population movements and the sprawl of megacities. In recent years, however, China has seen the emergence of "shrinking cities"[76], characterised by population decline and spatial concentration. It is a phenomenon with no equivalence in Europe.
In another continent and context, the South African legal framework might differ consistently then Europe incorporating and expressing concepts like "Ubuntu", with extensive and significant results in terms of interpretation of the Law[77].
Despite many relevant experiences in Big Data and cities, or even in Digital Twin Cities, they will not be analysed and discussed in the present work.

[76]See F. Guo, X. Qu, Y. Ma, and L. Tong. "Spatiotemporal Pattern Evolution and Influencing Factors of Shrinking Cities: Evidence from China", Cities 119, 2021): 103391. https://doi.org/10.1016/j.cities.2021.103391. The topic poses not trivial implications, as explored in the paper K. Wu, C. Yao, "Exploring the Association between Shrinking Cities and the Loss of External Investment: An Intercity Network Analysis", Cities 119, 2021, 103351. https://doi.org/10.1016/j.cities.2021.103351.

[77]See M.A. Wojcik in C. Régis, J-L. Denis, M. L. Axente, and A. Kishimoto, eds. *Human-Centered AI: A Multidisciplinary Perspective for Policy-Makers, Auditors, and Users.* First edition. Chapman & Hall/CRC Artificial Intelligence and Robotics Series. Boca Raton: Chapman & Hall, 2024. https://doi.org/10.1201/9781003320791.

Chapter 2

2.1. Methodology

Summary: 2.1.1. Methodological Considerations - 2.1.2. Methodologies and Research Design

2.1.1. Methodological Considerations

The present work is located in the LAST-jd Joint Doctoral Program. As one of the main core of the PhD programme, it will adopt an interdisciplinary approach to its methodology, combining -in this specific case- legal analysis with computer science studies.
The legal perspective will be predominant, due to the possibilities and expertise of the Author. The topic of the city, or the inequalities, will be primarily discussed in the legal realm. The integration with Computer Sciences, however, will aim to ensure a more comprehensive coverage of the multifaceted issues surrounding Big Data and cities.
Before dealing with specific considerations about the methodology adopted, the present work will take into consideration the contribution by De Toni et al. (2022)[78]] about modellisation and narration, as reported by Professor Silvano Tagliagambe in his book (2022)[79]. In fact, the contribution appears foundational for the discourse on the interdisciplinary approach to problems and the integration of -as in the present case- law and computer science applied to the digitisation of the city.
Urban studies seem, in fact, the perfect example of how the ability of *modelling*, offered by scientific disciplines like Computer Sciences, is technically and operationally combined with the *storytelling* coming from humanities, alongside the connected "historical competence" of situating projects and

[78]see A. F. De Toni, A. Vianello, and G. Marzano. *Antropocene e le sfide del XXI secolo.* Meltemi Editore, 2022. For "Anthropocene" see also W. Steffen, J. Grinevald, P. Crutzen and J. McNeill, "The Anthropocene: conceptual and historical perspectives", Phil. Trans. R. Soc. A.369842–867, 2011, available at link: http://doi.org/10.1098/rsta.2010.0327; S. Lewis, M. Maslin, "Defining the Anthropocene". Nature 519, 171–180 (2015). https://doi.org/10.1038/nature14258.

[79]See S. Tagliagambe, *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022.

views on society or projects[80].
As De Toni et al. (2022) write, "the human mind is modelled not for the stories, but by the stories"[81]. At the same time, it is important for the present work to consider the possibility that the city, similarly to a living organism, is forged by information, documents and in a broader sense "stories" (this passage will be explored more in detail in Chapter 3). Modellisation and narration are complementary, synergistic, "destined to constitute the two poles whose potential difference causes the current to flow that can illuminate the complexity of the real in which we are immersed"[82].
The role of narration will be highlighted citing the contribution of philosopher and Professor Maurizio Ferraris about documentality and documediality, concepts later developed and concluded in what the Italian philosopher called "documanity"[83].
Can "modelling" and "storytelling" become the cornerstones for a renewed debate around the city as well? Certainly, as Tagliagambe writes, and as is confirmed by many sources[84], the crisis of science is a general crisis, but one that in the writer's opinion manifests a particular moment of distress with regard to the study of the city. And this despite the cities' expansion and their relevance on the world stage.
One of the causes of this crisis seems to lie precisely in the absence of a solid methodology for the study of the city and its problems, given that even today, and all too often, the city is seen as a set of components that are "easy" to separate and isolate, to be studied in their own right.
However, it is precisely on the understanding of the city and the relations between its parts that a fundamental game is played in order to have a scientific knowledge (as such, transitory and subject to periodic re-evaluation) of the city (of an individual city, or of the city in the abstract - on this point,

[80] see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 49 - translation by the Author.

[81] see A. F., De Toni, A. Vianello, and G. Marzano. *Antropocene e le sfide del XXI secolo.* Meltemi Editore, 2022, pag 115, as cited in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 49 - translation by the Author.

[82] See A. F., De Toni, A. Vianello, and G. Marzano. *Antropocene e le sfide del XXI secolo.* Meltemi Editore, 2022, pag 115, as cited in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 49 - translation by the Author.

[83] See M. Ferraris, *Documentalità. Perché è necessario lasciar tracce.* Roma-Bari: Laterza, 2014; M. Ferraris. *Documanità: filosofia del mondo nuovo.* I Robinson. Bari: GLF editori Laterza, 2021;

[84] See for an introduction Treccani, "Einstein, Heisenberg e Gödel: la grande crisi dei fondamenti e delle certezze di inizio Novecento", at link: https://www.treccani.it/magazine/chiasmo/scienze_naturali_e_tecnologia/Crisi/sgss_einstein.html (link consulted on 06.02.2025); there's an ongoing question in social science also about the reproducibility of results, as explained for example in C. Young, "Model Uncertainty and the Crisis in Science". Socius: Sociological Research for a Dynamic World 4, 2018. https://doi.org/10.1177/2378023117737206.

see Paragraphs 3.1. and 3.2.).
The crisis of the study of the city participates, today, in the absence of sources of theoretical thought collapsed in modernity and contemporaneity[85]. Positions placed at the extremes, such as the absolute unknowability of the city (and, we will see, its ungovernability[86]), as well as grand hypotheses of integral reform (as in the case of some interpretations of "smart cities"[87]), have shown that they cannot sustain a prolonged historical confrontation.
The attempt of the present work, mentioned here for its relevance to the Methodology, is to look at the fragments and at the possible sources of a new theoretical thought about the digitised city, relevant for the Law in particular, as it is never true that theoretical thinking does not exist. It is the role of philosophy to reconnect these shreds and offer a new overview[88]. The position is also shared by Luciano Floridi, when he writes of "philosophy as conceptual design"[89].
The following section outlines the methodological framework for the research. It aims to provide a clear roadmap for how the research will be conducted, with the proposal of a robust and comprehensive analysis of the legal aspects surrounding the use of Big data in cities to address inequalities.

2.1.2. Methodologies and Research Design

The study situates itself in the field of Legal Informatics, as intended and described both from the experience of the Legal Informatics tradition in Bologna (Cirsfid) and Milan (University of Milan). It is also part of the Philosophy of Law in the Italian academic system, in the same group (IUS/20, at the time of writing)[90] as the Sociology of Law.
For the implication in the research, it is important to note that:

- Legal informatics is a young discipline
- is collocation was debated in the current "canon" of disciplines, has a "practical" component and it is strongly devoted to interdisciplinary, connecting disciplines and research fields otherwise divided

[85] See Philippe Daverio in the course "Rudimenti di Etica per il design" (Polimi, 2013/2014).
[86] See Paragraph 3.2.2.
[87] See Neom in Saudi Arabia.
[88] See Philippe Daverio in the course "Rudimenti di Etica per il design" (Polimi, 2013/2014).
[89] see L. Floridi, *Pensare l'infosfera.* Milano: Raffaello Cortina Editore, 2020.
[90] As noted by G. Ziccardi, citing M. Jori: "a university discipline is a bureaucratic, not a theoretical entity, and that its usefulness should be assessed separately in terms of teaching and research, which do not always provide unambiguous answers". See G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 202, translated by the Author.

- however, its notion and approach is quite clearly and precisely stated in several doctrine pieces

In particular:

- Legal informatics refers to the scientific discipline that studies how information and telematic technologies are applied to the theory and practice of law[91]
- In terms of research as well, legal informatics deals with "theoretically wide-ranging and interdisciplinary topics"[92], incidentally concerning other disciplines of law (but not only), but also with the aim of constituting "a simple and immediate working tool for jurists"[93]

It is therefore a "discipline of interconnection" and prepares to "analyse new challenges, prevent future risks and stimulate opportunities"[94].
In drafting a methodology for the present work, the following path was defined:

- Legal Informatics serves the purpose of "connecting" classical themes and fields, which are divided in academia but connected (or unified) by digital technologies.
- This interpretation as "connection" seemed particularly important for the present study, as shown later, and it authorised a research design oriented to a recollection of traces of relevant knowledge about the city and the digitisation of the city.
- Those traces are mostly documents (literature in different disciplines, but also policy papers, legislation and other cultural contributions) so that seemed ideal to site the research in the area of studies properly called "Documentary Legal Informatics" (*Informatica Giuridica Documentale*), intended as a specific subsection, with own differences then the "Management Legal Informatics" (*Informatica Giuridica Gestionale*)[95].

[91] See G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 197, translated by the Author.

[92] See G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 198, translated by the Author.

[93] See G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 198, translated by the Author.

[94] See M. Palmirani "Il CIRSFID e l'informatica giuridica", in G. Peruginelli e M. Ragona (a cura di), L'informatica giuridica in Italia. Cinquant"anni di studi, ricerche ed esperienze, ESI, Napoli 2014, pp. 285-304, cited and commented in G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 197, translated by the Author.

[95] See G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 198-199, translated by the Author.

- The scientific attention to the concept of "document" is not limited to the specific format that data, information and knowledge take, but it is more radical and constitutes a true foundation for both the society (and the "idea of the city" itself) and the "information society" (see later in Paragraph 3.2.).

This theoretical position will be complemented in the present work by what Legal Informatics is intended in the Scandinavian Perspective, in particular regarding the Proactive Approach to Law.
This approach, and its specific relevance to the present work, was previously discussed in G. Suffia, 2023[96], has been defined by Peter Seipel in his works. In particular, this approach is necessary since:

1. we are exploring a highly technological territory, with components from 3D scanning to Information Models, from the 5G to the data servers.

2. we are exploring a highly hypothetical territory, which presents significant discrepancies between what is present in theory, or in announcements, and what are concrete implementations.

3. we are in a strongly interdisciplinary context, since a wide range of disciplines is touched by the implementation of a DTC and all its components (unlike the IoT sector, where the idea of the digital twin comes from).

For this reason, a proactive law analysis allows to outline future scenarios and to provide ideas and observations for the application of the Law (existing or drafted or desired) before the technological implementation produces "high impact effects". As Seipel himself reconstructs, Proactive Law is part of "Legal Informatics" (in turn originated – at least in some forms – by the Philosophy of Law), since in Legal Informatics a "pro-active perspective on law" has always been present. Thus, early studies of the adaptation of legal rules to automation appeared already in the 1960s and advanced attempts to develop a legal theory of databases were made during the 1970s. For this reason, continues Seipel, this methodology "seems the most adequate to be considered as a starting point for the legal analysis".
In order to examine the potential and risks of using Big data in urban contexts for social problems such as addressing inequalities, the research design of this research project consists of three main sections:

1. Legal literature review combined with other disciplines: The initial

[96] will be accepted the reference to G. Suffia, "Legal Issues of the Digital Twin Cities in the Current and Upcoming European Legislation: Can Digital Twin Cities Be Used to Respond to Urbanisation Problems?" In *Proceedings of the 15th International Conference on Theory and Practice of Electronic Governance*, 534–37. Guimarães Portugal: ACM, 2022. https://doi.org/10.1145/3560107.3560188.

phase of the research involves an extensive literature review spanning both legal and interdisciplinary studies. The particular design of this literature review was necessary given the multifaceted nature of the existing debate on the city, such that contributions from philosophy, sociology[97] and urban planning could not be left out. Their role is to enrich legal theoretical thinking and computer sciences, in the interest of the need to develop normative frameworks that take into account these different drives and instances. By integrating the perspectives of various disciplines, the research aims to capture the multifaceted nature of digital twin cities and their normative, social and technological dimensions.
This literature review will serve the aim of:

- *recollecting the applicable law* on the matter, in the European context, in particular highlighting the spatial dimension of the legislation and its "direction" from up to down and from down to up (Paragraph 3.3.4. and Chapter 4);

- tracing the most relevant *critical reflections* on the matter, to help define problems. Critical reflections from other disciplines (for instance, from sociology and urban studies) will be used to pose questions to the Law (Paragraph 3.2.2.).

2. Following the literature review, the research will continue with a detailed legal analysis of existing digital twin city projects, limited to those projects that, in whole or in parts, deal with addressing inequality. This limitation is necessary given the aforementioned multidimensional nature of urban digital twins projects and the use of Big Data in the city.
   The analysis will focus on assessing the legal frameworks, governance structures and regulatory challenges associated with these projects. The research aims to make an initial legal framing of the phenomenon, with an indication of the relevant legislation in an all-comprehensive way on the city (albeit limited to the indicated areas).
   This effort appears, from the outset, to be lacking in the existing academic literature, with very few exceptions. This effort is further framed in the legal analysis that aims at identifying not only the existing and applicable legislation, but also possible uncovered areas from

[97] New technologies have, as explained by G. Ziccardi citing M. Jori, "a very important sociological aspect, which obviously falls within the field of study of the sociology of law', and "It is fortunate, therefore," Jori concludes, "that legal informatics is in Italy included in the grouping in which the sociology of law is also found". In G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022, p. 203, translated by the Author.

which harmful profiles for citizens' rights can emerge, but also loopholes and overlapping legislations may arise. Attention to these latter aspects is justified by the global context, in which technological evolution (also of cities) is a terrain of competition and even geopolitical clash between different systems, and legislation has become one of the weapons for conducting this competition[98].

3. The final phase of the research involves developing "Four Test Scenarios" according to the most relevant "function" of the city, and the most important expectation the Cities have to deal with in the proximate future (also according to the literature review conducted). These "Scenarios" envision the futuristic developments of digital twin cities. The methodology of scenarios for legal analysis is partially borrowed and derived from the studies of Prof. Mireille Delmas-Marty and her "Compass of Possibilities". The concept is described and used by the author in what seem suggested as a "scenario methodology" to legal analysis[99]. It will be described later in Paragraph 4.4.3. and Chapter 5.

   Each scenario will be informed by the findings from the literature review and legal analysis, ensuring that they are grounded in both theoretical and practical insights.

   - Prevent = in this scenario, the DTC framework will be designed (and put under stress) to prevent pandemics and health disruptions, analysing implications and challenges;
   - Manage = in this scenario, the DTC framework will be designed to manage extreme-weather events, related to climate change (promoting monitoring, alerting and response to them), analysing implications and challenges;
   - Protect = in this scenario, the DTC framework will be designed to protect from crime, analysing implications and challenges;
   - Reward = in this scenario, the DTC framework will be designed to "reward positive behaviour" of citizens without using the social scoring, and to maximise the correspondence between individual

[98] More on this see 'Hybrid CoE Trend Report 3. Hybrid Threats and the Law. Concepts, Trends and Implications'. Trend Report. European Centre of Excellence for Countering Hybrid Threats, 2020; Kittrie, Orde F. *Lawfare: Law as a Weapon of War.* Oxford, UK ; New York, NY: Oxford University Press, 2016; G. Suffia, Pulire l'infosfera, Giuffrè Francis Lefebvre, Milano, 2022. ISBN: 9788828840251 in the series Informatica Giuridica, vol. no. 13.

[99] See the conference "Les Printemps du Droit - International Seminars on Mireille Delmas-Marty's Work", University of Bologna, 8 may 2023, and M. Delmas-Marty, *Una bussola dei possibili.* edited by Emanuele Fronza and Carlo Sotis. https://doi.org/10.12878/1088pressbyte2021_1.

behaviour and individual/collective benefits, analysing implications and challenges.

By employing this research design, the study aims to provide a comprehensive and interdisciplinary analysis of digital twin cities, offering valuable insights into their legal, social, and technological implications.
Based on the analysis of the current "digital twin city" model as referred to in literature and practises, it will be possible to elaborate comparisons, studies and tools to shape a renewed "digital twin city" model, on the basis of European best practices in the field of sustainability and social innovation. This will also be done by taking into account data that could be generated, but are in fact absent from the first model under study (because, for example, experiments and experiences suggested by academic research in urban sociology and sociology of law), as well as data governance proposals.
A thesis to verify is that the objective to have effective simulations of smart cities" projects is possible thanks to hybrid AI, synthetic data and constitutive instead-of-regulative rules. All those elements would help in predicting the results of smart cities projects on a simulation-basis.

Chapter 3

3.1. An Historical Overview

Summary: 3.1.1. The Digital Twin of the City and the Hypothesis on the City - 3.1.2. An Historical Perspective - 3.1.3. Projects in Europe (other than DUET) - 3.1.4. DUET (Digital Urban European Twins) - 3.1.5. Future

3.1.1. The Digital Twin of the City and the Hypothesis on the City

In light of the current global landscape characterised by the digital revolution and the advent of artificial intelligence, the European Union is facing an unprecedented regulatory challenge.

Compared to the past, society is characterised by an increased level of complexity. It is precisely from the digital revolution, with the possibility to create and analyse data, that we seek to find recurrences and patterns that can serve as an aid for decision-making, particularly for those that affect communities. The current revolution is affecting the world, and the law in particular, due to a number of different factors that contribute to destabilising the existing framework and which, because of their number, make it impossible to draw easy forecasts of future developments.

Recent legislative innovations introduced by the EU represent a significant effort to govern the complex dynamics of digital transformation. However, the speed with which these regulations have been developed and implemented has raised numerous questions about their coherence and overall effectiveness. Some experts speak of a veritable "regulatory bulimia"[100], an acceleration that, while testifying to the EU's willingness to proactively address the challenges posed by the digital age, also risks creating a fragmented and potentially conflicting regulatory patchwork.

The programmatic tendency of the law is nowadays increasingly entrusted to the reading of data, with considerable criticality both with regard to the very function of the law (which, virtually, is expanding to touch every sphere

[100] See the use of the expression "regulatory bulimia" for example in https://www.thinktank.vision/en/media-en/publications/is-it-possibile-to-regulate-artificial-intelligence-2.

of human life[101], and with regard to the sustainability of the current model.

The current regulatory situation is objectively one of the most complex ever faced by the EU. The question that arises is whether we are faced with regulatory uncertainty or whether, on the contrary, the legislation created by the EU fits perfectly into a coherent framework. The reality seems to be more blurred, with regulations that, like a blanket, may overlap or conflict with each other, while leaving important regulatory gaps. These grey areas represent fertile ground for future legal and interpretative disputes, which will require careful analysis to determine whether they entail danger profiles that need to be resolved or whether they can be tolerated within an evolving regulatory framework.

Moreover, the introduction of sectoral regulations establishing new independent authorities adds further layers of complexity. It is unclear how these authorities will affect other regulated areas, such as antitrust, data protection or environmental protection. For example, one might wonder how to resolve a possible conflict if an environmental protection authority questions the energy consumption of artificial intelligence used by the city administration. These interactions raise fundamental questions about the integrated governance of emerging technologies and the need for a holistic approach that considers the interconnections between different regulatory sectors.

In this context of an "open construction site", as defined for some time by the EU Commission itself, the goal of regulating every aspect by 2030 is an ambitious and complex challenge. The challenge of being a global leader in technology regulation requires to move into complex legal balances between technological innovation, the protection of fundamental rights and legal certainty. It requires also to be the first to draft and adopt such regulations. It will be crucial for the EU to monitor and continuously assess the effectiveness of existing regulations and make necessary changes to ensure to achieve (and maintain) such a position.

In this context, in fact, the digital society has potentialities and vulnerabilities that naturally unfold within it. Under its characteristics, however, the digital society can deploy effects outside of itself as well, and to export its models - its contingent mechanics, due to the historical evolution of processes - even where attempts to counter it are strongest. For example, platforms and e-commerce are today able to erode ever larger slices of any market, almost everywhere, and it is not clear to legislators how to counteract this process and protect local economies. This is particularly the case because of the speed at which the digital world and, in particular, the most developed countries, have been transformed into "digital societies".

In this context of rapid technological and regulatory change, the Digital

[101] See S. Rodotà, *La vita e le regole. Tra diritto e non diritto.* 3rd ed., 2018.

Twin Cities concept emerges as an innovative "knowledge hypothesis" that promises to transform the understanding and management of cities. However, the current state of technologies and tools associated with Digital Twins is still at an embryonic stage, with initial maturity levels reflecting the experimental nature of many solutions.

Currently, there are several proposals to harness Big Data for the benefit of urban communities, but none of them have yet established themselves as definitive or successful solutions.

This situation poses a significant challenge for the law, which has to navigate a landscape characterised by uncertainty and continuous evolution such as never before. What is simple and clear to write, like that the law should adopt a flexible and adaptive approach, capable of evolving in parallel with emerging technologies, is less easy to make in practice. This, in fact, must be not only in an efficient way, but most importantly without losing the protection of fundamental rights and the security of citizens. In the absence of established solutions (because legislation is missing, or not yet applicable, or harmful loopholes or overlaps) the legal framework should foster innovation and experimentation[102], while trying to establish clear guiding principles that can steer the development of digital technologies in an ethical and sustainable manner.

To address the problem, it is necessary to take a step back[103] before arriving at the law in the strict sense.

3.1.2. An Historical Perspective

The historical perspective is always necessary for understanding a phenomenon, especially when the human dimension is involved. This paragraph explores the historical development and implementation phases of Digital Twin Cities, highlighting key milestones and technological advancements.

The history of the usage of twins for the city is recent, but already with important milestones marking its development. Today, the concept of a city's digital twin has become feasible due to advancements in information technology and increased computing power. This progress enables the establishment of a new development paradigm, or the realisation of previous efforts to define the smart city, centered around the notion of a "digital twin." The idea was originally introduced by Professor Michael Grieves during his lectures on product lifecycle management at the University of Michigan in 2003[104]:

[102] on experimentations, see Par. 3.4.4. and Par. 4.4.

[103] See See Luciano Floridi, lesson 2022.06.06, Bologna Seminars.

[104] See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities".

"A digital twin consists of three crucial parts: physical products, virtual products, and the connections tying them. A digital twin fully describes a potential or actual physically manufactured product from the micro atomic level to the macro geometrical level (Grieves and Vickers, 2017). Digital twin technology deeply integrates hardware, software, and IoT technologies to enrich and improve virtual entities."[105]

Some sources[106] trace back the origins of digital twins to NASA's Apollo program in the 1960s and 1970s, where engineers created virtual models of spacecraft to simulate and solve problems remotely.

Initially in industry (e.g. used to simulate wear and tear and perform preventive maintenance), today the concept of the "digital twin" is extendable to - potentially - any other dimension of the IoT (Internet of Things), but also to non-native digital dimensions such as the human body (cf. health)[107], the entire planet[108] and, for the present analysis, the city.

The idea of applying digital twins to cities emerged more prominently in the early 21st century, as smart city initiatives faced a phase of strong presence in media[109], but also a phase of not delivering exactly what was promised[110].

Journal of Management Science and Engineering 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

[105]See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities". *Journal of Management Science and Engineering* 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

[106]See the Apollo 13 case, for example at "Digital Twins and Living Models at NASA", https://ntrs.nasa.gov/citations/20210023699 (link consulted on 02.02.2025). Other sources cite the David Gelernter's 1991 book, *Mirror Worlds*, which proposed the concept of virtual representations of real-world systems. See D. H. Gelernter, *Mirror Worlds, or, The Day Software Puts the Universe in a Shoebox: How It Will Happen and What It Will Mean.* Oxford Scholarship Online. New York: Oxford University Press, 2020. https://doi.org/10.1093/oso/9780195068122.001.0001.

[107]See digital twin in healthcare, in P. Armeni, I. Polat, L. M. De Rossi, L. Diaferia, S. Meregalli, and A. Gatti, "Digital Twins in Healthcare: Is It the Beginning of a New Era of Evidence-Based Medicine? A Critical Review", *Journal of Personalized Medicine* 12, no. 8, 2022: 1255. https://doi.org/10.3390/jpm12081255; E. O. Popa, M. Van Hilten, E. Oosterkamp, and M-J. Bogaardt, "The Use of Digital Twins in Healthcare: Socio-Ethical Benefits and Socio-Ethical Risks". *Life Sciences, Society and Policy* 17, no. 1, 2021: 6. https://doi.org/10.1186/s40504-021-00113-x. See also the concept of "computational health" in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022.

[108]See at link: https://www.esa.int/ESA_Multimedia/Images/2020/09/Digital_Twin_Earth (link consulted on 02.02.2025).

[109]See presence in media of Smart Cities (ex multis, in G. Suffia, A. Lavorgna, S. Icardi, *Polizia "smart" tra paure e realtà: un'analisi esplorativa sulla rappresentazione mediatica dello smart policing in Italia*, Studi sulla questione criminale, XVII, n. 3, Carocci Editore SpA, 2022, (ISSN 1828-4973) pp. 95-116.

[110]See also G. Suffia, A. Lavorgna, S. Icardi, *Polizia "smart" tra paure e realtà: un'analisi esplorativa sulla rappresentazione mediatica dello smart policing in Italia*, Studi sulla

This phase coincided with advancements in Building Information Modeling (BIM) and the proliferation of Internet of Things (IoT) devices. BIM, which allows for detailed digital representations of buildings, served as a precursor to the broader concept of urban digital twins.

The first implementations of urban digital twins focused on creating 3D digital models of city environments, aiding in planning and infrastructure management. Many cities began exploring digital twins, like Helsinki, but it is the city-State of Singapore that emerged. The city of Singapore, known for its forward-thinking approach to urban development, launched the "Virtual Singapore" project in 2014, with the goal of creating a dynamic 3D digital model of the entire city[111]. This project was a pioneering initiative at that time, and still represented one of the most advanced first digital twin of an entire city (and also an entire country, what makes Singapore a true "infoState"[112]).

Launched as part of Singapore's Smart Nation initiative, the project began in 2012 with the Singapore Land Authority (SLA) undertaking the development of a comprehensive 3D national map. By integrating high-resolution LiDAR scans and aerial imagery, Virtual Singapore aim to provide a detailed digital representation of the city-state, encompassing both above-ground and subterranean spaces. But not only. The platform serves as a collaborative data hub for various government agencies, enabling them to utilize a common 3D model for urban planning, infrastructure management, and environmental monitoring. The digital twin was later adjusted to incorporate real-time data from a network of sensors[113], allowing for more and more dynamic simulations and analyses to aid in decision-making processes related to urban development, disaster management, and transportation optimisation. Virtual Singapore aim to play a crucial role in facilitating informed urban planning and enhancing the quality of life for its residents through data-driven insights and innovative solutions, since Singapore faces challenges such as land scarcity, unstable geopolitical environment and climate change.

The topic of the "purpose" is fundamental in understanding and categorising smart city projects, and even more when it comes to digital twins. In

questione criminale, XVII, n. 3, Carocci Editore SpA, 2022, (ISSN 1828-4973) pp. 95-116.

[111] See the links: Virtual Singapore: A Digital Gateway to Urban Innovation (https://experionglobal.com/virtual-singapore/), Singapore's digital twin – from science fiction to hi-tech reality (https://infra.global/singapores-digital-twin-from-science-fiction-to-hi-tech-reality/), https://www.geospatialworld.net/prime/case-study/national-mapping/virtual-singapore-building-a-3d-empowered-smart-nation/. (all last access 20.10.2024)

[112] See infoState in P. Khanna, *La rinascita delle città-Stato*, Fazi Editore, 2018. See also later in Par. 3.2.2.

[113] A true "society of sensors", G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni*. Raffaello Cortina Editore, 2022.

the case of Virtual Singapore, it is stated that the project is designed to support urban planning, enhance national security, assist in climate change adaptation, and drive the Smart Nation initiative.

For this purpose, Virtual Singapore integrates a variety of advanced technologies for real-time data collection, enhancing its capabilities as a dynamic digital twin of the city-state. Key technologies include:

1. Internet of Things (IoT) Sensors: A network of IoT devices is deployed throughout Singapore to gather real-time data on various urban parameters. Those are, among all: air quality, temperature, noise levels, and traffic flow. These sensors provide continuous updates that feed into the digital model, allowing for accurate simulations and analyses of urban conditions[114].

2. Geospatial Data Acquisition: Detailed 3D models of the urban environment are created by adopting high-resolution LiDAR scans and aerial imagery. This geospatial data forms the foundation of Virtual Singapore, capturing buildings, infrastructure, and natural elements[115].

3. Data Integration Platforms: Specialized software, such as the French Dassault Systèmes' 3DEXPERIENCE City platform, is employed to synthesize and visualize the collected data. This integration allows for the seamless combination of real-time sensor data with existing datasets from various government agencies, enriching the digital twin with comprehensive information[116].

4. Simulation and Analytical Tools: The platform supports advanced simulation capabilities, enabling urban planners to model different scenarios and assess the potential impacts of urban interventions. This includes disaster management simulations, transportation optimization, and environmental monitoring, all driven by real-time data inputs[117].

This integration, as seen, starts with the acquisition of high-resolution geospatial data, including LiDAR scans and aerial imagery, to capture the 3D geometry and layout of buildings, infrastructure, and natural elements. It is fundamental to provide a clear, geographical setting for the whole project, since the geography is still a critical component for the analysis[118]. The platform integrates pre-existing data from various government agencies, such as building blueprints, utility maps, and other relevant information to

[114]See https://www.tech.gov.sg/media/technews/5-things-to-know-about-virtual-singapore/ (last accessed 19.09.2024).
[115]See https://experionglobal.com/virtual-singapore/ (last accessed 19.09.2024).
[116]See https://experionglobal.com/virtual-singapore/ (last accessed 19.09.2024).
[117]See https://www.tech.gov.sg/media/technews/5-things-to-know-about-virtual-singapore/ (last accessed 19.09.2024).
[118]See G. Suffia, *Geografia delle cyberwars*, Giuffrè Francis Lefebvre, Milano, 2018.

enrich the digital twin. The 3D model is semantically enriched, meaning the computer understands the real-world meaning and context of the information. For example, it knows what kind of building a representation depicts and its architectural details[119].

By combining historical geospatial data with real-time sensor inputs, Virtual Singapore aims to create an even more dynamic and data-rich digital representation of the city. This real-time data streams can be considered "classical" (in smart city terms), since monitor various urban parameters like traffic, weather, and energy usage. Air quality, temperature, and noise levels is incorporated into the digital twin, enabling simulations and analyses related to urban pollution and environmental conditions[120]. Real-time traffic data are also used to simulate and optimise transportation systems.

Real-time data integration enables planners to monitor urban dynamics continuously. This visualisation aims to help planners understand the current state of urban systems and how they evolve over time, enabling informed decision-making[121].

This solution is considered a "technocratic" solution[122], giving emphasis on the data and the pragmatical idea to improve in urban KPI (key performance indicators), where improving the "quality of life" for its residents is a "paradigmatic pillar" for this approach.

A collaborative approach is designed into the system, to foster collaboration among various government agencies and stakeholders by providing a centralized platform for data sharing and analysis.

Virtual Singapore is developed by the government, and its legal basis stems from several key pieces of legislation:

- The Singapore Land Authority Act empowers the Singapore Land Authority (SLA) to develop and maintain a national 3D map of Singapore. This provides the legal foundation for SLA's role in creating the geospatial data foundation of Virtual Singapore.
- The Government Technology Agency Act establishes the Government Technology Agency (GovTech) and gives it the responsibility to develop and maintain whole-of-government information and communica-

[119] See https://www.tech.gov.sg/media/technews/5-things-to-know-about-virtual-singapore/ (last accessed 19.09.2024).

[120] See. 5 things to know about Virtual Singapore - GovTech (https://www.tech.gov.sg/media/technews/5-things-to-k (last access 20.10.2024)

[121] See the links: https://graphics.straitstimes.com/STI/STIMEDIA/Interactives/2017/09/smart-nation/virtual-urban-planning.html; https://experionglobal.com/virtual-singapore/; https://www.geospatialworld.net/prime/case-study/national-mapping/virtual-singapore-building-a-3d-empowered-smart-nation/.(all last access 20.10.2024)

[122] See P. Khanna, *La rinascita delle città-Stato*. Roma: Fazi Editore, 2018.

tions technology (ICT) systems. This enables GovTech to lead the technical development and integration of Virtual Singapore.

- The Public Utilities Act requires utility companies to provide data on their underground infrastructure to the SLA. This data is incorporated into Virtual Singapore's 3D model, ensuring it has comprehensive information on the country's subterranean assets.

Other laws that indirectly support Virtual Singapore include the Personal Data Protection Act, Building Control Act, which requires building plans to be submitted to authorities, and the Telecommunications Act, which facilitates the deployment of telecoms infrastructure data in the digital model.

Advanced features are, particularly interesting for the present work:

- the Scenario Simulation: The platform allows planners to run simulations of different development scenarios, such as the impact of new infrastructure projects or changes in zoning regulations. By analysing how these changes interact with both historical and real-time data, planners can identify potential challenges and optimize designs before implementation, reducing risks associated with urban development[123].
- Disaster Preparedness and Resilience: The integration of historical data on past disasters with real-time environmental monitoring allows planners to simulate potential disaster scenarios, such as flooding or earthquakes. This capability aids in developing effective emergency response strategies and enhancing the city's resilience to future challenges[124].

The example of Singapore highlights the varied uses of digital twin technology in urban environments. Between 2016 and 2020, there was significant progress in this field, fueled by advancements in data analytics, artificial intelligence, and the Internet of Things (IoT). This period saw digital twins becoming increasingly sophisticated, allowing for more precise modelling and simulation of urban systems.

For European legislators, the Singapore experience serves as a compelling case study, with some "caveat". It underscores the potential of digital twins to revolutionize urban planning and management. By integrating real-time data and predictive analytics, digital twins can enhance decision-making processes, optimize resource allocation, and improve the quality of urban life. However, European policymakers must balance the valuable insights from Singapore adapting and implementing strategies to address the unique challenges faced by cities across Europe. This approach not only supports

[123]See https://www.tech.gov.sg/media/technews/5-things-to-know-about-virtual-singapore/ (last accessed on 20.09.202).

[124]See https://experionglobal.com/virtual-singapore/ (last accessed on 20.09.202).

sustainable urban development but also aligns with the broader goals of digital transformation and smart city initiatives within the European Union.

In 2018, Zurich initiated a digital twin project aimed at enhancing urban planning. The project leverages nearly two decades of coordinated efforts in spatial information management, which have established a robust foundation for the city's spatial data infrastructure.

Similar to Singapore's approach, this project offers a detailed 3D spatial representation of the city. The primary goal of the Digital Twin is to tackle the challenges posed by population growth and to aid in urban development strategies in Zurich. This initiative was spearheaded by the GIS City of Zurich (GIS Stadt Zürich) in partnership with 25 municipal service departments[125]. Key aspects[126] of Zurich's Digital Twin are:

- 3D Spatial Data: At the heart of Zurich's Digital Twin is a comprehensive 3D spatial data collection. This includes detailed representations of various urban components such as buildings, bridges, vegetation, and other elements of the city's infrastructure.
- Data Enrichment: The Digital Twin of Zurich continuously enhances its 3D spatial data repository. This involves managing the lifecycle of both individual components and the dataset as a whole, ensuring that the information remains current and useful.
- Open Data: The spatial data is released as Open Government Data. This approach encourages widespread access and fosters the development of innovative applications by making the data freely available to the public.
- Real-time Connections: Whenever feasible, real-world elements are integrated with their digital counterparts in real-time. This integration allows for dynamic updates, ensuring that the digital representation reflects changes as they occur in the physical environment.

Further analysis of the key applications of this model will be discussed later, in Paragraph 3.4.2.

Meanwhile, between 2019 and 2022, Cambridge University began developing

[125]See G. Schrotter, C. Hürzeler. "The Digital Twin of the City of Zurich for Urban Planning". *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2; V. V. Lehtola, M. Koeva, S. Oude Elberink, P. Raposo, J-P. Virtanen, F. Vahdatikhaki, and S. Borsci, "Digital Twin of a City: Review of Technology Serving City Needs". *International Journal of Applied Earth Observation and Geoinformation* 114, 2022: 102915. https://doi.org/10.1016/j.jag.2022.102915.

[126]See G. Schrotter, C. Hürzeler. "The Digital Twin of the City of Zurich for Urban Planning". *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

a dynamic digital twin model at both building and city levels. This project aimed to explore the potential of digital twins in managing large-scale urban environments, focusing on mobilities and journeys[127].

The COVID-19 pandemic highlighted worldwide the importance of digital infrastructures and urban resilience.

In 2021, the "Connected Urban Twins" (CUT)[128] project was launched as a collaborative effort between the German cities of Hamburg, Munich, and Leipzig. Scheduled to run until 2025, this project aims to develop interoperable urban digital twins that can be used for integrated urban development and enhanced public participation.

The University of Twente launched collaborative initiatives like the Digital Twin Geohub, focusing on sustainable urban development through digital twin methodologies. It included projects for groundwater management and solid waste management, showcasing the practical applications of urban digital twins in addressing real-world challenges[129].

A significant increase in research publications related to urban digital twins is observed, indicating growing academic interest and practical applications. The World Economic Forum publishes a report detailing frameworks and global practices in Digital Twin Cities, emphasising their role in sustainable urban development[130]. From the report emerges undoubtedly that the main examples of DTC are in Asia, particularly in China. To cite just some of them: - Xiong"an New Area, China: digital supervision of the whole life cycle of the city using the BIM Management Platform - Kunming, China: Building a digital twin city traffic database to improve comprehensive traffic management - Shenzhen, China: Mawan Smart Port – using digital twin technologies to achieve smart port operation and navigation management - Georgetown, Malaysia: projecting the potential impacts of new urban projects through digital twin city models

By 2030, urban digital twins are expected to play an increasingly central role in city planning, sustainability efforts, and public safety.

[127]See https://www.cdbb.cam.ac.uk/research/cambridge-living-laboratory-research-facility/digital-twin-prototype-journeys-work

[128]See https://www.connectedurbantwins.de/ (last accessed 13.06.2024).

[129]See https://www.utwente.nl/en/stories/science/1485854/how-digital-twin-cities-are-shaping-tomorrow/?tag=digitalisation (last accessed on 20.09.202).

[130]See World Economic Forum, report "Digital Twin Cities: Framework and Global Practices", 2022, available at link: https://www.weforum.org/publications/digital-twin-cities-framework-and-global-practices/ (last accessed 09.02.2025).

3.1.3. Projects in Europe (other than DUET)

The concept of Digital Twin Cities has gained significant traction also in Europe, with several cities at the forefront of its development and implementation. in some experiences, it is limited to a single building or place, like in the case of the parks in Tallin and Helsinki[131], or the Barcelona stadium[132]. However, cities are embracing digital twins in a more expanded ways:

- Helsinki has been a pioneer in digital twin technology, using it for urban planning and sustainability initiatives for over two decades. The city's urban planning digital twin has evolved into an Energy and Climate Atlas, modelling building-level energy consumption data to help achieve carbon neutrality by 2030. Helsinki's digital twin leverages high-accuracy data (20 cm) to calculate the most effective mix of heating systems for buildings, empowering homeowners to compare the cost and environmental impact of different heating options[133].
- Barcelona has developed digital twins to simulate the city's mobility, accessibility, urbanism, and health. The Barcelona Supercomputing Center – Centro Nacional de Supercomputación (BSC-CNS) has created models to validate future initiatives, such as assessing the feasibility of underground infrastructure projects or the impact of street pacification. In 2021, BSC-CNS researchers analyzed Barcelona's Low Emission Zone and "superblocks" using digital twins, providing insights into the potential impacts of these interventions on air quality and traffic[134].
- Bologna has been actively involved in the development of digital twin technologies through various European projects[135], also in conjunction with the city of Barcelona. The city's initiative aims to create virtual city replicas to help understand the complex interrelations between urban factors like traffic, air quality, and energy consumption. More specific urban twins, like the Torre Garisenda's, are destined for specific purposes, but might allow the city to explore the potential of digital twins for evidence-based decision-making and policy choices[136].

[131] See https://www.tallinn.ee/en/valisprojektid/greentwins-tallinn-helsinki-digital-green-model (last accessed 12.02.2025).

[132] See https://cordis.europa.eu/article/id/428483-supercomputing-at-the-service-of-barcelona-football-fans (last accessed 12.02.2025).

[133] See https://stardustproject.eu/news/virtual-cities-for-very-real-benefits-from-local-digital-twins-to-the-cityverse/ (link consulted on 06.02.2025).

[134] See https://www.tomorrow.city/discover-the-alternative-barcelona-europes-first-digital-twin/ (link consulted on 06.02.2025).

[135] See https://www.bolognatoday.it/cronaca/barcellona-bologna-gemello-digitale-alleanza.html (link consulted on 06.02.2025).

[136] See https://www.comune.bologna.it/notizie/gemello-digitale-torre-garisenda (last ac-

- The LEAD project will create Digital Twins of urban logistics networks in six cities in TEN-T urban Nodes, namely Madrid (Spain), The Hague (the Netherlands), Budapest (Hungary), Lyon (France), Oslo (Norway) and Porto (Portugal). In particular Lyon's involvement in this initiative comes with the partnership with Dussault System, the same, French company behind the engine of Virtual Singapore[137]. In Lyon, the focus is on the integration of various data sources to create a comprehensive virtual representation of the city[138].
- Freiburg has created a detailed 3D city model functioning as a digital twin, which allows the city to study urban dynamics and strategise for future growth. This initiative is part of a larger movement in Germany to employ digital twins in smart city projects, with an emphasis on sustainability and engaging citizens[139].
- Similarly, Rotterdam is utilising digital twin technology to improve urban planning and management. The city's efforts involve combining real-time data with existing urban datasets to model different scenarios and evaluate the effects of urban interventions, thereby enhancing decision-making processes[140].

3.1.4. DUET (Digital Urban European Twins)

In addition to the previously mentioned cities, the DUET project is considerably one of the most advanced example of development and implementation of Digital Twin technologies in European cities. The DUET (Digital Urban European Twins) initiative, successfully concluded in November 2022, supported European cities in developing their own Digital Twin Cities[141] with establishing a common framework and methodology for creating local digital twins (LDT), which can be adapted and replicated by other cities. This includes guidelines for data integration, simulation modelling and stakeholder engagement. The replicability is a key part of DUET, and testify the broadness of its initial (and vary) diffusion: Flanders (Belgium), Athens (Greece) and Pilsen (Czech Republic).

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cessed 12.02.2025).

[137] See the experience "Virtual Singapore" on the Dassault Systèmes website at link: https://www.3ds.com/insights/customer-stories/virtual-singaporelink (link consulted on 06.02.2025).

[138] see the website https://www.digitalurbantwins.com (link consulted on 06.02.2025).

[139] see at link: https://vc.systems/en/digitale-zwillinge-in-europa-einblicke-in-den-bericht-der-europaeischen-kommission/ (link visited in 02.02.2025).

[140] see at link: https://vc.systems/en/digitale-zwillinge-in-europa-einblicke-in-den-bericht-der-europaeischen-kommission/ (link visited in 02.02.2025).

[141] Digital Urban European Twins (DUET) - Connecting Europe through (https://www.gotostage.com/channel/4eb3a121a9b543f2b66150d396454a57/recording/55270de53a8d46c89f7fb8f27bf392 access 20.10.2024)

By providing a standardised approach, through its pilot cities DUET aimed to lower the barriers for cities to start their own digital twin projects. In addition, DUET brings together a consortium of partners from various European countries, including research institutions, technology providers, and city representatives. This collaboration facilitates knowledge sharing and peer-to-peer learning among cities. The DUET project provided also technical expertise and support to cities interested in creating their own digital twins. This included assistance in data collection, model development, and the integration of advanced technologies like cloud computing and high-performance analytics.

The DUET initiative places significant emphasis on policy impact exploration, offering city managers a virtual environment to experiment with various policy decisions. This innovative approach enhances collaborative decision-making by enabling stakeholders to visualise and discuss potential outcomes of different policies. It seems to be a crucial point in the discussions about Digital Twin Cities, as it will explored more in the following chapters. By leveraging this feature, urban planners and policymakers could make more informed choices, potentially leading to improved urban management strategies and more effective resource allocation.

At the core of DUET's offerings is a comprehensive base platform that facilitates the integration of diverse city-data. This platform consolidates information from various sources, including maps, topology, traffic patterns, weather conditions, and noise levels. This approach doesn"t deviate significantly from what seen in Singapore, aiming to help officials understand the implications of various urban interventions before implementation.

Virtual City Systems[142] played a crucial role in the DUET (Digital Urban European Twins) project by providing technical expertise and innovative solutions for the development and implementation of digital twins across participating cities:

1. Technical Expertise: Virtual City Systems offers specialized knowledge in developing 3D city models and integrating various data sources. This expertise is essential for creating accurate and functional digital twins that can simulate urban dynamics effectively.

2. Data Integration and Management: The organisation helps cities leverage large open data sources and advanced cloud computing technologies to enhance decision-making processes. By integrating diverse datasets, Virtual City Systems enables cities to visualize and analyze urban systems comprehensively.

[142]See https://vc.systems/erkunden/events/digital-urban-european-twins-duet/ (last accessed 19.09.2024).

3. Policy Impact Exploration: Virtual City Systems supports the exploration of policy impacts through digital twins. By simulating different urban scenarios, cities can assess the potential outcomes of various policy decisions, leading to more effective and democratic governance.
4. Collaboration and Capacity Building: As a project partner, Virtual City Systems fosters collaboration among various stakeholders, including city administrations, researchers, and technology providers. They also contribute to capacity-building efforts by sharing best practices and lessons learned from pilot projects, helping other cities in their digital twin journeys.
5. Innovation in Urban Management: The tools and technologies developed by Virtual City Systems are designed to enhance city management by enabling rapid experimentation with different decision impacts. This capability allows city managers to respond quickly to real-time events and engage citizens in the planning process.

The DUET project, with Virtual City Systems as a key partner, received the World Smart Cities Award in 2021 for Best Enabling Technologies[143]. This recognition enhanced the project's credibility and pushed to actively engage with policymakers at the European level to advocate for greater support and funding for digital twin initiatives.

DUET promoted a collaborative network among participating cities, researchers, and technology providers. Like every network, similar experiences and future applications will benefit from a more advanced framework to enable knowledge sharing and risk containment, ultimately promoting the development of more sustainable and resilient urban environments.

Last but not least, in fact, to support the effective use of these technologies, DUET offers capacity-building programs through training initiatives (Massive Open Online Courses (MOOCs) and workshops) and resources. it is a fundamental pillar, even if it lacks in comprehensive and structural understanding of the matter involved, in favour of a vision that "technology explains itself".

3.1.5. Future

Despite these advances, several challenges remain. The complexity of accurately modelling entire cities, with their myriad socio-economic processes and environmental factors, poses significant technical and conceptual obstacles. As seen, application cases are limited either in the spatial dimension or in the integration of only one, or a few, areas of urban life. In this, the

[143] See https://vc.systems/en/explore/research-projects/duet/ (last accessed 19.09.2024).

analysis shows how urban digital twins are more like maps than replicas of the city. As maps, they highlight only one or a few aspects of the physical counterpart. And it could not be otherwise[144]. Issues related to system interoperability and high implementation costs, before data privacy, have slowed down a more widespread adoption of urban digital twins. As cities face growing challenges related to climate change, population growth and resource management, digital twins could become either indispensable to ensure sustainable urban development, or counterproductive by diverting critical resources from more direct applications. However, realising this potential will require significant investments in infrastructure, cross-sectoral collaboration and policy frameworks. It will be the task of the following paragraphs to try to provide, based on the indications already present in the literature, a renewed theoretical framework around the Digital Twin Cities.

[144]See Umberto Eco, as cited in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022.

3.2. Critical Reflections on Cities and Digitisation

Summary: 3.2.1. Defining the Digital Twin City? Unclear - 3.2.2. Critical Studies on How the Digitisation is Done - 3.2.3. A Blended Approach: Rediscover the Places - 3.2.4. The Re-Ontologisation and Re-Epistemologisation of the World - 3.2.5. Questions that Arise

3.2.1. Defining the Digital Twin City? Unclear

At this point of the present work, the definition of a Digital Twin City remains unclear.

Historically, the concept emerged is still elusive, lacking a clear and universally accepted definition. Historically, the development of Digital Twin Cities has been marked by an absence of solid theoretical foundations, particularly concerning the intricate relationship between the digital twin and the physical city it represents. This relationship is nuanced, and dense of questions. Some are fundamental: could a Digital Twin City be considered a public good, an infrastructure that serves the collective interest? Or is it primarily and solely a sophisticated tool in the hands of city administrators to enhance urban management? Are citizens the owners, the users or the clients of this system? Being a digital counterpart of a city, mimicking its physical attributes is a new frontier in human history, and no clear answers are yet in place.

These questions gain significance as the role of Digital Twin Cities broadens beyond traditional areas like energy management, traffic control, and waste management. With the integration of artificial intelligence, Digital Twin Cities are poised to influence a wider array of urban issues, including complex social challenges such as gentrification and socioeconomic inequalities. The potential for Digital Twin Cities to play a role in addressing such issues is both intriguing and complex, with a risk factor set very high to produce adverse effect and undesired outcomes.

Some scholars have begun to explore the concept of Digital Twin Cities through the lens of "swarm intelligence", a notion inspired by the collective behaviour observed in nature, such as in ant colonies. In his book "Emergence: The Connected Lives of Ants, Brains, Cities, and Software"[145], Steven Johnson discusses how decisions in ant colonies seem to emerge organically from the collective actions of individual ants. This idea resonates with the work of scholars like S. Tagliagambe[146] and is further explored in

[145] See S. Johnson, *Emergence: The Connected Lives of Ants, Brains, Cities and Software*. 1. Scribner trade paperback ed. New York, NY: Scribner, 2004.

[146] See S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali*

the context of decentralized systems like Bitcoin by S. Capaccioli[147].

This perspective is interesting and suggestive, but doesn"t seem particularly clear in its terms. The law, with its need to translate principles into practical consequences, finds itself unprepared to regulate "swarm intelligence", a concept never previously used or regulated. This is evident when one considers that, in the artificial intelligence sector alone, legal problems are now emerging at all levels. Indeed, what could be considered the first form of swarm intelligence in the service of human beings (the LLMs, emerged globally at the end of 2022 and in 2023) presents numerous legal challenges, including issues related to data training, content copyright, profit distribution and the employment of underpaid labour. These issues, although not exhaustive, highlight the complexity and urgency of developing an appropriate regulatory framework to address the implications of systemic phenomena like swarm intelligence, or (more directly) a digital twin city.

However, realising this vision remains a distant prospect. We are far from fully grasping the legal and ethical implications of such a transformation. The integration of AI and digital twins into urban governance raises numerous questions. If digital and human elements interact synergistically, this suggests the analogy of a living organism, a completely new paradigm (even if proposed to describe cities at least more than 50 years ago[148]) for understanding the relationship between a city and its digital twin. Much like ants or bees, humans and AI could collaborate to achieve a form of swarm intelligence within urban environments. Such a framework could redefine how cities are managed, potentially enabling administrators to make more informed and nuanced decisions. But how can we ensure that the benefits of such technology are equitably distributed among all citizens?

The potential for Digital Twin Cities to exacerbate existing inequalities cannot be ignored. If not carefully managed, these technologies could reinforce existing power dynamics, privileging certain groups while marginalising others. Therefore, a critical examination of the socio-legal dimensions of Digital Twin Cities is essential to ensure they contribute positively to urban life.

To do so, as proposed in the Methodology (Paragraph 2.2.) we need to go back approach the subject in an interdisciplinary way, evaluating the whole

e artificiali. Mondadori Università, 2022.

[147]See S. Capaccioli, "Blockchain, Bitcoin and Stigmergy: An Explanation and a New Perspective for Regulation". *BioLaw Journal - Rivista Di BioDiritto*, 2 July 2020, 467-476 Paginazione. https://doi.org/10.15168/2284-4503-672.

[148]See Giorgio La Pira's speech in Florence on 2 October 1955 to mayors around the world, as in G. La Pira, *Le città non vogliono morire = The cities do not want to die*, edited by Marco Pietro Giovannoni, I libri della Badia Studi e testi, 21 7. Firenze: Edizioni Polistampa, 2015; See also M. De Giuseppe, *La diplomazia delle città : Giorgio La Pira e la Federazione mondiale delle città unite*. I Libri della Badia ; 31. Firenze: Polistampa, 2022. http://digital.casalini.it/9788859622505.

range of theories that have concerned the "city of the future", variously articulated in the debate on the so-called "smart city". The current foundation of the urban digital twin, in fact, presents both revolutionary potential and an approach in execution that does not deviate significantly from the theories that have concerned the city in the last century and its technological transformation, and that are criticised and contested by many[149]. A more complex and richer collection of theories, integrating different perspectives, is needed to fully understand the implications and opportunities offered by digital twins. This requires a dialogue between disciplines such as computer science, urban planning, law and sociology to build a normative and operational framework that can guide the development of digital cities in a sustainable and inclusive manner. A stronger philosophical foundation will be provided. Only through a holistic and collaborative approach can we hope to address the challenges and exploit the opportunities that swarm intelligence and digital twins bring.

3.2.2. Critical Studies on How the Digitisation is Done

Multiple paths could have been explored to break down the topic of smart cities. For the following chapter, the topic will not be explored chronologically, but having in mind the main philosophies behind the designing and developing of the digitisation of cities. The concept of Smart Cities has evolved from early visions of urban automation, like the "Magic Motorways" and "Futurama" diorama at the 1939 New York World's Fair[150]. This envisioning of integrated automation in urban and transportation planning evolved through the decades[151]. The digital era brought a significant shift, introducing digital computing and technologies as fundamental tools for improving urban life quality and efficiently managing growing urban populations. A working definition of a smart city could be "a city defined by the integration of Information and Communication Technologies (ICT) into the physical urban environment, aiming to enhance predictability and responsiveness to urban dynamics and inhabitants" needs.

It is fundamental, however, to consider how this integration (or encoding) is done. By "encoding" we refer to the process of digitisation on, and in, the

[149] See, *ex multis*, P. Allmendinger, *The Forgotten City. Rethinking Digital Living for Our People and the Planet.* Bristol: Policy Press, 2021; B. Green, *The Smart Enough City.* Cambridge, MA: The MIT Press, 2019; A. Greenfield, *Against the Smart City.* New York, 2013.

[150] See G. Halegoua, *Smart Cities.* Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

[151] For a story of Smart cities see G. Halegoua, *Smart Cities.* Cambridge, MA: The MIT Press Essential Knowledge series, 2020; will be accepted the reference to Suffia in G. Ziccardi, E. E. Akin, and S. Klimbacher. *Smart Cities, Artificial Intelligence and Digital Transformation Law: A Handbook for Students and Professionals.* Milano University Press, 2024. https://doi.org/10.54103/infolawsoc.186.

city. As the previous chapter shows, this constitutes a relevant difference in smart city projects. As Halegoua[152] defines, cities can be "smart-from-the-start" cities or, more frequently in the European context, "retrofitted smart cities".

In the first case, "smart-from-the-start" cities are cities in which the encoding of Information and Communication Technologies (ICT) into the physical urban environment is done from the initial planning of the city in itself. This means that the city could be adapted to follow the specific needs of ICT and their planned use. Relevant examples of these types of cities can be listed as the new cities under development in Saudi Arabia (New Murabba and The Line), but also numerous cities built in China in the last 20 years. The possibility of designing a city in a "smart way" from the beginning it is fascinating and promising. However, as the Chinese example shows clearly, it presents challenges and problems that could undermine the entire effort. Many "smart-from-the-start" cities, in fact, are not performing as expected or are even abandoned[153].

As mentioned, in the European context it is unlikely the case that cities can be encoded in this way. This leads to the irrelevance of the category for the present work, apart from newly planned city districts.

In the second case, cities can be "retrofitted" to incorporate Information and Communication Technologies. In the European context, it is this second option the most frequent. In fact, the cities in Europe have a long tradition that is not only present and visible in the stratification of buildings and styles.

To map the transformation of the society to the digital (in other words, to map the progress of this encoding process), several indicators were elaborated. Those developed as benchmarks, but rapidly transformed themselves into strategic areas of development, key indicators of success: - Smart Governance, - Smart Economy, - Smart Environment, - Smart Living, - Smart Mobility, - Smart People. The presented list, by Giffinger et al. (2007)[154], it is certainly the most dominant among scholars, and also through practitioners, as it states objectives and allows for measurement progress.

This approach, guided by city rankings and benchmarks for evaluating the effectiveness of smart initiatives, doesn"t come uncontested. From a legal

[152]See G. Halegoua, *Smart Cities*. Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

[153]See, among others, the case of Ordos, China. In https://edition.cnn.com/style/article/china-ordos-ghost-town/index.html (link consulted on 02.02.2025).

[154]See R. Giffinger, C. Fertner, H. Kramar, R. Kalasek, N. Pichler-Milanović, and E. Meijers. "Smart Cities: Ranking of European Medium-Sized Cities". Wien University of Technology, 2007.

perspective, it is highly unclear what some terms mean, for example "smart governance" or "smart people". Legal and scholarly debates have highlighted issues of legal imprecision and fragmentation regarding the Smart City concept, with its definition and application in legislation remaining a challenge due to its evolving nature and varied interpretations across different contexts. It was also pointed out how a "corporate view" on the Smart City has profoundly taken this term to propose a specific point of view on the digitisation, as Söderström, Paasche and Klauser (2014)[155] noted and Halegoua (2020)[156] reported with precision in her work.

Over the last 15 years, many critics emerged to the idea of smart city. The smart city approach developed as a policy and development model that uses digital technologies, big data, and computer algorithms to monitor, control, and manage urban infrastructure, resources, and even people. It is a top-down approach that focuses on the use of technology to solve urban problems[157]. On the other hand, an emerging re-orientation in studies around the cities moved to a new Smart Urbanism[158]. Smart Urbanism could be defined as a broader concept that encompasses a range of approaches to urban development that prioritise sustainability, social justice, and citizen participation. It is a bottom-up approach that emphasises the importance of local social-economic, cultural-political, and environmental contingencies in analysing the development, implementation, and effects of urban policies[159]. This vision can be recollected emerging from critical studies like "Against smart cities"[160], or "The Smart Enough City"[161], that criticised the Smart City approach for its technocratic way of governing cities and its potential implications and risks. Smart Urbanism approaches are seen as more inclusive and participatory. For example, the authors argue that Smart Urbanism approaches can contribute to the further development of Smart City approaches by addressing underdeveloped dimensions such as

[155]see O. Söderström, T. Paasche, and F. Klauser. "Smart Cities as Corporate Storytelling". City 18, no. 3, 2014: 307–20. https://doi.org/10.1080/13604813.2014.906716.

[156]see G. Halegoua, *Smart Cities.* Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

[157]see H. Verrest, K. Pfeffer, "Elaborating the Urbanism in Smart Urbanism: Distilling Relevant Dimensions for a Comprehensive Analysis of Smart City Approaches". *Information, Communication & Society* 22, no. 9 (29 July 2019): 1328–42. https://doi.org/10.1080/1369118X.2018.1424921, p. 5.

[158]see H. Verrest, K. Pfeffer, "Elaborating the Urbanism in Smart Urbanism: Distilling Relevant Dimensions for a Comprehensive Analysis of Smart City Approaches", *Information, Communication & Society* 22, no. 9, 2019: 1328–42. https://doi.org/10.1080/1369118X.2018.1424921.

[159]see H. Verrest, K. Pfeffer, "Elaborating the Urbanism in Smart Urbanism: Distilling Relevant Dimensions for a Comprehensive Analysis of Smart City Approaches", *Information, Communication & Society* 22, no. 9, 2019: 1328–42. https://doi.org/10.1080/1369118X.2018.1424921, p. 9.

[160]see A. Greenfield, *Against the Smart City.* New York, 2013.

[161]see B. Green, *The Smart Enough City.* Cambridge, MA: The MIT Press, 2019.

social-economic inequalities and citizen participation.

The Smart Urbanism was also liked with the trend of the so-called "Social Cities"[162].

Many critiques arise also on the idea itself of a Smart City, emphasising a return to the essence of cities as places for people to live with contemporary technology. They suggest a shift from a technology-centric to a people-centric approach, highlighting the importance of collective intelligence and sociality. The "Smart Citizen" concept emphasises citizen agency and what is defined as collective intelligence (see later for more on the point), focusing on the capabilities and collaboration of individuals, contrasting with the more traditional, technology-centric approach of "Smart Cities." Smart Citizens are seen as foundational to smart cities, suggesting that the success of a smart city should be measured by the empowerment and involvement of its citizens. This has to happen in urban development and problem-solving, rather than just the implementation of technology[163]. The focus on Smart Citizens promotes a shift from viewing cities as spaces needing technological solutions to viewing them as communities where people work together on broader concerns like education, poverty, and housing, beyond just efficient services. This approach re-envisions smart cities as collaborative spaces, where technology serves to enhance human capabilities rather than being the primary focus, suggesting that effective solutions can also be non-technological and driven by human creativity and cooperation.

Alongside these reflections, other is emerging.

An authoritative reminder comes from town planning. In the reflections on over 50 years of history and evolution of the subject, expressed by Bernardo Secchi, it is emphasised how: town planning has *strong and precise responsibilities in the worsening of inequalities.* He continues: *The responsibilities of town planning, however, do not lie on the terrain of values and the consequent definition of the objectives that its project proposes to achieve, but rather on the terrain of techniques, of analytical and planning devices that are proposed to face and resolve a variegated series of problems inherent to the project of the city.* In fact, *some of these problems have been conceptually and operationally constructed in such a way that they cannot lead, beyond the subjective intentions of the individual proposers, to anything other than the worsening of inequalities.* According to the author, *In other words, they have produced an unbridgeable distance between the "urban narrative" and*

[162] see G. Halegoua, *Smart Cities.* Cambridge, MA: The MIT Press Essential Knowledge series, 2020.

[163] one topic of debate, on point, is the electronic vote. The implementation of a technological solution didn't affect the participation, as in W. Linder, S. Mueller, *Swiss Democracy: Possible Solutions to Conflict in Multicultural Societies*, Cham: Springer International Publishing, 2021. https://doi.org/10.1007/978-3-030-63266-3.

the concrete possibility of counteracting the formation and growth of social inequalities.

Secchi defines the "urban narrative" from a 1984 book of the same name, as part of the author's attempt to outline as clearly as possible the reasons and identity of urbanism. Contrasting (in the sense of "different directions taken"), in the book Secchi (2013)[164], the concrete possibility of counteracting the formation and growth of social inequalities.

Instead, Secchi defines the "urban narrative" as (p. VII), *the city project* must *be one of the starting points of any policy* aimed at eliminating or contrasting inequalities.

According to the Author (p. IX), *social inequalities are one of the most relevant aspects of what I refer to as the "new urban question" and that this is a not secondary cause of the crisis that the major economies of the planet are going through today.* The "new urban question" requires that even "the rich" become fully aware that *a better world is only possible if* (…) *social inequalities are precisely one of the most relevant aspects of what I refer to as the "new urban question" and that this is a not insignificant cause of the crisis currently affecting the planet's major economies.*

In particular (p. 3), *In western cultures, the city has long been imagined as a space for social and cultural integration.* And while *In the western city rich and poor have always met and continue to meet, they are also, and increasingly, made visibly distant.* This is also why *there is a growing gap between wealth and poverty.* While for almost a century *these distances had shown a clear tendency to decrease in western countries, the last decades of the twentieth century showed that they could grow again in unexpected ways.*

There are two main theses: 6) Global megacities, in all likelihood, *will face similar problems in the near future, which together constitute the "new urban question". Social inequalities and their giving rise to evident forms of spatial injustice, together with the consequences of climate change and problems related to a conception of mobility as part of the rights of citizenship, represent one of the most relevant aspects of this.* 7) *Every time the structure of the economy and society changes, the urban question returns to the forefront.* The author wonders, therefore, how it changes after the "liquid society" (Bauman), the "risk society" (Beck), the "age of access" (Rifkin). He continues: *Each time, on the other hand, the urban question has brought to light new themes, new conflicts and new subjects that have cultivated new and different ideas of equality and inequality.* And *every time, the emergence of a new urban question has also generated different policies and projects for the city -especially spatial policies-. Themes, conflicts, subjects, policies and*

[164]see B. Secchi, *La Città Dei Ricchi e La Città Dei Poveri.* Anticorpi 36. Roma: Laterza, 2013.

projects have overlapped and accumulated over time without erasing themselves. The contemporary city and territory are its archive.

The "new urban question" today *emerges in years of profound crisis in Western economies and societies, years in which the increasing individualisation and deconstruction of society and a greater awareness of the scarcity of environmental resources, combined with growing demands for security, health and education, technological progress and changing rules of social interaction, construct images, scenarios, policies and projects that are in part at odds with one another.* (here the author links the theme of complexity and the *proliferation of largely metaphorical terms with which the contemporary city is referred to today).*

According to the Author (p. 5), *In the great metropolitan theatre, social injustices increasingly reveal themselves in the form of spatial injustices.* He continues: *in all large cities an increasingly contrasted social topography is emerging*, and *over time it has transformed from a topography into an equally clear topology recognisable in the practices of urban space as in collective and individual imaginaries.*

Some scholars[165] argue that the core issue does not reside "within the smart city" itself, but rather in the persistent limitations it faces today. They have pointed out that, in the face of large corporations and emerging technological powers—which have become overwhelmingly dominant—traditional political mechanisms have lost their relevance. According to this perspective, democratic institutions are increasingly ineffective in regulating these forces. Any compromise achieved through political processes, they argue, will ultimately undermine the public interest, as local authorities and corporations possess disproportionate power and expertise. This view is notably articulated in the work *Planning Against the Political.* These authors advocate for a shift away from democratic principles towards a model of authoritarian technocratic governance. In this model, highly empowered civil servants would be granted the authority to regulate without the constraints of traditional governance mechanisms—eschewing consultations, public participation, voting, majority rule, negotiations, and compromises.

This perspective is not limited to technocratic thinkers, such as proponents of independent authorities, but is also echoed within the new Marxist tradition. According to this view, only grassroots social movements have the capacity to mobilize the public and effect meaningful change in the current landscape.

Proponents of this position further argue that classical social science, particularly the legacy of Max Weber, has lost its relevance; cities, they claim, are no

[165]The following section originates from an inspiring lecture by Prof. Tommaso Vitale for the chair of "Smart Cities, AI and Digital Transformation Law", 2021.

longer capable of enacting significant change. This sentiment is poignantly captured in the description of governance as "the tired, disoriented, twilight spectre" (Metzger, Allmendinger, Oosterlynck, 2015), reflecting a broader critique of contemporary political structures.

This line of thought aligns with the concept of "post-politics," which suggests that traditional political frameworks have become obsolete in addressing the challenges posed by modern urban and technological realities.

It is true that a partially concordant doctrine on autocracy exists, which acknowledges the limitations of traditional democratic governance while proposing alternative models. One such perspective can be found in the work of Parag Khanna, particularly in *La rinascita delle città-Stato* (2018). Khanna suggests a hybrid approach that combines the technocratic efficiency exemplified by Singapore with the democratic principles of Switzerland.

This model seeks to balance strong, centralized decision-making with elements of participatory governance, offering a potential solution to the challenges posed by both unchecked technocratic control and ineffective democratic institutions.

Partially concordant doctrine to "post-politics" and Autocracy argues for the "Uniqueness of Cities" (Radical Contextual Approach). Each city is a world apart.

This perspective views cities as laboratories where micro-interactions and local dynamics shape governance in ways that are not easily replicable elsewhere. The origins of this approach can be traced back to the extensive body of literature (for example the case of Chicago).

According to these Authors, even the same technology has completely different effects, because of the uniqueness of cities. For advocates of the Radical Contextual Approach, local politics and the interactions between actors and coalitions are crucial. They argue for more focused work on governance and policy-making at the local level, but without attempting broad comparisons across different urban contexts. Methodologically, this approach relies heavily on case studies and historical analysis, with findings that are deeply rooted in past experiences and, therefore, not easily transferable or generalizable to other cities.

Before asking to ourselves what this "uniqueness" could mean in legal terms (no possibility to harmonize regulations among different cities? local dimension as the best possible dimension for a detailed regulation?), it is worth noting that another part of the sociological doctrine questioned the governability of human societies.

According to these Authors, cities are nowadays too complex, difficult, im-

possible to govern. As Yates (1977)[166] writes: *"By ungovernable I mean that the urban policy making system is incapable of producing coherent decisions, developing effective policies, or implementing state and federal programs. This means that even if the state or the federal government were to commit large fiscal resources it is unlikely that the founds would solve urban problems".*

A possible answer finds exactly the practical approach of technocracy as the only, suitable and sustainable way to improve cities and societies.

However, the smart city solution, made up of simple indicators (KPIs) and the constant improvement of quality of life through the satisfaction of these indicators appears lacking.

From the analysis of this approach it does not seem far-fetched to agree with Allmendinger (2021)[167] that DTCs lend themselves to being *a repackaging of the "city as a machine" school of thought, a perspective that has a long tradition in urban planning. The computed city attitude has come to the fore at various times, not least in the 1960s, only to be frustrated by public demands for a say in the future of their cities. The reason for this push-back is simple: despite the image and promise of optimisation, modelling and prediction deeply involve political decisions that cannot be computed anyway.*

In fact, Secchi (2013) again writes, According to the Author (p. IX), *territory is not a pure mirror of society, much less is it a pure mirror of the economy.* He continues: *Wealth and poverty have a multidimensional character that is difficult to encapsulate in a few simple indicators.*

Not only that: one can see how, where smart city projects are implemented, this is not primarily for the satisfaction of these indicators, but for the substantial creation of "closed communities", which more naturally lead to better quality of life levels as they expel the poor and different from them. In this they do not resolve inequalities, but create them and make them invisible.

The "gated communities" are an experience certainly present and documented in Europe and the two Americas, similar to the Argentine "barrios cerrados" and the Brazilian "condominios fechados".

The effectiveness of a techno-centric vision is also contested by other paths of "Urban studies", which emphasize how closely this vision is tied to the prevailing power structures within the digital sphere. These critiques raise

[166] see for example D. Yates, *The Ungovernable City: The Politics of Urban Problems and Policy Making*. 4. print. MIT Studies in American Politics and Public Policy 3. Cambridge, Mass.: MIT Press, 1980.

[167] see P. Allmendinger, *The Forgotten City. Rethinking Digital Living for Our People and the Planet*. Bristol: Policy Press, 2021.

important questions about the underlying assumptions of such an approach.

Not only is there skepticism about the extent to which the extraction of data and the analysis of patterns from a city truly generates meaningful knowledge about that city and its citizens —a point to which we will return later— but this critique also extends to Urban Studies itself. Scholars in this field question whether a purely data-driven understanding can adequately capture the complexities of urban life, or whether it merely reinforces existing power dynamics by privileging certain forms of knowledge over others. This debate highlights the tension between technological determinism and more nuanced, context-sensitive approaches to understanding cities and their inhabitants.

This literature fails to conclusively prove its point. Even in regions like Asia —specifically in countries such as India, China, and Japan— there is no clear evidence of technocratic authorities dominating urban governance. Instead, these nations are characterised by the presence of strong political parties (sometimes a single dominant party) and a powerful state apparatus that continues to play a central role in decision-making (with technology or not).

It is true that cities in these contexts are increasingly focused on urban planning, which has become one of the key tools local political authorities use to navigate the challenges posed by urbanisation and globalisation. However, the standardisation that often accompanies such planning efforts —while beneficial for developers— reflects a compromise reached by political authorities, who balance various interests in an effort to manage urban growth.

Moreover, this standardisation has yielded some positive outcomes. It helps reduce costs through economies of scale and improves the compactness of cities, which can lead to more efficient use of resources and better urban sustainability. While not without its drawbacks, this approach demonstrates that political authorities still retain significant influence over urban development, even in highly globalized and technologically advanced contexts.

The studies on the "uniqueness of cities" (Radical Contextual Approach) are undeniably fascinating, but they also present significant risks. One of the primary concerns is the lack of a macro-level network or dialogue among these scholars, as they often fail to engage with broader experiences and comparative studies. This insularity can lead to a form of determinism rooted in past conditions, which does not imply that cities are only similar to one another, but rather that such an approach can limit broader understanding.

It is also problematic to adopt the view that governance is entirely impossible. While it is true that not everything is governed, some aspects certainly are. Government does indeed govern, though not every sector, individual, or issue all the time. Certain sectors, such as public policy, fall under the

purview of governance, while others —like social regulations, markets, socio-technical systems, and institutions— remain outside of direct governmental control. These latter areas often marginalise public policies and political actors, but they are not static; they evolve over time.

Historically, periods of significant urban change have often been accompanied by catastrophic visions of urban crises, ungovernability rhetoric, and predictions about the end of cities. However, what is not governed in a traditional governmental sense may actually be more central to understanding what makes a city function effectively. This has led some scholars to advocate for a *Rebuilding Theory in (Weberian) Urban Sociology*[168], which offers a more nuanced perspective on urban governance.

This theory emphasises that the process of governing a city is never fully complete nor linear. Urban societies and regional economies are governed to varying degrees, and this level of governance can fluctuate depending on the region or period in question. The formation of coalitions —whether more or less democratic— plays a crucial role in these processes. Governance is always a work in progress, yet it can make significant differences over time.

A key question arising from this theory is: *What is weakly governed? Who or what escapes the government?* These inquiries highlight the importance of understanding the areas where governance is lacking or ineffective and recognising that these gaps may hold the key to comprehending how cities truly operate.

As part of this evolving doctrine, scholars are increasingly focused on understanding that the process of governing a city is inherently incomplete and non-linear. The governance of urban societies and regional economies varies across regions and time periods. Coalition-building —whether democratic or otherwise— remains central to these processes, which are always ongoing but have substantial impacts over time.

3.2.3. A Blended Approach: Rediscover the Places

To identify a body of literature on *Digital Twin Cities (DTC)* that:

- aligns with the complexities discussed earlier;
- transcends the simplistic view of DTC as merely a technological or engineering product;
- and embraces a multidisciplinary approach to the urban phenomenon, drawing from various fields and studies,

the contribution of *Gouverner la ville numérique* by Antoine Courmont and Patrick Le Galès (2019) offers a comprehensive perspective on many of the

[168]The following section originates from an inspiring lecture by Prof. Tommaso Vitale for the chair of "Smart Cities, AI and Digital Transformation Law", 2021.

forces shaping the digital city. This work is particularly valuable in its ability to navigate beyond reductive interpretations of digital governance and instead engage with the intricate relationship between data, technology, and urban life.

The authors are especially interested in exploring the intrinsic contradictions between the formalism of digital systems and the informality that characterizes urban environments. As they note on page 7, there exists an *"contradiction intrinsèque entre le formalisme numérique et l'informalité qui caractérise l'urbanité."* Understanding this tension is crucial for any meaningful discussion about the relationship between data and cities, particularly when considering two key factors:

- The dynamic nature of cities: The authors describe cities as *"le théâtre du développement de nombreuses innovations numériques car elles sont le lieu des innovations, des échanges, de la création de richesse, de la dynamique des marchés du travail, de la mobilité sociale, de formes de démocratie, de fabrique sociale et d'interactions."* In other words, cities are not only hubs of technological innovation but also spaces where social, economic, and political interactions constantly evolve.
- The problematic dimensions of urban life: Cities also present numerous challenges for human life, including *"la ségrégation, les déchets, l'inégalité et l'isolement social, la dégradation de l'environnement, la pollution, la violence, la congestion et les conflits entre groupes."* These issues complicate the role of digital technologies in urban governance.

In light of these complexities (as discussed on page 8), digital technologies can either *"refléter, minorer ou amplifier ces processus."* That is to say, technology can reflect existing social dynamics or exacerbate inequalities. Technologies can act as both facilitators of social inclusion and instruments of exclusion.

The challenge (also outlined on page 8) is finding forms—potentially digital—of collective action and governance that contribute to resolving these pressing urban issues. As the authors put it: *"Compte tenu de l'échelle de ces enjeux, trouver des formes (numériques?) d'action collective et de gouvernance qui contribuent à la résolution de ces problèmes est un enjeu crucial en Europe et dans les grandes métropoles mondiales."* This highlights the urgency for innovative governance solutions that address both technological advancements and socio-political challenges in global cities.

This theme is revisited on page 21 in relation to the difficulties faced by *Sidewalk Labs* in Toronto and in commentary on *high-tech private new towns*. These examples illustrate the real-world challenges of implementing digital governance frameworks in complex urban environments, where private initiatives often clash with public interests and where technological solutions

must grapple with deep-rooted social issues.

From such a dialectic, something new seems to emerge. The existing contradiction between data and urbanity can neither be ignored nor prevent any form of dialectical resolution.

An important indication comes from recent studies in geography.

As emerged in discussions on Anthropocene and Aesthetics, Michel Lussault writes (pag. 41)[169]: *The Anthropocene is the bearer, as a set of knowledge, discourses and images, of a specific aesthetic of the contemporary and of political action.*

This is later confirmed by citing Hannah Arendt[170], p. 49: *Space is fundamentally political: it is this human condition that demands individuals and societies learn to think about, manage, and regulate the distance that separates human beings —and more broadly all distinct realities (to be distinct means to be isolated in space)— and in doing so build the arrangements that compose living environments.*

The author identifies two main spatiality regimes (pp. 254-255):

1) The *global regime*, characterised by the potential connection on a planetary scale between every spatial phenomenon and another, wherever they may be located. This is due to the process of urban globalisation and our entry into the Anthropocene;

2) The *local regime*, which manifests through the assembly at a specific point of social realities in topographical contact—often in the context of a deliberate co-habitation (whether functional or more politically driven).

Lussault suggests that perhaps we should add a third regime:

3) The *territorial regime*, which refers to a broader spatialisation—an assembly that defines limited areas or spaces touched by a territorial imaginary. These spaces exceed mere locations but are encompassed by the world. This regime applies to entities like the State or even the European Union.

He continues: *The three regimes —this is the crucial point— are 'always-already' mixed together in acts of 'human agency.' We are not inhabitants of just one space, fixed and endowed with a single stable scale: we live continuously from an initial and matrix-like 'site,' which is our body (…),*

[169] see M. Lussault. *Iperluoghi. La nuova geografia della globalizzazione.* Milano: Franco Angeli, 2019.

[170] see H. Arendt, "Frammento 1", Che cos'è la politica?, Milano, Einaudi, 2006, pp. 7-8, in A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019.

through spatialities touched by all possible dimensions depending on our experiences. We must manage as best we can the relationships between each one.

This perspective ("Lo spazio di vita", pag. 255) connects with the Third Space described in Iaconesi S., Persico O., Digital Urban Acupuncture, Springer, (2017).

As Georges Perec writes in *Species of Spaces* (1989): *To live is to pass from one space to another while trying not to hurt yourself too much.*

Thus, living space consists (pp. 255-256) of *a cloud of points—those anchors of our spatialities—of more or less durable and more or less vast footholds brought into contact by movements and connections. In practice, it is a mutable constellation that we unfold through our choices and decisions regarding spatial action. We give it meaning (both direction and significance) through narratives and figures that allow us to tell its story and describe it. This is why spatiality is an everyday adventure that we must attempt to frame through routines, habits, regular functional supports—which it is important to emphasize through these aforementioned 'anchors.' The localization processes I have analyzed manifest individuals' capacity to order and give meaning to their co-habitation.*

According to Lussault, and particularly through the use of technology (planned or unplanned), individuals nevertheless invent an *"adaptive spatial regime" that allows for self-expression* (p. 94), even through micro-actions of adaptation and appropriation. In his words, *human beings cannot help but inhabit, despite everything-*

He continues: *This is a crossing of an (in)definite number of material and immaterial lines —lines of flow, lines of life— that intertwine, mix together, and give substance to something that takes shape precisely from this interaction.* (pp. 100-101)

The complex relationship between regulations, technology and the city (or the territory) has even deeper implications. In a formula, one could say that a re-epistemologisation and re-ontologisation (cf. Floridi) of the city as a whole is taking place with the digital.

3.2.4. The Re-Ontologisation and Re-Epistemologisation of the World

The digital revolution, as Professor Luciano Floridi wrote[171], is fundamentally transforming our understanding of reality by "re-ontologising and re-epistemologising" the world. This transformation is particularly evident in

[171] Especially L. Floridi, *Pensare l'infosfera.* Milano: Raffaello Cortina Editore, 2020.

cities, but before, to grasp the magnitude of this phenomenon, it is essential to unpack the notions of "re-ontologising" and "re-epistemologising".

"Re-ontologising refers to the process of redefining the fundamental nature of reality, effectively altering our understanding of what the world is. It means changing our understanding of what the world is at its core. The new phase seems to be rooted in the philosophical ideas of thinkers like Giambattista Vico and Thomas Hobbes. They argued that knowledge is a construct, influenced by Aristotle's notion that we can truly know only what we create. Hobbes emphasised that knowledge is linked to "making", suggesting that our understanding of reality is shaped by our creations. In this sense, the digital is re-ontologising modernity (or what is left of it) by reconfiguring our comprehension of the world's underlying structure. This idea can be transferred also to cities and their structures. This is crucial because it implies that the digital revolution is reshaping the very essence of reality as we experience it. The idea that "we can only know what we create" resonates strongly with the digital era, where virtual environments, data-driven models, and digital constructs increasingly define our reality. This transformation is particularly evident in urban spaces, where cities, traditionally understood as physical spaces, are now perceived as dynamic, data-driven ecosystems. The digital overlay—smart infrastructures, real-time data feeds, and augmented realities—reconfigures our understanding of what a city is, blending the physical with the virtual.

Re-epistemologising, on the other hand, refers to the process of conceptualising knowledge about reality. It involves changing how we understand and acquire knowledge about reality. Epistemology deals with the nature and scope of knowledge, and the digital revolution is redefining this by altering how we perceive, process, and interpret information. This shift can be understood through Leibniz's framework of input, process, and output, which highlights, centuries later, how digital tools change the way we gather and process knowledge about our world. The digital revolution disrupts traditional epistemological models by introducing new ways of acquiring and processing knowledge—through algorithms, machine learning, and AI—challenging our conventional notions of truth and understanding. In the urban context, this re-epistemologising might manifest in how we understand city dynamics through big data analytics, sensor networks, and predictive modelling, which offer new insights into urban life but also raise questions about the nature of knowledge produced by these tools.

Together, these changes are prompting a reevaluation of both our understanding of what the world is, and how we come to know it. This seismic shift has far-reaching implications for various domains (starting from the lack of precise understanding of our era, somehow -and incompletely- defined as "post-modern" by many), including the urban landscape, where the

digital is reconfiguring the very essence of the city. This happens not only changing infrastructures and services, but also influencing how people interact and experience urban spaces. This ongoing transformation challenges us to rethink our relationship with the urban environment in the digital age.

Professor Luciano Floridi proves his words with a series of de-attachment and re-attachment (the formula "cut and paste") profundly interesting for the present work. Worth to mention the relationships "presence $\neq$ location" (you were able to interact only where your body was), or "law $\neq$ territoriality" (After Westfalia, the boundaries of the State became the boundaries of the legal systems)[172], "owner $\neq$ usage", "currecy $\neq$ money", "agency $\neq$ intelligence", or the new pastes "offline + online = onlife" or "production + consumption = prosumer", "authenticity + memory = blockchain", "analog + digital = infosphere" and "information + identity = data subjet". Our dependency on this "cut and paste" is increasing, with following risks and opportunities.
Professor Floridi correctly points out that we are democratising more the risks than the opportunities, because the ladders seem more oriented (or only reserved) to those who are on the correct side of the digital divide[173].
This vision could be critiqued for overstating the extent to which these shifts are entirely novel. Many of the philosophical challenges posed by the digital era have roots in earlier technological revolutions. For instance, the industrial revolution also profoundly altered our understanding of reality and knowledge, yet it did not lead to a complete overhaul of ontology or epistemology. Thus, one could argue that the digital revolution represents an evolution rather than a fundamental rupture in our philosophical frameworks.
To partially accomodate this critic, worth situating the digital revolution in the ongoing development (sometimes progressing, sometimes disrupting) of "documentality", understood in a broader sense as our relationship with documents.
Some words on this connection (infosphere and documentality) were already spent in G. Suffia, "Pulire l'infosfera", but seems appropriate to spend few more time on the peculiar link that involves also cities.
Indeed, the city has produced writing and writing has produced the city. It is, therefore, a relevant element in the equation that describes our current ontology and epistemology of the world.

Originally created as a means to record the storage of foodstuffs and products, writing has evolved through the millennia while maintaining its funda-

[172]See GDPR: if "law $\neq$ territoriality", but "identity = personal information" (you manage information of my citizens), then GDPR is trying to leverage this cut&paste to impose its law. The non-territoriality of the law requires solutions like the GDPR. See Luciano Floridi, lesson 2022.06.08, Bologna Seminars.
[173]See Luciano Floridi, lesson 2022.06.08, Bologna Seminars.

mental function. Today, the "document production" of the city is, of course, the document production of society as a whole (which, as mentioned at the beginning of this work, lives above all in the city) and finds a new face in the possibility of using documents once again in the service of the city (with data and so-called Big Data). Once again, however, these documents will also produce a city: a certain type of city, a specific declination of it, which we do not yet know but which we can partially hypothesise and which we must evaluate as of now. Throughout the ages, recording has been a constitutive activity of the human. It has not only made it possible to keep track of the material conditions around him, but over time (in a path that we could indicate from Mesopotamia to the Middle Ages, with various phases) it has also become a spiritual instrument, of historical awareness, of narration and knowledge of the world, of regulation and also an instrument of planning. In all these passages, documentary production has been central: the "document" has taken the form (to name but a few) of the wax tablet destined for the account, of celebratory inscription for future memory, of philosophical writing and of law.

The innovations that could be cited are innumerable. To limit ourselves to just a few, significant examples (and to get faster to the digital), it might be significant to mention the innovation of the quill pen, which introduced a new "style" of writing, "seismographic", into the French chancelleries, which together with other constituent elements changed the aesthetics (e.g. Gothic). It requires writing rooms, and light: this also changes the architecture (which until then had been "Romanesque") and introduces the broken arch from the East (with the Crusades). Thus, Gothic began in Paris, responding to the need for more writing. It is mutation of languages and aesthetics, based on the mutation of technologies.

With the introduction of printing, then, the document undergoes a first revolution: writing is no longer done manually, requiring the direct intervention of a person in the act of writing ex novo or copying a text, but can now be "mechanised" to produce more copies in a short time. The revolution is not only important for the dissemination of knowledge and libraries. Not only does it allow a new sensibility to take shape around the idea, revolutionary for the time, of being able to read the sacred text on one's own (Luther), but it also sees implications of a more practical magnitude: the technological advancement corresponds to a total aesthetic crisis[174] (there is a loss of some knowledge), but also the passage from a non-knowledge to a new knowledge, with a slow acquisition of new knowledge and the formation of a new aesthetic.

[174]Explanation by Philippe Daverio in the course "Rudimenti di Etica per il design" (Polimi, 2013/2014). The adjective is retained here out of fairness and affinity (see Paragraph 2.1.1.) between aesthetic design and philosophical-legal design around the digital.

Access by a larger share of the population leads to a real "broadening of bases" or "growth of access rights". A circumstance that, in other contexts, seems closely linked, as far as we are concerned here, with the emergence of a "new urban question"[175].

New languages and aesthetics have followed each further innovation, but nothing has been as disruptive as the advent of the digital.
The digital, as Prof. Floridi recalls, has entailed our shift from the ability to "record information" to the ability to "manipulate information".
If AI is understood as "autonomy to act without intelligence", then it is nothing other than the ability to "process" documents (in the broadest sense of the term, as per GDPR) even without the intervention, case by case, of humans.
According to this reconstruction, the "re-ontologisation" and the "re-epistemologisation" overcome the criticism and acquire a specific position in a debate on the digitalisation of the city.

It is not the purpose of the present work to present a deterministic view of technology, suggesting that digital advancements unilaterally reshape our understanding of reality and knowledge. While digital tools indeed have transformative potential, the way they are integrated and interpreted in society depends heavily on human choices, political power structures, and cultural values.
However, it can be argue that "docu-cities" are the cities in which lives the so-called "dochumanity" ("documanità" in the original Prof. Ferraris idea), a concept that is not far from the "smart citizens" already encountered in the literature on smart cities[176].

[175]See B. Secchi, *La Città Dei Ricchi e La Città Dei Poveri*. 1. ed. Anticorpi 36. Roma: Laterza, 2013.

[176]To explore further: an attempt to define the characteristics of "smart citizens" can be found in the interplay between "connectivity" and "documentality". "Connectivity" originates from the technical level of the digital society and stresses the point of the availability of technology. it is direct and deep implication can be found in the studies on the "infosphere", as proposed by Professor Floridi (see for example L. Floridi, *La quarta rivoluzione*. Milano: Raffaello Cortina Editore, 2017; *Pensare l'infosfera*. Milano: Raffaello Cortina Editore, 2020). "Documentality", by Professor Ferraris, is already explained in the text of the present work (see more in M. Ferraris. *Documentalità. Perché è necessario lasciar tracce*. Roma-Bari: Laterza, 2014; *Documanità: filosofia del mondo nuovo*. I Robinson. Bari: GLF editori Laterza, 2021): only the citizen who has the practical ability to use the technology provided by the "connectivity", in fact, can be really considered a smart citizen. In a stricter sense, the connectivity has to support the documentality, but both are useless if not paired with each other. The ability to process documents, called "documentality" is what is now developed in a "documediality", and it is creating a "dochumanity", at least in the meaning that now, more than in each revolution of documentality, we are exploring territories in which the information is at the centre. On the "dochumanity and the"infosphere" more can be said. For the purpose of this analysis, they emerge as new pillars on which further expansion are possible, on various branches and topic like digital rights, human-machine relationships, and so on. For more implications on this analysis,

This seems to be particularly true in a city that is going to have (and interact with) a "digital twin".

According to Michel Lussalt, the urban revolution is the main instituting and imaginative force of the contemporary world.

Quote: *(…) an* urban revolution*: widespread urbanization, with its most active phase beginning after 1950, accelerating since 1990 and skyrocketing after 2010, it is* the main instituting and imaginative force of the contemporary world*, which is both globalized and globalizing.*

This urbanisation has created a geo-historical reality in which everything is in interaction and no phenomenon is independent of others.

Quote: *We humans have built a geo-historical reality in which everything is in interaction and in which any phenomenon is no longer independent of the myriads of phenomena that it activates in return each time it manifests itself.*

This interaction is the interaction of documents (literature in every form, but also policies and regulations) around the city.

The digitisation impacts the city in various way. Critical voices in urban studies pointed out that *the city is no longer represented from the outside, but through the activities of individuals. These traces have no meaning unless they are related to each other. Big data" is therefore inseparable from the algorithms that give meaning to these worlds of data.*[177]

With an "Individualisation" that becomes "Gouvernementalité algorithmique", is imposed a vision founded (Courmont, Le Galès (2019), p. 19) on *strategies of segmentation and personalisation built into these algorithmic devices*, which oppose the *unification of cities and sociospatial equality between the populations connected to the network*[178].

This analysis resonate with the broader debate on the society and on the origin of the masses (which is the cause-effect of the birth of modernity), their directionality (their historical vector), and their consequent disappearance in today's world also due to technologies, such as digital technologies, which

will be allowed the reference to G. Suffia, "Smart cities e Digital divide. Una proposta di analisi", Ciberspazio e Diritto, Mucchi Editore, 2021.

[177] see A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019 - translation by the author.

[178] In the authors' opinion, one seems to read, therefore, that traditional networks (*alors que les réseaux ont joué un rôle central dans le développement et le fonctionnement des villes modernes* (citing Joel Tarr, Gabriel Dupuy (dir.), "Technology and the Rise of the Networked City in Europe and North America", Philadelphie, Temple University Press, 1988)) may be sidelined and "challenged" in their ideology-view precisely because of the personalised results provided by algorithms.

allow precisely a dispersion of vectors and their cancellation in a zero-sum game[179].

However, the push on the development of tools like the "digital twins" is not only justified as a way for the administrators to re-gain control over the disorganised, individual vectors of nowadays individuals (in other words, to re-understand society). It has also roots in the crisis of science and in the attempt to process what the last Century lead us to discover in science.

As is well known from several sources[180], science is engaged in a long transformation in which new scientific discoveries also call into question much of the past. A particularly relevant example of this is quantum mechanics. Following Prof. Tagliagambe's argument, the example is apt because it highlights how atoms and planets, imagined as point-like particles in their respective systems, actually have a complex internal structure that limits the applicability of the theory by giving rise to important physical phenomena. It is therefore worth emphasising, as the professor does, that theories as such, as scientific, can also be questioned, they can nevertheless continue to be used legitimately in their own domain of validity. What is important, however, is to understand what this domain of validity is, because beyond this all theories, indeed, go beyond their own nature. This while there is no problem in using different models of the same class of phenomena, or in replacing current models with more powerful ones once they are found[181]. Starting from this starting point, Prof. Tagliagambe points out[182] how the world of science seems to be inviting us to start from the formalism of mathematics in order to look for further characteristics and properties of the "bodies" under study, which have not yet been discovered and which could give us, as in some examples quoted by Tagliagambe in the book, opportunities to move the range of our knowledge even further. These are discoveries that, without this formalism, would not have been possible. The professor likens reasoning in formal terms as being like pruning, or pruning, which makes it possible to lighten the concepts with which one is working, avoid-

[179]This implies, consequently, that we are in a transversal society, also referred to by some as neo-medieval society.

[180]see Carlo Rovelli in see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 145-160: *The theoretical revolution taking place is dazzling and unhinges a whole range of old knowledge culminating in what Carlo Rovelli in 2014, for example, describes as an ongoing theoretical revolution, with the shift from an ontology of properties to an ontology of relations. Fundamental aspects of this reversal of perspective, such as the fact that "Relations give rise to things, not vice versa" and "Physical space is the resulting fabric of a web of relations," bring to light how the observer's gaze, the strategy he or she pursues when focusing his or her attention on a given object, becomes fundamental.* - translated by the Author.

[181]See S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 39 ff.

[182]For a longer explanation see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 45 ff.

ing the need to deal with all the possible entanglements in the real world and all the varieties and differences found in it. The advantage of this is to focus attention only on those aspects that are pertinent, significant for achieving the objective of finding an interpretative key to explain the phenomena and processes under study.
A first criticism of this procedure lies in the need to make a "reconnection" between the formalism and reality, an operation that is far from simple, although in the professor's opinion it is "relatively easy, once one has clarified, (…), the process of abstraction that defines the mathematical context on which to work."[183]

This process is strongly characterised by two components, in which we already seem to glimpse the digital twin we are dealing with: "modelling" and "storytelling"[184].

- On the one hand modelling, as defined by De Toni, Marzano and Vianello in 2022[185], is the key competence provided by the scientific disciplines and increasingly constitutes the operational tool of their research.
- On the other hand, narration: humanistic studies (such as law) provide the capacity for narration and the historical competence that flows from it.

For De Toni, Marzano and Vianello, modelling and narration are complementary, synergetic, destined to constitute two poles whose difference in potential makes the current flow that can illuminate the complexity of the real in which we are immersed. At this point, Tagliagambe goes on to write, the digital object constitutes a structure (software) in which the two main components are the data, i.e. the sequence of bits in which the information is transcribed, and, precisely, the metadata, which define a specific global identifier for the data itself. Metadata contain information that enables the data itself to be identified and used according to appropriate criteria. The digital object, therefore, welds together information about the object language and information about the language (metadata)[186].
In these words we can find all the reflection carried out by Prof. Ferraris on "documentality", in particular on the capacity of the digital to "record" from the very origin of communication itself. This is fundamental both with

[183]See S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 45 ff.
[184]See S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 49 ff.
[185]see A. F. De Toni, A. Vianello, and G. Marzano, *Antropocene e le sfide del XXI secolo.* Meltemi Editore, 2022, in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022.
[186]See S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 63.

a view to producing more documents, and to producing documents even without the explicit intention of doing so[187].
This is why Tagliagambe conducts a whole refined analysis on epistemology, the epistemological gaze starting from data and metadata. On the basis of the experiences, crises and solutions proposed by logic and science, we now come to say not only that the epistemological gaze is the one that allows us to recombine different knowledge and organise it within a coherent and integrated vision, but also that from such a gaze new perspectives emerge that highlight the role of the observer in the process of knowledge formation[188]. Applying such reasoning to the digital twin (which, however, Prof. Tagliagambe too often, though not entirely unmotivated, assimilates to the Metaverse[189]), it augments reality, not simplifies it. It is not an exact map of it[190], but it is nevertheless a tool for the emergence of new knowledge[191].

The digital twin is compared to a shadow, with all the load of suggestions and analyses that have been made of the shadow in art, especially in the last two centuries, when artists began to realise the need to relate to the shadow in order to rediscover themselves. And this is the potential inherent in the digital twin, which becomes a shadow for the original physical object to look at and find itself in.
Approaching the famous portrait of Dorian Gray[192], further considerations emerge, this time tending towards the dimension of "simulation".

[187] Consider the case of a court document originating from an environmental interception: the specific document only comes into being *a posteriori*, on the basis of the "recording" that the digital has caused to work. See M. Ferraris. *Documanità: filosofia del mondo nuovo*. I Robinson. Bari: GLF editori Laterza, 2021; M. Ferraris, *Documentalità. Perché è necessario lasciar tracce*. Roma-Bari: Laterza, 2014.

[188] see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 64 ff.

[189] see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022.

[190] see about maps in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 59-61: *Ogni mappa mette in evidenza e propone all'attenzione aspetti diversi del territorio, come la sua morfologia, la sua varia rete viaria, il suo patrimonio artistico e culturale, ecc. E funge quindi da filtro che concentra lo sguardo su una di queste sue specifiche caratteristiche, lasciando in ombra le altre. Più modelli abbiamo da utilizzare, più la fenomenologia dei comportamenti di un sistema sarà ricca. Tutto questo ci ricorda il principio di indeterminazione di Heisenberg e il principio di complementarietà tra conoscenze diverse di uno stesso sistema enunciato da Bohr, i quali, lungi dall'essere espressione di una stranezza quantistica, sono la norma per i sistemi complessi. Nessuna mappa sarà mai tanto estesa quanto l'intero territorio che deve rappresentare, ma non di meno potrà essere utile.*

[191] see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 77 ff.

[192] see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 77 ff.

If every behaviour of ours in world one leaves irreversible traces in world four of the metaverse, the real and virtual twins form an inseparable totality, since what is recorded in the case of the one finds a correspondence that is not instantaneous, but nevertheless precise and inevitable, and not subject to any condition in the other. Citing the EPR paradox (of Einstein, Rosen and Podolski), one arrives at the conclusion that this property, two "entangled" systems, must be considered part of a single system that globally has some defined property, which remains undefined for the individual component systems. The measurement on one of the two components breaks the entanglement and attributes defined properties to the components. This relationship between the physical domain and its digital twin is analogous, in that in it too we can repeat what has been said in the case of entangled particles, making only the necessary adjustments. The system of the two twins, physical and digital, must therefore be considered as a whole, which has some properties, in the sense that they must be regarded as related parts of a single system, whereby any information acquired with regard to one finds almost immediate correspondence in the other. The digital twin gradually develops in almost real time, by virtue of the two-way flow of data, guaranteed by the presence of the sensors and actuators that link it to the physical one. This is true, but also in a different form, namely as an offshoot of documentality and the city, where the city is created with documents and creates documents. Every modification of these documents, every generation of new documents is a permanent modification on the city, which becomes the archive of all the projects (urban planning and others) that have followed one another[193].

The analysis made by Tagliagambe is long and would deserve much more space[194]. However, to stick only to the aspects strictly essential to the present work, the further question of what time is and, in particular, the causal relation arises, considering that it is not only through causal relations that it is possible to move in the world of data. On the contrary, very often the causal relationship is dictated more by correlation. Science today goes so far as to say not only that time is the fourth dimension of space, but that the observation of a phenomenon entails the emergence of something more, dictated by the interrelation between the different components of this phenomenon, but also by the theme of time flowing. With observation, it was realised that one cannot locate a particle at a point in space for more than a single instant. As Heisenberg's own uncertainty principle states, the more you try to locate the particle in a small region, the greater the speed

[193]see B. Secchi, *La Città Dei Ricchi e La Città Dei Poveri*. 1. ed. Anticorpi 36. Roma: Laterza, 2013.

[194]For a complete explanation see the original text in see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 107 ff.

with which it will move away. The same is true for any kind of observation, and it is precisely in this that observation prevents the geometric image of a circle closing in on itself from being evoked, which seems to have to be replaced by that of a spiral, of a curved line that, precisely because of that irreducible gap, returning on itself instead of closing, uninterruptedly generates circles without a centre. As Cerrigone[195] points out, this image is so powerful that it sums up in itself, like a symbol, the essence of the question we are dealing with. The spiral is not a missed circle, it is a curve that makes a defect productive[196]. It is a lack, what from the point of view of the circle appears as a defect. What appears as a lack to be erased and filled in the spiral becomes the criterion of a new kind of order[197].

At this point, also citing Pavlov's experiments on association, a question that is clearly epistemological in nature comes into play and concerns the genesis of the structures that preside over the functioning of brain processes. They emerge from data, that is, entirely from our relationship with our environment and the contingencies that characterise it, or from an environment and internal organisation that shape and give form to the contingencies of the world.
It is therefore not enough to imagine that we can record events in order to know, but events can only provide information. It is our ability to get a picture of how things are in our environment that makes us capable of attributing meaning to these events, of reacting to them by developing more or less forms of understanding them[198], like Pavlov's dog that reacts only to certain conditions to certain conditioning rather than to others.

Tagliagambe again writes[199]: It is certainly not far-fetched to speculate that this unprecedented complex of modal opportunities and processes may, in turn, retroact and affect the further fine-tuning and refinement of the digital twin of our world one, gradually bringing to light unforeseen possibilities and applications. It speaks of a trickle-down effect that may bring forth even unimaginable outcomes, as the digital has already changed the way we think and do. The widening and enrichment of vision and perspective

[195]see M. E. Cerrigone, *La verità non si dice. Riflessioni intorno alla verità a partire da Pavel A. Florenskij*, Pentagora, 2019, p. 201, as cited in S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022.

[196]This dimension of excess, starting from a defect, seems to be the same vital excess that is perceived for the human, where the same image of the circle that does not close is attributed (in spiritual, and then religious, terms) to man. See Petrosino, Silvano, and Manlio Iofrida. *Contro il post-umano. Ripensare l'uomo, ripensare l'animale.* EDB, 2017.

[197]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 117-135.

[198]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 137 ff.

[199]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 169 ff.

that has occurred precisely by virtue of the welding and linking of the two levels, of object language and metalanguage, with the very entrainment of the observer who feels himself participating in yet another level, generates that relationship with reality that has also been defined by the postmodern, but which creates an inextricable triangle between the object, its representation and the observer who sees this representation. It becomes a chain of levels, like those of Escher in his paintings. Escher devises and figuratively realises the situations he describes so incisively and effectively that they are astonishing. The metaverse implements them, so that the viewer in this case does not only have the appearance of being invited in, but actually makes his entrance. What happens then, turning the coupling between a level that clearly represents fantasy and imagination and another level that represents reality into a lived experience? The digital twins, as we have seen, are the operational translation of this, which for Escher was just a birth of his extraordinary artistic creativity. What happens if reality and fantasy, physical and virtual, world one and world four, instead of being thought of alternatively and serially, in a linear chain, form a link, retroacting on each other? A new alliance opens up between these two types of network, world one and world four, between physical reality and the infosphere. It is a radical reversal of perspective, a rethinking of certain founding myths of our culture that continue to condition the way we see things.

In some respects, such a digital twin could even be a forerunner (if not already an expression - Tagliagambe speaks more properly of "8 billion brains connected through the infosphere", but it is evident that their expression could be, as in the case that interests us here, an urban digital twin) of what is the so-called "Popper's demon", that is the collective (or rather connective, in the sense in which Derrick de Kerckhove has defined it) intelligence[200]. The digital twin could therefore be the natural repository of the heritage of scientific and technological knowledge acquired by humanity throughout its history. More in a small way, of a city and its course (to return to the image of the archive, quoted above).
Such an idea launches more than a hook with the theme of "swarm intelligence", seen above.[201]

However, the important point Tagliagambe arrives at, also quoting Wolfgang Pauli, is the principle of exclusion and quantum mechanics. For man, prediction is not an end, but a means, a tool to make effective decisions, so it is necessary to move away from the one-dimensional idea of prediction to the much more complex one of strategy based on the active role of the observer[202]. This is a problem of decision-making, not prediction.

[200]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022, p. 37 ff.
[201]see Paragraph 3.2.1.
[202]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali*

This concerns the cognitive aspect of uncertainty: uncertainty is the moving frontier of knowledge, we have no other choice, since the split between the deterministic evolution of individual systems that do not interact does not exist. The shift to action that makes the observation of measurement possible forces us to realise how unfounded is the hope of those who believe that the probability of a future event is all the greater the greater the observed frequency of similar events. All the more so today in the Anthropocene[203].

What emerges is a digital twin defined as *a digital representation of the data, the state, the relationships and the behaviour of any physical entity*[204], in which the space of interaction converges and involves together the physical dimension, however understood, and the virtual one, and which is nourished by a procedure of data collection, analysis, elaboration of a profile, prediction of future behaviour, control on the basis of the choices actually made, modification of the profile in case of a gap between prediction and observation[205]. Starting again, in a real feedback loop[206].

The two-way flow of data generates an inescapable interconnection between the two dimensions, with the possibility of multiple inputs and multiple outputs simultaneously. This is crucial when dealing with open and complex systems, where the solution of a problem may require simultaneous interactions with multiple knowledge systems[207]. This ability is essential in view of the fact that a hypothesis may only be adequate for the solution of a problem in conjunction with other hypotheses[208].
The digital twin is therefore a world 4 (to use the expression Tagliagambe coined on Popper's lexicon), related to world 1 (the physical world) as its shadow, or representation, which at the same time records and simulates what world 1 could be. It is a simulation that modifies the simulant, a circumstance made evident by the very nature of the digital (it is already

e artificiali. Mondadori Università, 2022, p. 178 ff.

[203]see A. F. De Toni, A. Vianello, and G. Marzano. *Antropocene e le sfide del XXI secolo*. Meltemi Editore, 2022. For "Anthropocene" see W. Steffen, J. Grinevald, P. Crutzen and J. McNeill, *The Anthropocene: conceptual and historical perspectives*, Phil. Trans. R. Soc. A.369842–867, 2011, available at link: http://doi.org/10.1098/rsta.2010.0327; S. Lewis, M. Maslin, "Defining the Anthropocene". *Nature* 519, 171–180 (2015). https://doi.org/10.1038/nature14258.

[204]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 33.

[205]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 77 ff.

[206]see "Learning from Example", chapter 19, in S. J. Russell, Stuart, P. Norvig, *Artificial Intelligence: A Modern Approach*. Fourth edition, Global edition. Prentice Hall Series in Artificial Intelligence. Boston: Pearson, 2022.

[207]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 25 ff.

[208]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali*. Mondadori Università, 2022, p. 25 ff.

Turing's observation that there is a substantial identity between data and programme[209]), and which creates the age-old problem of the self-fulfilling prophecy of the smart city.

It is the axiom that the Smart City (= digitisation) will come about because of digitisation . For some, the "digital twin city" risks being the epitome of the ultimate self-fulfilling prophecy, since adaptation occurs on the basis of real-time information and predictions[210].
The intrinsic nature of this strange "simulation modifying simulant" presents multiple problems (among which the massive entry of private actors in the governance of the city[211]), but above all it leaves a sensitive nerve uncovered. As Courmont and Le Galès rightly write in "Gouverner la ville numérique": *The language of "solutions" here refers to problems that have not yet been identified, but which could be by the intervention of players with expertise in housing, transport, health, etc.*, which obviously poses well the question of what the purpose of the intervention is and, in particular, how uncertain the burden of proof is when it comes to public policy: who has to identify the solution is quickly said, but who has to identify the problem?

3.2.5. Questions that Arise

In the previous paragraphs, it was illustrated that the application of Big Data to urban and societal analysis presents a complex landscape of challenges and opportunities. This dichotomy reflects the ongoing debate in academic and policy circles regarding the implications of data-driven ap-

[209]see by Alan Turing already in 1936's 'On computable numbers, with an application to the Entscheidungsproblem', Proc. London Maths. Soc. (Series 2), 42: 230–265 (available online at link: https://www.abelard.org/turpap2/tp2-ie.asp, link (link consulted on 02.02.2025), as reported at link: https://plato.stanford.edu/archIves/fall2018/entries/turing/ (link consulted on 02.02.2025).

[210]in A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019. pag. 10. This is possible under certain conditions, citing the text by Antoine Picon "Smart Cities. Théorie et critique d'un idéal auto-réalisateur', Paris, Éditions B2, 2013, that the ideal of ubiquitous computing was realised under certain conditions: *The fiction of ubiquitous computing, this ideal of ubiquitous and invisible computing, has been partly realised thanks to the miniaturisation of sensors, the reduction in storage costs, the considerable increase in computing power and the expansion of communication networks that are organised, regulated and sometimes financed by the public authorities.* Add to this (p. 11) the recent transformations of capitalism, which emphasise data as *créatrices de valeur.* Concordant doctrine can be found in C. Rabari, and M. Storper. "The Digital Skin of Cities: Urban Theory and Research in the Age of the Sensored and Metered City, Ubiquitous Computing and Big Data", Cambridge Journal of Regions, Economy and Society 8, no. 1, 2015: 27–42. https://doi.org/10.1093/cjres/rsu021, and in the idea of informatics "enveloping the world" by Luciano Floridi, lesson 2022.06.28, Bologna Seminars - all translation by the Author.

[211]see A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019, p. 11.

proaches to understanding and governing cities and societies.

The critical perspective highlighted in the literature review findings underscores profound concerns about the nature of contemporary urban existence.

One dimension refers to the inner structure of contemporary societies, and on the understandable desire for the public authorities to "understand society". However, as mentioned, nowadays individual privacy and autonomy are eroded in favour of pervasive monitoring systems.

Furthermore, the notion that no rules can be able to govern our cities, as found in part of the literature, is a relevant stimulus to always, and recursively, reconsider our legislation and our understanding of the relationship between law and society. Even if countered by other relevant doctrine, the situation does not seem completely in favour of the law. If, as found, only some aspects of societies and cities are governable, this idea raises critical questions about the efficacy of current policy-making processes and the need for new paradigms of governance that can keep pace with technological change.

The concept of "no places"[212], or the discovery of new types of relatioship with places like the "hyper-places"[213], clearly highlight the importance, for the law, to reconsider the spatial dimension. This perspective challenges conventional understandings of urban planning, community formation, and the role of physical infrastructure in shaping social experiences.

These contrasting viewpoints underscore the need for continued research and dialogue in the field of legal informatics and urban studies.

How we imagine the Digital Twin City (in other words, the relationship between the City, Big Data and Artificial Intelligence) has important consequences:

A first question that emerges is whether we consider the city "as a big computer", or as a "relational ecosystem" (for some, a living organism).
Underlying the first idea, which postulates that city problems can be solved by thinking of the city as a big computer, is the focus on the regulation of flows, such as energy, traffic and waste.

In Laurent et al. (2019)[214], experiences of "real-time organisation" of the city are discussed, such as: *l'espace urbain comme un résultat sans cesse*

[212] see M. Augé, *Non-Places: Introduction to an Anthropology of Supermodernity.* 2nd English language ed. London ; New York: Verso, 2008.

[213] see M. Lussault. *Iperluoghi. La nuova geografia della globalizzazione.* Milano: Franco Angeli, 2019.

[214] see Laurent et al., in A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019, p. 59-60.

remanié par des opérations d'optimisation (urban space as an outcome that is constantly being reshaped by optimisation operations).

Underlying the second view, on the other hand, is the realisation that the simple management of city flows is, in itself, necessary but insufficient. Whatever the approach, and a correct division between the two perspectives may prove successful, it must be made explicit for each of the components and each of the digital services offered to the city.

A second issue that emerges is that of the need for a "re-spatialisation" of law, as will also be illustrated in the following section[215]. While it is true that the digital has led to the misalignment of the relationship between law and territoriality ("law $\neq$ territoriality", to use Floridi's words), care must be taken to ensure that this fracture does not reverberate in the age of "digital twins".

The point to start from is that of "smart citizens", as highlighted in the literature. The focus could be two-sided: - a first promising area is that of "proactive digital services". It's a new frontier and field of research in which public digital services are a type of digital service where public organisations approach citizens or businesses, rather than the other way around. In this type of service, citizens and businesses do not have -possibly, in the most advanced conceptualisations- to take any action to receive a public service. The goal is to increase efficiency and improve interactions between public organisations and citizens or businesses. The paper refers to them also as "clients", but with an important alert to note: no client receives a service without asking it. In this case, however, citizens and businesses could be able to receive proactively from the public administration, based on their rights. In their paper titled "Proactivity in digital public services: A conceptual analysis", Hendrik Scholta and Ida Lindgren attempted an initial conceptual analysis of how public organisations can use digital technologies to improve their interactions with clients. - On the second hand, on a broader dimension, the smart citizens of a smart city can be defined as citizens who are able to handle the complexity of the digital society[216]. The characteristics of the digital society can be described in various ways, but can briefly divided into two main areas: the technical capabilities to access and navigate the digital society; the ability to do so. For the purpose of this research, and for the simplicity in terminology, they can be described as "connectivity" and "documentality".

[215] see Paragraph 3.3.1.

[216] a previous attempt to illustrate and evaluate this framework was done in G. Suffia, "Per una partecipazione qualificata nella società iper-veloce". Mucchi Editore, no. 2 (2020), and G. Suffia, "Smart Cities e Digital Divide : Una Proposta Di Analisi". Ciberspazio e Diritto : Rivista Internazionale Di Informatica Giuridica : 22, 2, 2021, no. 2 (2021). https://doi.org/10.53148/1081.

3.3. The Reflection in Law

Summary: 3.3.1. Introduction on Law Literature - 3.3.2. The Risk of a "Mixed" Surveillance (A) - 3.3.3. Algorithmic Governability (B) - 3.3.4. "Spatial Turn in Law" (C) - 3.3.5. Closing Considerations

3.3.1. Introduction on Law Literature

In contemporary discourse, as demonstrated in the previous two paragraphs, there has been a notable progression in fields such as sociology, behavioural sciences, urban studies, and architecture, which have collectively advanced our understanding of the intricate dynamics of inequality and power balance in urban environments.
These disciplines are working deeply into how these social structures impact both individual and collective entities, offering nuanced insights into the mechanisms of prejudice and power dynamics within cities. This interdisciplinary progress has significantly enriched our comprehension of these complex issues, highlighting the multifaceted interactions that shape urban life.

Despite these advancements, the legal field has found itself lagging, struggling to keep pace with the rapid developments observed in other disciplines.

This lag is partly due to a traditional oversight within legal frameworks, which have historically neglected the spatial dimensions that are crucial to understanding and addressing urban inequalities. The legal system's focus has often been more abstract, overlooking how spatial (and power) factors can influence legal outcomes and perpetuate disparities.

The urgency of this discussion has intensified with the advent of the digital age, characterized by society's widespread digitisation and the rapid advances in artificial intelligence (AI).

The Internet of Things (IoT) represents a network of interconnected devices that communicate and exchange data, often without human intervention. In smart cities, IoT devices are ubiquitous, embedded in infrastructure, public spaces, and even personal devices. This pervasive presence raises significant privacy concerns, as these devices continuously collect and transmit data, often without explicit consent from individuals. The challenge lies in regulating the vast amounts of data generated by IoT devices, ensuring that it is collected, processed, and stored in compliance with privacy laws.

Big Data, characterized by the massive volume, velocity, and variety of data generated in today's digital age, presents another layer of complexity. In smart cities, data from various sources, including IoT devices, social media,

and public records, is aggregated and analyzed to derive insights and drive decision-making. While Big Data offers numerous benefits, such as improved urban planning and enhanced public services, it also poses significant privacy risks. The potential for data repurposing and re-identification of individuals from anonymized datasets challenges existing data protection frameworks, necessitating robust regulatory measures.

Cloud computing, which enables the storage and processing of data on remote servers, is integral to the functioning of smart cities. However, the reliance on cloud services introduces concerns about data security, access control, and jurisdiction. The cross-border nature of cloud computing complicates the enforcement of data protection laws, as data may be stored in jurisdictions with varying legal standards. Ensuring the security and privacy of data stored in the cloud is paramount, requiring stringent safeguards and international cooperation.

The combination of IoT, Big Data, and Cloud computing in smart cities creates a complex ecosystem[217], now with AI, that challenges traditional regulatory approaches. Existing EU data protection laws, such as the General Data Protection Regulation (GDPR), provide a robust framework for protecting personal data. However, the rapid pace of technological advancement and the unique characteristics of smart cities necessitate a reevaluation of these laws to address emerging privacy threats effectively.

These technological developments have transformed urban landscapes and social interactions, introducing new dimensions of inequality and power dynamics. As AI and digital technologies become increasingly integrated into urban governance and everyday life, the need for legal frameworks to address these changes becomes more pressing.
The legal field must evolve to incorporate spatial and digital considerations, ensuring that it can effectively respond to the challenges and opportunities presented by the digital age.

Following the Peace of Westphalia (1648), the boundaries of the State became synonymous with the boundaries of the legal system, establishing a clear demarcation between jurisdictions based on territorial sovereignty.
This Westphalian model has long underpinned the organisation of legal systems, aligning legal authority with geographic boundaries.
However, in the contemporary digital age, this alignment is increasingly challenged, creating a discrepancy between law and territoriality, as noted by scholars like Luciano Floridi.

[217] see F. Paolucci, and O. Pollicino. "Intelligenza urbana e tutela dei diritti fondamentali. Antinomia o complementarità nella nuova stagione algoritmica?", Media Laws, no. 3, 2022; L. Edwards, "Privacy, Security and Data Protection in Smart Cities: A Critical EU Law Perspective", SSRN Electronic Journal, 2016. https://doi.org/10.2139/ssrn.2711290.

Digital technologies transcend traditional geographic boundaries, enabling activities and interactions that are not confined to any single jurisdiction. For example, online platforms like social media networks operate globally, often leading to legal complexities when content posted in one country violates the laws of another. Similarly, e-commerce platforms facilitate cross-border transactions that can evade local consumer protection laws, complicating enforcement.
These examples highlight the growing need for legal frameworks to adapt to a digital landscape where territorial boundaries are less relevant, necessitating new approaches to jurisdiction and governance that account for the borderless nature of digital interactions.

This transition has been particularly addressed in fundamental works of geo-legislation, such as Natalino Irti's "Norma e luoghi". Irti explores how the traditional alignment of legal systems with territorial boundaries is increasingly inadequate in the face of today's changing society.

This calls for a rethinking of legal frameworks to adapt to the realities of a digitally interconnected world in which traditional territorial boundaries are increasingly blurred.

A first consideration from a legal point of view is that the split between "law = territoriality" is only true up to a certain point. For example, in criminal law, territorial jurisdiction is fundamental. Although challenged by new cases, the monopoly on the use of force still resides with the state, which exercises it through its police and judicial branches.
While it is true that there are also principles of extraterritorial jurisdiction that allow a state to prosecute crimes committed outside its borders, as in the case of international crimes or acts of terrorism, it is true that it is state territoriality that is still the foundation, and not the exception, even in international criminal law.
Similarly, international law, while theoretically operating above individual national jurisdictions, creating a legal system that is not limited to the territorial borders of a state, finds in state territoriality its very assumption of existence, going to regulate relations between states (and, therefore, between their territories) and only on this assumption going to address global issues such as human rights and international justice.

A second consideration is that the law is trying, albeit with difficulty, to promote a new union of "identity = personal information" in order to overcome certain critical issues related to digitalisation. With the advent of digital technologies, personal identity is increasingly defined by the personal information that is collected and shared online. In response, regulations such as the European Union's General Data Protection Regulation (GDPR) seek to protect personal data by recognising the link between identity and personal information.

The GDPR seeks to regulate how the personal information of European citizens is managed by global entities, reflecting the need for legal solutions that respond to the non-territoriality of digital interactions. The specific legal literature on data protection highlights how the GDPR has set new global standards for the protection of personal data, influencing similar legislation in other jurisdictions.
This attempt to renew the concept of legal identity reflects the need to adapt laws to technological and societal changes, while ensuring the protection of individual rights in an increasingly digital environment.

Also and especially thanks to the intersection of Big Data, the city and artificial intelligence, which as seen in Chapter 1 is crucial for today's era, law is promoting at least other 2 new "unions", again using Luciano Floridi's cut-and-paste metaphor:

- "New powers = new responsibilities". With the introduction of the Digital Services Act (DSA) and the Digital Markets Act (DMA), the European Union is trying to address the new power dynamics created by digital platforms. These laws stipulate that new forms of economic and informational power bring with them new responsibilities, imposing stricter obligations to ensure transparency and accountability of large online platforms. The legal literature on DSA and DMA, along with constitutional and administrative law, discusses how these laws are redefining the relationship between technology and regulation, attempting to balance innovation and the protection of fundamental rights.
- "Justice = place". Perhaps the most significant of these new pastes is the one that links justice to places, recognising that access to justice and the enforcement of laws must take into account the spatial dimension. In an increasingly urbanised and digitised world, cities become not only centres of innovation but also places where inequalities may be more evident. This calls for a legal approach that takes into account the local context and territorial specificities to ensure fairer and more accessible justice. Jurisprudence and legal theory are exploring how to integrate these spatial considerations into existing legal structures, promoting a more holistic approach to justice.

The areas of intersection between Big Data, the City and Artificial Intelligence raise at least three significant challenges:

A) Risk of "Mixed Surveillance" "Mixed surveillance" refers to the combination of traditional surveillance tools, often implemented by public agencies, with new forms of surveillance that Shoshana Zuboff refers to as "Surveillance Capitalism". The latter operate through the analysis and use of

data collected by private platforms for commercial purposes, contributing to new modes of social control. An extreme example of traditional surveillance is the use of facial recognition to monitor public events, with the risk of "crowd extraction", i.e. the identification and tracking of specific individuals within large groups.
This integration of public and private surveillance raises significant data protection concerns. Data protection regulations, such as the GDPR, impose strict limits on digitisation projects, requiring personal data to be processed in a compliant manner that respects individual rights. However, a persistent (and future) challenge is the distinction between personal data and non-personal data. Non-personal data are those that cannot be traced back to a specific person, even with significant effort. This distinction is crucial in determining the applicability of data protection regulations, but it becomes increasingly complex as data analysis technologies advance, which can potentially reveal personal information even from seemingly anonymous datasets.

B) Algorithmic Governability Algorithmic governability represents a crucial challenge in the age of new technologies, raising significant problems even of constitutional adaptation.
The integration of algorithms and artificial intelligence into public and private decision-making processes has led to the emergence of new rights, such as the right to an explanation of automated decisions, constantly debated by the doctrine, and new institutional figures, including the proliferation of independent authorities charged with regulating and monitoring the use of these technologies.
The opaque nature of many algorithms, coupled with the speed with which technologies evolve, makes it difficult for traditional institutions to adapt quickly and effectively. Moreover, the need to balance technological innovation with the protection of fundamental rights requires a sophisticated and flexible regulatory approach capable of responding to the ethical and legal challenges posed by the increasing use of automated systems in decision-making processes. The creation of an appropriate regulatory framework is essential to ensure that the adoption of algorithmic technologies takes place responsibly and in accordance with democratic and constitutional principles.
The governance of digital societies presents itself as a particularly complex and expanding field of study, which is set to grow further in the near future. Complexity arises from the need to integrate technical, legal, ethical and social considerations to develop governance models that are effective and fair.
Challenges include, among others, regulation of digital platforms, (public/private) ownership of programs and data, algorithmic fairness and transparency in automated decision-making processes. The rapid evolution of

technologies requires continuous adaptation of regulations and policies, as well as the creation of new institutions or adaptation of existing ones to manage new digital realities. The governance of digital societies must also address issues of inclusiveness and access, ensuring that the benefits of digital technologies are fairly distributed and that new forms of exclusion or inequality are not created. However, these topics pose themselves after having answered more foundational questions about digitisation (or "informatisation"[218]), which still constitute the essential core of "algorithmic governability".

C) Spatial turn of law The spatial turn of law represents a new perspective, emphasising the spatial dimension in legal analysis and application. Spatiality (especially the new, digitally hybridised spatiality) is not yet a fully developed concept in the world of law. Traditionally, law has considered space primarily in terms of territorial jurisdiction, but increasing urbanisation and digitalisation call for a more sophisticated approach that recognises how physical and virtual space influence legal and social dynamics.
This focus on spatiality implies a rethinking of traditional legal categories to include considerations of how urban and digital spaces shape social, economic and political interactions. This area of study is still very much unexplored, offering ample opportunities for interdisciplinary research involving law, geography, urban planning and technology. The aim is to develop a legal framework that recognises and integrates the complexity of spatiality, promoting a more adaptable legal system that is able to respond to the needs of an increasingly interconnected and globalised society.

3.3.2. The Risk of a "Mixed" Surveillance (A)

The concept of the "digital twin" represents one of the most promising innovations in the contemporary technological landscape, but its nature and implications raise complex questions. Although not explicitly born as a surveillance tool, at least in the traditional sense of the term, the digital twin cannot be easily placed in the category of "liberation technologies". As pointed out by P. Perri in his work "Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica" (Milan, 2020, p. 13 ff.) and by G. Ziccardi in "Internet, controllo e libertà" (Milan, 2015, pp. 193-222), technologies that aim to liberate individuals often face the paradox of surveillance.

Indeed, the digital twin risks turning into a "mixed" surveillance tool. This type of surveillance integrates elements of classical surveillance, such as state

[218] see A. Paulin, "Informating Smart Cities Governance? Let Us First Understand the Atoms!", *Journal of the Knowledge Economy* 7, no. 2 (June 2016): 329–43. https://doi.org/10.1007/s13132-016-0368-6. See Par. 3.4.

origin, with those of a new form of "capitalist" surveillance based on Big Data, a concept explored by Shoshana Zuboff. The massive accumulation of data, facilitated by digital twins, not only uses existing data, but also stimulates the creation and accumulation of new data. This phenomenon is particularly evident in urban contexts, where digital twins can continuously monitor user behaviour, generating constant and pervasive control.

Another critical aspect is the cognitive asymmetry between those who hold knowledge and those who hold power. Digital twins can anticipate users' desires, creating a context in which individual decisions are influenced by predictive behavioural models. This leads to a further expansion of the power of governance over the people, as suggested by Floridi, and a blurring of the figure of those who exercise control, as citizens become increasingly "transparent", as pointed out by Assange.

The integration of IoT technologies, often in the hands of private entities, with public purposes could theoretically represent a balancing act between two powers, making the digital twin an example of a liberal tool. However, there is also the risk of a new welding between powers, where one bends to the other or where they exchange mutual "favours". This could lead to an unprecedented and extremely pervasive form of "control". Therefore, an in-depth analysis on the topic of surveillance and its most recent developments appears warranted.

Perri's (2020) analysis on surveillance as a problem in today's society can be shared and extended, proposing it as a "caveat" in the creation of increasingly integrated and advanced digital twins, especially if the use of Big Data for their operation is pursued. This becomes particularly interesting in light of Perri's (p. 31) and Cohen's observations that "participatory surveillance" is closely linked to a vision of "neoliberal biopolitics". In such a vision, responsibility is shifted from government, institutions and central bodies to the individuals themselves. The digital twins, in the writer's opinion, seriously risk accentuating these dynamics, further extending the power of governance control over the people.

The balancing of interests must be done taking into account the potential benefits of "algorithmic governance", but without diminishing or forgetting the legacy of Western democratic traditions. It is crucial to put in place all appropriate safeguards to protect the fundamental rights of individuals, as pointed out by Perri (p. 31). Faced with the inevitability of the "society of surveillance", as described by Perri (p. 32) quoting Rodotà, it is necessary to define the conditions necessary to prevent it from resolving itself into authoritarian control, discrimination, old and new social stratifications productive of exclusion, and the domination of a market logic that seeks further legitimisation precisely in technology.

To meet these challenges, social processes and institutional solutions are needed that are capable of maintaining the framework of democracy and the rights of freedom. It is crucial that emerging technologies, such as digital twins, are developed and implemented with a clear understanding of the ethical and social implications. Only through an informed and critical approach can it be ensured that the benefits of technology are not achieved at the expense of fundamental rights and civil liberties. In conclusion, while digital twins offer potential benefits in terms of efficiency and innovation, it is essential that their development is guided by principles of transparency, accountability and respect for human rights.

Recent appeals inviting citizens to report people in distress, sometimes offering a dedicated telephone number or similar initiatives, raises important questions about the management and sharing of personal data in the urban context. This scenario recalls concerns expressed by non-governmental organisations, such as Emergency, which often find themselves in a delicate position: they wish to help vulnerable people, but fear that sharing data with public authorities may, paradoxically, worsen the situation of those in need rather than improve it.

Reporting people in need can certainly bring significant benefits, such as faster access to care and support services. However, there are also potential problems that need to be considered:

1. Opacities in information management: Information management by public authorities is often characterised by opacity, especially when public order and security reasons are invoked. This can lead to improper or non-transparent use of collected data, with the risk that vulnerable people's personal information is used in ways that do not respect their privacy or rights.

2. Compartmentalisation of bureaucracy: The public bureaucracy is often compartmentalised, with a lack of effective collaboration between different departments. For example, police authorities and social services may not share information adequately, hindering a coordinated and comprehensive approach to dealing with difficult situations. This fragmentation may lead to inefficiencies and a less effective response to the needs of vulnerable people.

3. Data protection violation: The protection of personal data is not always guaranteed, especially in contexts where privacy regulations are not strictly enforced or where resources to adequately implement them are lacking. This can expose people in need to risks of privacy breaches or unauthorised use of their personal information.

4. Wrongful sharing of datasets: Initiatives to promote the sharing of datasets between public and private entities may lead to reckless shar-

ing without the necessary safeguards. It is essential that such initiatives are accompanied by clear protocols and adequate security measures to protect the sensitive data of the individuals involved.

While reporting people in distress can be a powerful tool to improve access to support services, it is crucial that it is handled with care and accountability. Authorities must ensure transparency in data management, protect personal data and implement adequate safeguards in information sharing.

In summary, the digital twin represents a challenge and an opportunity. On the one hand, it can improve urban management and quality of life; on the other, it risks amplifying the dynamics of control and surveillance. It is therefore crucial that its development is accompanied by public debate and careful regulation, ensuring that technological advances are aligned with democratic values and fundamental rights.

3.3.3. Algorithmic Governability (B)

In the context of Digital Twin Cities, the use of Big Data for city governance represents a paradigmatic example of "algorithmic governability". This approach, based on the collection of huge amounts of data from sensors and IoT devices, and algorithms designed to optimise various aspects of urban life, aims to improve the operational efficiency and quality of life of citizens through informed and automated decisions. However, all too often this objective overshadows other important goals of the administration (such as that of operating effective actions for the well-being of the city), raising serious questions about the constitutional compatibility of "algorithmic governance".

In the literature, the concept of "algorithmic governability" has been variously explored, revealing aspects that are not immediately apparent.
As described by Rouvroy (as reported by Perri, 2020), "algorithmic governance" represents:

an unprecedented mode of government mostly powered by infra-personal, meaningless but quantifiable signals (raw data and metadata) addressed to individuals through their "profiles" - behavioural patterns produced on a purely inductive basis - rather than through their understandings and wills. Presented as "personalisation" (in commercial applications), augmented reality (in entertainment and self-quantifying contexts) or as routinised metabolism of security (strengthening police operations, crime and terrorism prevention, fraud detection, employment control), data mining and profiling techniques seduce industries and government institutions with the promise of real time and automatic, thus supposedly "objective", detection, and long-term sorting and evaluation of the invisible risks and opportunities brought by individu-

als.[219]

This approach also promises to sort out and assess in the long term the invisible risks and opportunities brought by individuals. However, while these technologies can improve the efficiency and responsiveness of urban management, they also raise important issues.

Among the main concerns is the issue of transparency of algorithms. Often, algorithm-based decision-making models are opaque, making it difficult for citizens and authorities to understand how decisions are made and on what data they are based. This lack of transparency can lead to a decrease in public trust and raises questions about the responsibility and accountability of automated decision-making processes.
An even more basic question would be to assess whether, before improving the efficiency and responsiveness of urban management, one is in the presence of the "right" solution to the problem one intends to address.

The issue of "right", or "wrong", obviously intersects ethical and political dimensions that are not the subject of this thesis. It is worth pointing out, however, how dependence on algorithmic profiles can lead to the solidification of political, party, and sometimes personal evaluations within the instrument itself.
This does not exhaust, but rather adds to, the well-known problem of reducing human complexity to mere statistical data, or the possibility of inherent bias in the data or algorithms themselves, with potential implications for justice and fairness in urban governance. These biases may perpetuate or even amplify social inequalities, negatively affecting the distribution of resources or the implementation of public policies. The literature emphasises the importance of developing fair and inclusive algorithms that take into account the diversity and needs of all urban communities, but also of limiting and regulating the careless use of datasets for purposes other than the original ones for which the datasets were collected[220].

In this sense, algorithmic governance in the Digital Twin Cities represents a complex challenge that requires a careful balance between technological innovation and the protection of fundamental rights.
On this challenge are also constitutional problems in certain countries, which should be examined on a case-by-case basis. In Italy, for example, the tension between digitisation conducted as a "centralised" intervention may conflict

[219] see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica.* Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020, p. 31, citing S. Baranzoni, P. Vignola, "Cosa Potrebbe Un Corpo? Il Dividuale e l'individuazione Della Filosofia Contemporanea", *La Deleuziana – Rivista Online Di Filosofia* – ISSN 2421-3098, no. N . 1 / 2015 – Crisi delle Biopolitiche europee (2015), p. 163 - translated by the Author.

[220] see P. Benanti, *Human in the Loop. Decisioni Umane e Intelligenze Artificiali.* Scienza e Filosofia. Milano: Mondadori, 2022.

with the decentralisation that the Constitution reserves to the Regions and local authorities[221]. The issue may find an obvious backing in the push, in many cases hoped for, for innovation from below as opposed to innovation too often lowered from above onto the territories.

Another important aspect is the attention on datasets. Legal scholars are already analysing and discussing the algorithmic governability focusing both on the algorithms and the datasets. An important contribution comes from Professor Palmirani in her article "Big Data e Conoscenza"[222].
Just as in the context of the automated decision-making (ADM) systems discussed in Monica Palmirani's article, the success of a Digital Twin City depends not only on the algorithms but also on the quality, transparency and accuracy of the datasets used to train and feed these systems.
Algorithms alone cannot ensure effective outcomes; the data they rely on is equally crucial.
It's essential to understand what data is used at each stage of developing and implementing algorithms for a Digital Twin City. For instance, during the initial stages, data might be collected from various urban sensors, like traffic cameras, environmental monitors, and social media feeds. This data is then processed and used to create simulations that reflect real-world conditions. At each stage, from data collection to processing and analysis, transparency about data sources and methodologies is vital to ensure accuracy and reliability.
Consider a scenario where a city uses a digital twin to optimize traffic flow. Data from traffic sensors, public transportation schedules, and GPS data from ride-sharing services are integrated to simulate and predict congestion. Understanding the provenance and accuracy of this data is crucial for effective traffic management. If traffic data are inaccurate, it might suggest inefficient traffic rerouting, leading to increased congestion and commuter frustration.
Palmirani emphasises the risk that distorted or opaque data can lead to incorrect automatic decisions. If the data feeding the digital twin lacks transparency or accuracy, the predictions and simulations generated could lead to biased, incomplete, or erroneous decisions. These inaccuracies can directly affect urban governance, infrastructure planning, and citizen well-being. This is not the only risk.
In line with Palmirani's emphasis on explainability, a digital twin city must ensure fully transparent and explainable data streams. The sources of city data, such as traffic patterns, environmental data, or citizen behaviour, must

[221] see A. Michieli, "Dal coordinamento informatico alla digitalizzazione: l'espansione della competenza statale e la marginalizzazione delle autonomie nella transizione digitale". Nomos, 9 January 2025. Anticipated in a dialogue with the Author.

[222] See M. Palmirani, "Big Data e conoscenza". Rivista di filosofia del diritto, no. 1 (2020): 73–92. https://doi.org/10.4477/97021.

be knowable and traceable. This transparency allows city administrators to make reliable and informed decisions.
Drawing a parallel with the right to explanation under Article 22 of the GDPR, citizens of a Digital Twin City have the right to understand how urban data influences automated decisions affecting their daily lives, such as traffic routing or energy distribution.
Another legislation requiring explanation is the AI ACT, with Article 86 (Right to Explanation of Individual Decision-Making):

1. *Any affected person subject to a decision which is taken by the deployer on the basis of the output from a high-risk AI system listed in Annex III, with the exception of systems listed under point 2 thereof, and which produces legal effects or similarly significantly affects that person in a way that they consider to have an adverse impact on their health, safety or fundamental rights shall have the right to obtain from the deployer clear and meaningful explanations of the role of the AI system in the decision-making procedure and the main elements of the decision taken.*

2. *Paragraph 1 shall not apply to the use of AI systems for which exceptions from, or restrictions to, the obligation under that paragraph follow from Union or national law in compliance with Union law.*

3. *This Article shall apply only to the extent that the right referred to in paragraph 1 is not otherwise provided for under Union law.*

For the interplay between AI Act and GDPR on this topic, many literature explained[223].
A better definition of the datasets used can help also in proper counterfactual reasoning. The impact of a DTC on the city has already been discussed, but city planners might use counterfactual reasoning to simulate the impact of a new public transport line on traffic congestion, allowing them to assess potential benefits and challenges before implementation.

The concept of counterfactual reasoning, discussed in Palmirani's article, is directly applicable to a Digital Twin City. Decision-makers should be able to change certain datasets, such as population density or traffic conditions, to simulate alternative urban scenarios.
"Counterfactual reasoning" aligns with the debate over the self-realisation of the smart city, even more evident in the case of a DTC, and discussed as inevitable in Par. 3.2.

[223]see for example: P. Hacker, J-H. Passoth, "Varieties of AI Explanations Under the Law. From the GDPR to the AIA, and Beyond", SSRN Electronic Journal, 2021. https://doi.org/10.2139/ssrn.3911324; A. Holzinger, R. Goebel, R. Fong, T. Moon, K-R. Müller, and W. Samek, eds. "xxAI - beyond Explainable AI: International Workshop", Held in Conjunction with ICML 2020, July 18, 2020, Vienna, Austria, Revised and Extended Papers. Lecture Notes in Artificial Intelligence 13200. Cham: Springer, 2022.

Similar to how Palmirani classifies data into personal, non-personal, statistical, and derived, Digital Twin Cities must differentiate between types of urban data. Personal data, such as citizens' movements, must be managed according to privacy laws like the GDPR, while statistical and aggregated data must maintain transparency.
The level of aggregation could be fundamental. Consider a scenario where a city's digital twin collects detailed location data from public Wi-Fi networks. While this data can help optimize public transport routes, it can also inadvertently (if the analysis is too close to individuals) track individual movements, raising privacy concerns if not properly anonymized and aggregated.
In the development and operation of Digital Twin Cities, the level of data aggregation plays a crucial role in balancing the need for detailed urban insights with the imperative of protecting personal data. While there is a desire to "know the city in each fragment" to enhance urban planning and management, overly granular data collection can inadvertently expose personal data, leading to privacy concerns.
Collecting data at a highly detailed level can increase the risk of identifying individuals, even if the data is not explicitly personal. For example, tracking individual movements through GPS data or analysing specific energy consumption patterns can reveal personal habits and routines. This level of detail, while potentially useful for precise urban analysis, poses significant privacy risks.
Aggregating data to the correct level can mitigate these risks by obscuring individual identities while still providing valuable insights for urban management. By summarising data into larger groups or broader categories, cities can maintain the utility of the data for decision-making without compromising individual privacy.
Instead of collecting individual energy usage data, a city could aggregate consumption patterns at the neighbourhood level. This approach allows city planners to identify areas with high energy demand and plan infrastructure accordingly, without exposing personal consumption details.
Achieving the right level of aggregation involves a careful balance. It requires understanding the specific needs of urban analysis and the potential privacy implications of data collection.

The problem of algorithmic governance concerns, as far as this work is concerned, the balancing of rights and duties, and more generally the translation of legal categories into algorithms. This process nowadays often takes place by assigning specific coefficients and values to each right, operating mathematical or algorithmic balancing. The evaluation of legal categories becomes nothing more than an assignment of variable values, with grids and guidelines assisting in this translation.
However, the question arises as to whether this approach really represents

the best possible balancing, or whether the "translation" is not reduced to a "simplification" that risks compromising the complexity and richness of the rights themselves.
The challenge is to maintain the integrity of rights without reducing them to mere numbers or values, and this is undoubtedly facilitated by the improvement of digital technologies (especially in the area of natural language interpretation). In this context, as Floridi reminds us, the effectiveness of artificial intelligence is mainly derived from our ability to adapt the complexity of the world to a machine-readable format.

On this topic, specific literature also from the computer science perspective deals with the problem of such "informability", as clearly Paulin defines it[224] (see Par. 3.4).

The risk is to formalise law in such a way that it is now comprehensible to machines, while sacrificing richness and complexity in the name of efficiency. This efficiency-driven formalisation clashes with the inevitable complexities of law, which does not have efficiency as its main, or only, objective. Sometimes, in fact, it is necessary to adopt procedures that are less efficient but more guaranteeing, ensuring the protection of all without leaving anyone behind. Sometimes the best efficiency is not only frustrated, but even harmful, if the measure is not also effective.
The real challenge is to determine how much of the law can be translated into machine-understandable language without losing its inherent legal complexity. It is crucial to strike a balance between formalisation for machines and human determination of what is appropriate in a given context, while ensuring the protection of all. Projects such as Akomantoso work on formalising law in machine-readable formats. These projects represent attempts to address the challenge of translating legal complexity into a format that maintains both legal precision and complexity and readability for artificial intelligence. Although we cannot go into detail in this work, such initiatives are growing and can be possibly integrated into future developments of urban twins or digital twin cities.
They keep open the space for a debate on the distinction between "Regulative" and "Constitutive Rules", pointed out by Searle[225] and cited by Floridi.
The distinction will be more explored when writing about simulation (see Par. 4.4). In brief[226], "Regulative rules" can be described as the rules which

[224]See https://www.reuters.com/article/us-global-cities/everything-weve-heard-about-global-urbanization-turns-out-to-be-wrong-researchers-idUSKBN1K21UU, as reported in https://ourworldindata.org/urbanization (both link consulted on 10.01.2024).
[225]see J. R. Searle, "Constitutive Rules", Università degli studi di Sassari, 2018. https://doi.org/10.14275/2465-2334/20187.SEA.
[226]see Luciano Floridi, lesson 2022.06.28, Bologna Seminars, about J. R. Searle, "Constitutive Rules", Università degli studi di Sassari, 2018. https://doi.org/10.14275/2465-

regulate the activity, but the activity is going on anyway. "Constitutive rules", instead, are the rules that create the game (games are available only after the rules, for example in chess, monopoly, etc.).
This distinction is critical because of the suggested idea that by dominating the "Constitutive rules" we can achieve a position of control the system and we are successful in it. Applied to Digital Twin Cities, we might even theorise a position of "algorithmic govern" over the city, opening several scenarios of possibilities[227]. However, our distance to achieve this position requires us more research and understanding[228].

3.3.4. "Spatial Turn" in Law (C)

In recent years, the legal field has been increasingly confronted with the issue of spatiality, in what can well be described as a "spatial turn" in law. This marks a significant shift in perspective for a topic that is on the surface so proximate, yet so undervalued by legal scholars. The "spatial turn" in law refers to that epistemological tendency to investigate normative issues in relation to territory (or, in other words, to investigate the relationship between normative issues and territory). Especially in public law, it aims at valorising local autonomy as a legal capacity to create spaces that counter centripetal forces, by virtue of norms and provisions that recognise local autonomy's vast spheres of intervention in modern Western societies.

This approach recognises the profound impact that physical and social spaces have on the development and application of legal norms, particularly as society grapples with the challenges and opportunities presented by emerging technologies and digital media.
The seminal work of N. Irti, particularly in his book "Norm and Place", offers an initial exploration of these issues by examining the interaction between legal norms and spatial contexts. Although Irti's work, published in 2006, cannot take into account the latest technological advances such as artificial intelligence, it nevertheless provides a critical framework for understanding how spatial considerations can influence legal thinking.

The spatial turn in law encourages a reassessment of traditional legal paradigms, leading to the development of concepts such as "spatial justice" and "spatial inequalities". These concepts focus on the role of space in perpetuating or mitigating discrimination and inequality, highlighting the need for legal systems to address the spatial dimensions of social justice.

2334/20187.SEA.

[227] Just, as example, the possibility to generate states of the system just through constitutive rules, creating and using synthetic data instead of historical (and even personal) data.

[228] See in Par. 5.2.3. "Limitations and Further Research". It seems that these concepts are absent from the debate on the ideation or configuration of new laws.

Spatial justice, for example, involves examining how legal structures and policies can contribute to or alleviate inequalities in access to resources, opportunities and rights based on geographic location. This perspective is particularly relevant in urban environments, where issues of zoning, land use and urban planning intersect with issues of equity and inclusion.

Moreover, the spatial turn aligns with broader movements advocating a renewed focus on the "right to the city" and the development of human rights cities. These movements emphasise the importance of local autonomy and the legal capacity of communities to create spaces that also counter the dysfunctions and criticalities of globalisation and turbo-capitalism. By empowering local actors to shape their own environment, the spatial turn in law supports the idea that spatial arrangements can be harnessed to promote social justice and human rights.

By integrating spatial analysis into legal research and practice, this approach offers a more nuanced understanding of how legal systems can better serve diverse communities and contribute to a more equitable society, becoming a means to address broader social and legal challenges.

In the Western context, the state is undergoing a profound and long-lasting transformation, part of a broader transition phase that began with the end of the 20th century. Although some observers speak of a dilution of the traditional bonds of the state, it continues to maintain a central role in the political and social landscape.

However, the situation is more complex than it might appear at first sight. The state has progressively devolved various functions to local authorities and territorial articulations, such as the regions, in an attempt to manage the transition and recognise ownership of powers to a dimension closer to the territories.
Since the 2008 economic crisis, however, there has been a significant loss of administrative and financial capacity on the part of local authorities.

At the same time, other local authorities (such as cities) have taken the lead in addressing global challenges such as climate change, migration and technological innovation.
This has led to an increase in inequalities between large urban poles (often referred to as "hostile cities") and other areas, the rural areas. The cities themselves, which were supposed to act as engines of development and innovation, in the absence of corrective measures and systemic vision are now often struggling with limited resources and growing social and economic inequalities.

In response to these challenges, a new model known as "spatial justice," a concept developed in French scholarship and associated with scholars such as Florance Lerique and Edward Soya, has emerged. Spatial justice focuses on

equity in the distribution of resources and opportunities within urban and rural spaces, seeking to correct the structural inequalities that characterise many contemporary societies. This approach promotes an integrated vision of urban development that takes into account the diverse needs of local communities and aims to create more inclusive and sustainable spaces.

The objectives of spatial justice focus on enhancing the development of the human person and creating equitable spaces in which human life can develop properly. This implies a spatial organisation that reorganises the capacities (capabilities) of communities, promoting an environment that fosters individual and collective well-being. In this context, spatial justice is already a fundamental tool for evaluating the European Union's territorial cohesion policies, which aim to reduce economic and social disparities between different regions, but it can also extend its scope to the analysis of urban policies[229].

A central issue in the academic debate, led by scholars such as Florance Lerique and Edward Soja, concerns the most appropriate levels of government to activate spatial justice policies[230]. Discussions focus on which level of governance is most effective: local, regional, state or European. Each level has specific advantages and challenges. At the local level, policies can be more targeted and tailored to the specific needs of communities, while at the regional or state level, broader and more systematic efforts can be coordinated. Finally, European cohesion policies provide a framework for transnational integration and cooperation, which is essential to address inequalities on a broader scale.

In the French context, Florence Lerique highlighted the strong central presence of the state, which has historically influenced territorial organisation. Although the objective is to ensure equal territorial organisation, significant differences emerge, as noted by the French Court of Auditors. The "Loi 3DS" ("Loi n° 2022-217 du 21 février 2022 relative à la différenciation, la décentralisation, la déconcentration et portant diverses mesures de simplification de l'action publique locale") is the legislative instrument that takes a step towards decentralisation, seeking to balance power between the central state and local entities. In the French experience, spatial justice seeks to

[229]Spatial justice is not limited to the urban context, but extends to all territories, encompassing both urban and rural areas. This approach recognises the importance of addressing inequalities through a fair distribution of resources and opportunities, guaranteeing the right to a "just transition" involving all communities. The right to the city is a central, but not exclusive, element of spatial justice, which aims to absorb inequalities even in less urbanised areas. However, for the present work, it will be cited in this focus.

[230]see also A. Magnaghi, *La biorégion urbaine: petit traité sur le territoire bien commun.* Rhizome. Paris: Eterotopia France, 2014, as cited (pag. 229) in M. Lussault. *Iperluoghi. La nuova geografia della globalizzazione.* Milano: Franco Angeli, 2019. Concordant doctrine can be found in: P. Khanna, *La rinascita delle città-Stato.* Roma: Fazi Editore, 2018; E. Manzini, *Abitare La Prossimità.* Milano: Egea, 2022.

conceive of local authorities not only as passive receivers of funding, but as active players in territorial development. This implies an approach in which policies are not imposed from above, but rather managed locally, allowing communities to adapt strategies to their specific needs and potential. An example is given, again in France, by the "intercomunalité", which is becoming a crucial tool to ensure representation of municipalities, which otherwise risk being under-represented in the decision-making process. Another important aspect is the re-evaluation of equalisation, which can be both vertical, between different levels of government, and horizontal, between entities of the same level. This mechanism is essential to reduce territorial disparities and promote a fair distribution of resources.

Attempts to address spatial injustices are intensifying, driven by the principle of European territorial cohesion (on which spatial justice lays one of its foundations). This principle, developed since the 1980s, was formally incorporated in the 2007 Lisbon Treaty (Article 3 of the Treaty on European Union), becoming a matter of shared competence between the European Union and the member states. Territorial cohesion aims to reduce economic and social disparities between different regions, promoting balanced and sustainable development.

A significant step in this direction was the Green Paper on Territorial Cohesion of 2008, which for the first time spatially declined the problems of inequality. This document stressed the need to reduce the concentration of wealth and opportunities in a few privileged territories, proposing an approach based on "place-based policies." These policies, which have benefited from the contribution of scholars such as Fabrizio Barca, focus on the development of local specificities, enhancing the intrinsic resources and potential of each territory.

Place-based policies represent a paradigm shift from uniform solutions to customised strategies that take into account the unique characteristics of each urban and rural context. This approach aims to actively involve local communities in the decision-making process, promoting more inclusive and participatory governance. In this way, territories can become laboratories of social innovation, capable of tackling spatial injustices and contributing to a more equitable and sustainable future for all citizens.

The concept of "integrated urban development" is a transversal subject that develops from the intersection of several principles, including sustainable development. This approach[231] aims to address complex problems affecting

[231] see Marzia De Donno (Profili e conseguenze istituzionali della giustizia spaziale in Italia) and Matteo Falcone (Le città nelle politiche di coesione territoriale europee: criticità e prospettive per una effettiva giustizia spaziale) in the conference ICON-S Italia 2023 (Milan). See M. De Donno, "Per un dibattito sulla giustizia spaziale dal punto di vista del diritto pubblico", Le istituzioni del federalismo, 2023.

cities in an integrated manner, recognising the need for strategies that go beyond sectoral solutions. An important reference point in this context is the Toledo Declaration on Integrated Urban Development, which emphasises the importance of a holistic approach to urban challenges.

A 2014 Communication launched the Urban Agenda of the European Union, further formalised this approach. COM(2014)490 is a European Commission Communication entitled "The Urban Dimension of EU Policies - Key Features of an EU Urban Agenda", published on 18 July 2014. This document aims to address the challenges and opportunities related to urban areas in the European Union by proposing an EU Urban Agenda that better integrates urban issues into European policies and promotes sustainable urban development.

The Communication recognises that cities are crucial centres of innovation, economic growth and social cohesion, but they are also places where problems such as social inequality, environmental pollution and urban congestion manifest themselves acutely. Therefore, the EU Urban Agenda aims to provide a strategic framework to coordinate and optimise urban policies at European, national and local levels.

A more detailed analysis of the Communication will be addressed in the next chapter, within the framework of the LDT or Urban twins projects. For what concerns here, it is sufficient to note that one of the main objectives of the document is to promote an integrated approach to urban development, which takes into account the different dimensions - economic, social and environmental - of sustainable development. The communication stresses the importance of actively involving cities and local authorities in the decision-making process, recognising their key role in the implementation of urban policies.

This is, as seen, a provision closely in line with the concept of "spatial justice", and which also authorises its application within the city perimeter.

Furthermore, the document highlights the need to improve urban governance through greater cooperation between different levels of government and better integration of sectoral policies. This approach is seen as essential to effectively address urban challenges and to fully exploit the potential of urban areas as engines of growth and innovation within the EU.

This document links to the EU's Fundamental Rights, emphasising the importance of an urban environment that respects and promotes citizens' rights.

Strategies for integrated urban development are articulated at national and European level, addressing spatial injustice with a place-based approach. However, this approach is not yet common ground. Critical scholars point

out that spatiality is not yet fully intertwined with social justice, while there is still a strong emphasis on bureaucratic procedures rather than the effectiveness of policies. This vision, although criticised for having a competitive rather than a redistributive approach, can nevertheless act as a trigger for local dynamics that are essential for overcoming inequalities.

The insights for the future in the context of urban development and spatial justice are many and require careful consideration. First, the assumption that working on territories can automatically benefit the people who inhabit them is an open question. It is essential to question the effectiveness of this approach: are we sure that focusing exclusively on territorial development will guarantee a direct positive impact on local communities? This doubt invites reflection on how territorial policies can be more closely aligned with people's needs.

Secondly, the focus on funding as the main tool for addressing inequalities raises questions about its effectiveness. Although there has been a move away from blind faith in markets as a solution to inequalities, there is a risk of overestimating the role of funding. It is important to consider that not only funding, but also rules and regulations, play a crucial role in promoting equity and social justice.

Some scholars[232] emphasise the need to rediscover planning, rather than focusing exclusively on specific projects. This approach implies a return to a more strategic and long-term vision of urban development, which considers not only economic aspects, but also social and environmental ones. Planning, in this sense, can provide a more robust and coherent framework to address urban challenges and ensure that policies are truly effective in improving people's quality of life.

These insights suggest the need for a more integrated and holistic approach, which considers the interconnections between land, people, finance and regulations, to build more just and sustainable cities and communities.

The theme of spatial injustice[233] and the new urban question[234], as outlined by Bernardo Secchi, is intertwined with the emerging idea of the "15-minute city". This concept, adopted in cities such as Paris and Barcelona, proposes an urban model in which residents can access all essential services, such as work, education, health and recreation, within a 15-minute walk or bicycle ride from their homes. This approach aims to promote greater sustainability, reduce transport dependency, and improve the quality of urban life.

However, the law has not yet fully addressed these new forms of urban

[232]see for example M. De Donno, "Per un dibattito sulla giustizia spaziale dal punto di vista del diritto pubblico", Le istituzioni del federalismo, 2023.
[233]see Par. 3.2.2.
[234]see Par. 3.2.2.

organisation, such as the "15-minute city" and the "diffuse city," risking ignoring situations that become difficult to regulate or perpetuate structural inequalities. The 15-minute city, for example, is a socio-technical device with the potential to profoundly influence urban inequalities, often more than many existing regulations. However, the law seems to take little interest in this issue, leaving it confined to the realm of urban policies.

A significant criticism of the 15-minute city concerns the need to ensure that workers who provide services in these areas can also live within 15 minutes of their workplace. Without this inclusivity, the model risks exacerbating inequalities, creating elitist neighbourhoods accessible only to those who can afford to live there.

At the same time, the "diffuse city" is often criticised as a high-tech form of closed community that excludes the different and the poor, leading to a "clubbing" of urban life. This model can accentuate social and spatial segregation, creating enclaves of privilege that do not address the needs of the most vulnerable populations.

In sum, the law must evolve to address these new urban configurations, ensuring that urban policies promote equity and inclusion, rather than perpetuating or exacerbating existing inequalities.

Law should pay more attention to the topic of proximity, a concept that has several dimensions and significant implications for the regulation of modern cities. Ezio Manzini, with his concept of "relational proximity," and Michel Lussault, with his distinctions between "topographical proximity" and "topological proximity," offer valuable insights into how spatial and social relations can be rethought in an urban context.

The distinction between topographical proximity and topological proximity, in particular, seems to open up an important space of exploration for law in the advent of complex tools such as an urban digital twin.

Topographic proximity refers to proximity that is expressed by physical co-presence, the direct and immediate contact between people or things in the same space. In contrast, topological proximity is mediated by mobility and communication networks, allowing actions in different spaces to be connected. This type of proximity is particularly relevant in the context of modern cities, where mobility and digital technologies allow for interactions that transcend geographical limitations, but there is still a lack of reflection on its full explication within an urban context.

One only has to think of the example, cited by Lussault, of "three hundred and sixty-degree experiments to define new "mobilitarian", to use the neologism created by experts, less energy-intensive and more efficient mobilities". These are urban experiments from below, which may sometimes even

conflict[235] with municipal regulations that are not adapted to the changing times.

The new forms of proximity require adequate regulation to address the challenges and opportunities they present. Some areas, such as the management of social networks, are already the subject of study and regulatory enforcement. However, much remains to be done, especially in the context of smart cities and "urban digital twins," where citizen participation and data management require new forms of governance.

In this scenario, the law must evolve to ensure that urban policies and technological regulations promote greater equity and inclusion. This implies not only adopting regulations governing new forms of mobility and interaction, but also imagining new models of civic participation that harness the potential of digital technologies to create more sustainable and just cities. Any kind of decision-making about the city (be it transport, energy or waste management) greatly impacts the city itself, the lives of its citizens, conditioning their rights, possibilities and obligations[236].

3.3.5. Closing Considerations

This paragraph attempted to draft insights from the legal field in what is already the process of adaptation to the significant societal changes driven by digital technologies and urbanisation. However, while fields like sociology and urban studies have evolved to address issues of inequality and power dynamics, law has been slower to respond. The traditional Westphalian model, which ties legal authority to territorial boundaries, is questioned in a world where digital interactions often ignore geographic limits. The re-evaluation of jurisdictional frameworks and governance models, to better align with the realities of global platforms and cross-border transactions, is a pressing demand.

The use of big data and AI in urban management, as seen in digital twin cities, offers both promising opportunities and serious challenges. The law is already reflecting on the important concerns about transparency, fairness, privacy, and surveillance potential raised by technologies. More challenging,

[235] A paradigmatic example of conflicting interests occurred in Milan in early February 2024, when several trees placed by residents on Via Aselli to prevent uncontrolled parking were removed by the municipality. The residents, who had taken this initiative to counteract the improper use of public space, were not only met with the removal of the trees but were also fined for unauthorized occupation of public land. News at https://www.milanotoday.it/attualita/via-aselli-volontari-multati.html (link consulted on 07.02.2025).

[236] See S. Rodotà, *La vita e le regole.* Tra diritto e non diritto (third edition), Feltrinelli, 2018, but also (highlighting the hostile potential of the instrumental use of legislation) A. Sari, "Hybrid CoE Trend Report 3: Hybrid threats and the law: concepts, trends and implications", European Centre of Excellence for Countering Hybrid Threats, 2020.

but not absent in literature, is the idea to re-imagine the urban governance. Concepts like "algorithmic governance" can bring these issues to the forefront, highlighting the dangers of biased datasets and the lack of accountability in automated decision-making processes. Scholars like Shoshana Zuboff and Luciano Floridi provide valuable insights into these challenges, advocating for careful consideration in the deployment of such technologies.

The General Data Protection Regulation (GDPR) stands out as a key example of how legal frameworks can evolve to protect personal identity in the digital age. By linking identity to personal data, the GDPR has established new global privacy standards, influencing at least partially the laws worldwide. This adaptation underscores the ongoing need for legal frameworks to evolve in response to digital challenges, an effort that can link "new powers" with "new responsibilities".

Furthermore, the "spatial turn" in legal thinking invites an interdisciplinary approach that considers both physical and virtual spaces in shaping legal and social dynamics. The intersection of law with geography, urban planning, and technology presents rich opportunities for research that can inform more effective legal responses to contemporary issues. It could be an already present jointure between "spatial justice" and "space", or "places". The literature recollected advocates for a balanced approach that integrates technological innovation with fundamental rights, and this can be done using the spatial dimension as a lens. Legal scholars must be encouraged to explore how law can adapt to these evolving challenges while protecting individual rights and promoting justice in both physical and digital spaces. This requires a commitment to ensuring that advancements in AI and related technologies do not undermine democratic values or exacerbate existing inequalities, especially in the "spatial dimension" that is so crucial in the present time, and will be even more crucial in the future. By doing so, the legal field can play a crucial role in fostering a more equitable and just society in our increasingly digital world.

3.4. Big Data & Cities - the Computer Science perspective

Summary: 3.4.1. An Introduction from a Computer Science Perspective - 3.4.2. A Selected Literature Review - 3.4.3. Maturity Models and Levels - 3.4.4. The Laboratory and the City

3.4.1. An Introduction from a Computer Science Perspective

The ongoing debate within the scholarly community regarding the management of cities through big data revealed a significant division, with scholars aligning themselves with two distinct positions.

On one hand, a critical view suggests that the reliance on big data for city management is inherently limited and risks oversimplifying the complex nature of urban environments. Critics argue that such an approach leads to a reductionist perspective, flattening the city's multifaceted dimensions into proxies that fail to capture its true essence. This concern is echoed in the works of scholars[237], who highlight the inadequacy of current big data techniques in representing cities with several dimensions.

On the other hand, it could be argued that it is possible to manage urban environments using big data, drawing parallels to the unexpected insights gained from the "world of mathematics". These scholars assert that the methodologies and analytical tools developed in mathematical sciences can be effectively applied to enhance our understanding of urban dynamics, leading to more informed decision-making processes. The inadequacy is temporary, as new theories and techniques will take place if proven to be more effective in certain circumstances.
This perspective is particularly embraced by the computer science literature, which emphasises the technical feasibility of transferring industry knowledge about data analytics and simulation to urban management.

The tension between these positions underscores a fundamental challenge in urban informatics: balancing the potential of big data to enhance urban management with the need to preserve the rich, multidimensional character of cities.
As the discourse evolves, it becomes imperative for researchers and practitioners to critically evaluate the implications of big data technologies, ensuring that they complement rather than constrain our understanding of urban

[237] Many sources are pointing out the inadequacy of current big data techniques in representing cities with more than four dimensions. See K. Lelo, S. Monni, F. Tomassi, *Le Sette Rome: La Capitale Delle Disuguaglianze Raccontata in 29 Mappe*. Saggine 352. Roma: Donzelli editore, 2021; B. Brollo, F. Celata, "Temporary Populations and Sociospatial Polarisation in the Short-Term City", *Urban Studies* 60, no. 10, 2023: 1815–32. https://doi.org/10.1177/00420980221136957.

life.

As mentioned, according to part of the doctrine, the state of the art in smart city simulation is the so-called 'digital twins'. In this way, as previously mentioned in the Chapter 1, the term will be considered.

In the paper "A Comprehensive Review of Digital Twin - Part 1: Modeling and Twinning Enabling Technologies - part 1"[238], it is made clear that:

1. A digital model necessitates a hands-on transfer of data between tangible and virtual entities, with alterations in the physical entity having no effect on its digital counterpart.

2. A digital shadow advances this concept by enabling unidirectional data flow, where modifications in the physical system are mirrored in its digital counterpart.

3. A digital twin is characterised by a two-way data communication, implying that any change in one will lead to an adjustment in its corresponding entity.

The last point is the most problematic one in a digital twin city, and must be considered with great attention. It will be discussed particularly in Par 3.4.4.

According to this premise, Deng et al. (2021) write:

As a new model for building smart cities, the DTC will reshape the city governance structures and rules and inject a continuous momentum for the development and transformation of cities. Many of the important cities around the world have launched plans to build digital twin cities. The rapid development of digital twin technologies has also made it possible to construct digital twin cities. By analyzing the existing digital twin technologies, based on the development of smart cities, this paper proposes a pattern of digital twins. A self-perceiving, self-determining, self-organizing, self-executing, and adaptive platform for urban operation and maintenance is constructed through surveying and mapping technology, IoT perception, collaborative computing, simulation, and deep learning. The development of DTCs will create a new management pattern that can trace past events and explore frontier directions, which will be a trend for future research on DTCs.[239]

[238] See A. Thelen, X. Zhang, O. Fink, Y. Lu, S. Ghosh, B. D. Youn, M. D. Todd, S. Mahadevan, C. Hu, and Z. Hu, "A Comprehensive Review of Digital Twin – Part 1: Modeling and Twinning Enabling Technologies", 2022. https://doi.org/10.48550/ARXIV.2208.14197.

[239] See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities". *Journal of Management Science and Engineering* 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

It would appear possible, therefore, in the interpretation offered, that DTCs offer the possibility of experimenting with "frontier directions" and, with them, also respond to the demands for the enhancement and optimisation of smart city projects.

Types of Digital Twin Cities can be divided into two main categories, based on an initial abstraction from case studies:

- Functional Digital Twin Cities: These are digital twin cities that focus primarily on optimising and improving specific functions or sectors within the urban environment.
- Comprehensive Digital Twin Cities: These are digital twin cities that aim to replicate and simulate the entire urban ecosystem, encompassing multiple sectors and functions within the city.

This distinction, however, seems to be too broad for a practical adoption in the present work, even if it suggests possible differences based on the scale of the "encoding" on the city.

A more articulated taxonomy for classifying Digital Twin Cities could be based on:

- Level of Detail: This refers to the extent to which a digital twin city replicates and represents the physical city.
- Granularity: This refers to the level of detail or resolution at which the digital twin city operates[240]. It can range from a macro-level view of the city to a micro-level view of individual buildings or even specific components within buildings.
- Domain-specific Focus: This refers to the specific domains or areas of the city that the digital twin city focuses on. For example, some digital twin cities may prioritize transportation and mobility, while others may emphasize energy efficiency or urban planning.

Digital twin cities are formed by installing numerous sensors and mechanisms for collecting data within cityscapes. Many authors tried to classify the Digital Twin Cities based on some characteristics. These efforts are useful, even if not done from a legal point of view, to understand the phenomenon.

[240]See the term as, for example, in PwC, "How digital twins can make smart cities better", 2022. This concept can be aligned with the concept of High-Frequency and Low-Frequency City as seen in M. Batty, "Digital Twins", *Environment and Planning B: Urban Analytics and City Science* 45, no. 5, 2018: 817–20. https://doi.org/10.1177/2399808318796416; C. Wildfire, "How can we spearhead city-scale digital twins?" *Infrastructure Intelligence*, 2018. Previously available at link: http://www.infrastructure-intelligence.com/article/may-2018/how-can-we-spearhead-city-scale-digital-twins, then available here https://www.mottmac.com/views/how-can-we-spearhead-city-scale-digital-twins (last accessed 19.09.2024).

Attempts are primarily using the concept of "maturity level" of integration and development, as in:

- 2022, Uhlenkamp et al. "Digital Twins: A Maturity Model for Their Classification and Evaluation"[241]
- 2023, Sophia Weß, *Wie können digitale Zwillinge die Aufgabenerledigung deutscher Kommunen verändern? eine Analyse von Einsatzbereichen, Veränderungspotenzialen und Rahmenbedingungen* (How can digital twins change the way German municipalities perform their tasks?)[242].
- 2024, Haraguchi et al. "Assessing Governance Implications of City Digital Twin Technology: A Maturity Model Approach"[243].

What is anticipated in this Paragraph 3.4.1. will be tested with a deeper analysis of a selected Computer Science literature, in the form explained in the Methodology section (see Chapter 2) and later developed in this Chapter 3.

3.4.2. A Selected Literature Review

A deeper look into the computer science and informatics Digital Twin literature could be useful to better understand the functionalities of the system, to then use the acquired knowledge in the legal analysis (Chapter 4). An initial dive into the topic can be found in the Definitions and Major Trends highlighted in the Paper titled *"Digital Twin Paradigm: A Systematic Literature Review"* by Semeraro et al. (2021).

The paper by Semeraro et al. (2021)[244] presents a comprehensive review of the Digital Twin (DT) concept, focusing on its definition, applications, components, technical challenges, and future research directions. It provides insights into how DT technology is evolving, especially within the context

[241] See J-F. Uhlenkamp, J. Baalsrud Hauge, E. Broda, M. Lutjen, M. Freitag, and K-D. Thoben. "Digital Twins: A Maturity Model for Their Classification and Evaluation". IEEE Access 10, 2022: 69605–35. https://doi.org/10.1109/ACCESS.2022.3186353.

[242] See S. Weß, *Wie können digitale Zwillinge die Aufgabenerledigung deutscher Kommunen verändern? eine Analyse von Einsatzbereichen, Veränderungspotenzialen und Rahmenbedingungen* (How can digital twins change the way German municipalities perform their tasks?), edited by Jörn von Lucke. TOGI Schriftenreihe (The Open Government Institute), Vol. 24. Berlin: epubli, 2023.

[243] See see M. Haraguchi, T. Funahashi, and F. Biljecki, "Assessing Governance Implications of City Digital Twin Technology: A Maturity Model Approach", *Technological Forecasting and Social Change* 204, 2024: 123409. https://doi.org/10.1016/j.techfore.2024.123409.

[244] See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

of *Industry 4.0*, which refers to the ongoing industrial revolution driven by digitalisation, automation, and smart manufacturing.

The paper presents various definitions of the *Digital Twin* from different sources and groups them into clusters based on similarities. A slightly different qualitative analysis, from the one proposed in the paper, can help us extract some of the most important features (or expectations) on DT, linked with the purpose of the present work. The list can be reduced to the following:

- Grieves (2014), but dating back to a definition of 2002: *a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level. At its optimum, any information that could be obtained from inspecting a physical manufactured product can be obtained from its Digital Twin. The Digital Twin concept model contains three main parts: a) physical products in Real Space, b) virtual products in Virtual Space, and c) the connections of data and information that ties the virtual and real products together.* This definition, as already mentioned, remains as a milestone and shaped all the following.
- Glaessgen & Stargel (2012): *an integrated multi-physics, multi-scale, probabilistic simulation of a complex product and uses the best available physical models, sensor updates, C1 etc., to mirror the life of its corresponding twin.* This definition points out the multi-physics and the multi-scale dimensions of the DT, but also focuses on its nature of "probabilistic" and "simulation".
- Lee et al. (2013): *a coupled model enables a digital twin of the real machine that operates in the cloud platform in parallel with the real process and simulates the health condition with an integrated knowledge from both data driven analytical algorithms as well as other available physical knowledge. The coupled model approach first constructs a digital image of a machine from the early design stage.* This definition has the merit of paying attention on the cloud component to perform a DT, explaining that each twin must "live" in parallel. The digital counterpart will "simulate the health condition" with "an integrated knowledge", that in an object is information coming from sensors, but in a city is left open to be broader in sense.
- Ciavotta et al., 2017: *a digital avatar encompassing CPS data and intelligence, representing structure, semantics, and behaviour of the associated CPS, and providing services to mesh the virtual and physical worlds.* This definition, other than highlighting the nature of CPS (Cyber-Physical Systems: Systems that integrate physical and computational components, closely tied to the concept of DT.), pays

attention to the structure level, the semantics and the behaviour of the CPS.

- Schleich et al., 2017: *a bi-directional relation between a physical artefact and the set of its virtual models, enabling the efficient execution of product design, manufacturing, servicing, and various other activities throughout the product life cycle.* This definition highlights the "efficiency" as a key destination in DT and the nature of the "cycle". Both the concepts are fundamental in what a DT really is.

- Schluse et al., 2017: *a one-to-one virtual replica of a "technical asset" (e.g., machine, component, and part of the environment). A digital twin contains models of its data (geometry, structure, …), its functionality (data processing, behaviour, …), and its communication interfaces. It integrates all knowledge resulting from modelling activities in engineering (digital model) and from working data captured during real-world operation (digital shadow). A Digital Twin contains models of its "data" (geometry, structure, …), its functionality (data processing, behaviour, …) and its communication interfaces.* This definition has many merits, in particular to break down the phases of a DT and suggesting the relationships between them. It contains also the concept of Digital Shadow, which other literature[245] more strongly opposes to the concept of DT.

- Weber et al., 2017: *a digital representation that contains all the states and functions of a physical asset and has the possibility to collaborate with other digital twins to achieve a holistic intelligence that allows for decentralized self-control.* This definition particularly doesn"t align with a city, if the DT is intended to replicate all the states and functions of a city, but poses the topic of achieving a "holistic intelligence" when, in this case, collaborating with other digital twins. This view reconnect with the idea of a "swarm intelligence" expressed in Paragraph 3.3. and refined also later (Par. 4.4.1.).

- Z. Liu et al., 2018: *"a living model that continually adapts to change in the environment or operation using real-time sensory data and can forecast the future of the C4 corresponding physical assets for predictive maintenance."* This definition has the merit to highlight the need of a constant adaptation between the physical and the digital layer, to keep the DT "alive". In the context of a DTC, it could mean a transparent re-assessment of the correspondence between the city and the model, mimicking not only the city's expansion or contraction but also the

[245]see A. Thelen, X. Zhang, O. Fink, Y. Lu, S. Ghosh, B. D. Youn, M. D. Todd, S. Mahadevan, C. Hu, and Z. Hu, "A Comprehensive Review of Digital Twin – Part 1: Modeling and Twinning Enabling Technologies", 2022. https://doi.org/10.48550/ARXIV.2208.14197.

relevance and the significance of the data collected (for example, the sensors used in public transport to determine the commuting time of workers must be re-assessed in their purpose if the labour market change, or the work change).

The common elements across the definitions include: - Bidirectional (sometimes real-time synchronisation) between physical and virtual entities. - Collection and usage of specific data, for specific purposes (but generally for optimisation and efficiency) - The possibility to simulate behaviours and to predict the outcomes. It seems possible to say that a Digital Twin is a virtual representation of a physical entity that is continuously updated with real-time data from the physical system. In stricter technical terms (and we saw in the literature proposed before that many DT projects for cities don"t match exactly this definition).

Starting from the premises that Digital Twins are widely applied across the entire *product lifecycle*: from design and production to service phases, and already applied in different domains (like healthcare, manufacturing, city management, aerospace, and maritime industries) that use DTs for various purposes.
Predictive Maintenance is probably the most common application of DTs, where they are used to predict equipment failures and plan maintenance activities, reducing unplanned downtimes. The evolution, however, is pushing the boundaries of the use to a better integration for Performance Optimization, where DTs analyze real-time data and suggest ways to optimize the operation of physical systems. The advancements in the technology, combined with the Digital Revolution (described above) suggested the possibility of applying DTs also to "Decision-Making Support. it is undeniable that DTs can provide information to decision-makers with real-time insights, simulations, and predictions to help optimize processes, designs, and services. The debate, however, as it is intended in the present work, remains open (and unaddressed in computer science literature) on the reconstruction of the legal framework of DTCs to juridically qualify these real-time insights, simulations, and predictions.

Other two components are Data centers and the City information model - CIM.

Paragraph from Deng et al. (2021) explain: *Data are the core strategic resource of digital twin cities. A data center, especially the super data center for a city, manages the entire life cycle of all the data in the DTC. With the growing use of mobile data, one challenge is to provide multifunctional, scalable, and flexible platforms that could address new problems with minimum cost and power. Ham and Kim (2020) proposed a new framework to bring crowdsourced visual data-based reality information into a three-dimensional (3D) virtual city for a model update with interactive and immersive visu-*

alization. Fan, Jiang and Mostafavi (2020) proposed an integrated textual-visual-geo framework to enhance social sensing techniques in the context of disasters, and this framework had been proved effective during Hurricane Harvey in 2017. However, owing to the explosive rise in the amount of data being generated by smart city devices, managing and storing these data on the data center is unreliable and inefficient. Uploading data to the cloud servers might cause long delays or even compromise data integrity. Therefore, it is necessary to explore the balance of efficiency and safety.[246]

So, the following two important tasks need to be considered: - (1) through parallel heterogeneous computing, accelerating the computation and processing on massive real-time heterogeneous data networks - (2) perceptually modelling in the urban environment and designing an adaptive vision algorithm that is robust to the environment.

it is acknowledged[247] that in each context *digital twins have their own specificity within the life cycle phase of the product: namely design, manufacturing, and service. As a result, each application of DT varies depending on a different perspective and needs accordingly.* However, the city management DT are not fully expanded, living the idea that in literature the city is perceived as a complex system, as describe in these words:

Cities are areas of human settlement, with high population density, complete infrastructure, and buildings. Digital Twins, in City Management, improve the urban environment and people's quality of life. The digital twin can simulate people movements and emergency evacuations, modelling smart buildings, road traffic, air quality, infrastructure, and circular urban economies. The benefits of modelling range from preventive maintenance to operational efficiencies and cost savings. The DTs improve services for citizens, and increase safety and security (Mohammadi and Taylor, 2017)[248]*.*

What seems lacking, in this source, is a critical reflection on the real similarities between a city and an object. If we accept, to use the same words of the paper, that *each application of DT varies depending on a different*

[246]See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities". *Journal of Management Science and Engineering* 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

[247]See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[248]See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130 (September 2021): 103469. https://doi.org/10.1016/j.compind.2021.103469. They cite N. Mohammadi, J. E. Taylor, "Smart City Digital Twins". In 2017 IEEE Symposium Series on Computational Intelligence (SSCI), 1–5. Honolulu, HI: IEEE, 2017. https://doi.org/10.1109/SSCI.2017.8285439.

perspective and needs accordingly, it is then worth considering that a DT in a city, or for city management, can be different from any other application of DT technologies.

This problem is partially managed by the so-called City information model - CIM:

Deng et al. (2021) continue: *Establishing a CIM to realize the digitization of the whole process and all elements of the city is critical. This model integrates the geographic information model, the building information model, the IoT, AI, and big data technology. It is a fullspace, three-dimensional, and high-precision CIM. It can achieve real-time visualization of the entire city, realize the simultaneous planning and construction of digital and real cities, and empower the entire process of urban planning, construction, and operation management. The DTC of Atlanta is a virtual reality-based platform containing a fully modeled city of Atlanta in three dimensions. This platform is interactive and data-driven, enabling reciprocal spatiotemporal infrastructure. Through the analytics module, the platform can capture the information from infrastructure and society networks to monitor dynamic performance, such as operation, allocation of resources, and consumption (Mohammadi and Taylor, 2017). Therefore, richer insights are fed into a living digital simulation system for examining a variety of scenarios in the future.*[249]

Coming back to Semeraro et al. (2021)[250] analysis, the authors performed a systematic literature review, analysing over 150 relevant papers (2002–2020) from databases such as Scopus, Elsevier, and ScienceDirect, using text mining techniques, including hierarchical clustering (HCA) and topic modelling (LDA - Latent Dirichlet Allocation). Applying Formal Concept Analysis (FCA) to group and understand the technical details of the DT paradigm, especially in terms of lifecycle phases, functions, and architectural components. They found that DTs are primarily used to accelerate product development, improve customer satisfaction by identifying needs, optimize performance, and provide remote monitoring and diagnostics. These functions vary based on the lifecycle phase: - *Design phase*: Used for conceptualising, simulating, and validating designs before physical prototypes are created. This phase uses DTs to incorporate customer feedback and preferences. - *Production phase*: DTs enable real-time monitoring, analysis, and optimisation of manufacturing processes, improving efficiency, quality, and reducing downtime.

[249] See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities". *Journal of Management Science and Engineering* 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

[250] See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

Examples include predicting equipment failures or optimising resource allocation. - *Service phase*: Involves predictive maintenance, remote diagnostics, and optimisation of product performance over its lifecycle. DTs are used to monitor the health of systems and predict failures or service needs.

As mentioned earlier in this work, DT architectures are structured in layers (physical, virtual, and service layers). These architectures integrate physical systems (with sensors and actuators), virtual representations, and real-time data flows between the two spaces. The analysis finds that the architecture of a DT can vary based on application, but it typically consists of three main layers (as the original description by Grieves 2014[251]. See also (Boje et al., 2020)[252]): - Physical Layer: This includes the real-world system, equipped with sensors and actuators to collect real-time data (e.g., vibration, temperature, torque). - Network Layer: Ensures the communication between the physical and virtual systems, often through IoT technologies, *RFID* (Radio Frequency Identification), and *Wireless Sensor Networks* (WSN). - Virtual/Computational Layer: Hosts the virtual representation of the physical system, consisting of data-driven models and physics-based simulations. This layer is responsible for processing, analysing, and optimising the data received from the physical layer.

This basic description can be specified further as in literature[253]. Each layer is characterised by some DT components (for example hardware or software technologies, models, information structures) with commonalities in their scope of use and interactions, having also complementary functionalities[254].

These Technological Components that can be more interesting for the present work are: - Sensors and Actuators: critical for collecting real-time data from the physical system, these devices monitor (in industry) key operational parameters such as temperature, pressure, or machine vibrations. In a city, they can be used to collect data from city-flows (traffic, energy, waste management) or for more advances uses (making possible

[251]See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[252]see C. Boje, A. Guerriero, S. Kubicki, and Y. Rezgui. "Towards a Semantic Construction Digital Twin: Directions for Future Research". Automation in Construction 114 (June 2020): 103179. https://doi.org/10.1016/j.autcon.2020.103179, as cited in See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[253]See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[254]See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

the "sensor-society" (Ziccardi, 2021[255])). IoT technology integrates RFID networks and Wireless Sensor Networks (WSNs) for real-time tracking and data acquisition. - Big Data and Analytics: DTs leverage vast amounts of data from their physical counterparts to run predictive algorithms and simulations. Machine learning models are often employed to predict system behaviour and suggest optimisations. Many DT systems rely on cloud platforms for data storage, computational power, and advanced analytics. Main developers in this area, for city management[256], are private companies like Microsoft Azure, SAP Leonardo Platform, Dassault 3D Experience (as seen in Singapore, Par. 3.1.2.), IBM Watson, Oracle Cloud.

Another interesting analysis is the one contained in Deng et al. (2021)[257]. They specify how a Digital Twin City (DTC) must integrate a range of advanced technologies, each contributing uniquely to its comprehensive functionality. Surveying and mapping technology serves as the foundation for acquiring static data on urban structures, creating a precise digital representation of the city's physical environment. Building Information Modeling (BIM) plays a critical role in this ecosystem by providing detailed digital representations of building geometries, spatial relationships, and geographic information, which are essential for effective asset and infrastructure management. This allows city planners and managers to optimize maintenance schedules and resource allocation. The Internet of Things (IoT) and 5G networks are indispensable for collecting dynamic data, facilitating seamless real-time communication between various city components. These technologies enable the continuous monitoring of environmental conditions and urban activities, enhancing the city's responsiveness to changing circumstances. Collaborative computing, enhanced by 5G's high-speed connectivity, supports efficient real-time decision-making processes.

Deng et al. (2021) mentioned also the Blockchain technology, which could play a role in registering or transactions. Additionally, simulation technology provides robust support for policy-making, urban planning, and early warning systems by enabling detailed scenario modelling and predictive analysis.

Collectively, these technologies create an interconnected framework that enhances the operational efficiency and adaptability of a DTC. Several chal-

[255]see G. Ziccardi. *Diritti Digitali. Informatica Giuridica per Le Nuove Professioni.* Raffaello Cortina Editore, 2022

[256]See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[257]See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities". *Journal of Management Science and Engineering* 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

lenges, however, remain even in the technical development of the concept, like: - Data Management: Handling large volumes of real-time data, ensuring *interoperability* between different systems, and maintaining data security and privacy are key challenges. - Standardisation: There is no universally accepted framework for DTs, which makes implementation in diverse industries difficult. - Scalability: As DTs grow in complexity, scaling them to large, distributed systems (like smart cities or industrial complexes) presents a challenge. Other challenges include cybersecurity, privacy concerns with real-time data use.

Semeraro at al. (2021)[258] identifies several key areas for further research: - Developing Standardized Frameworks: To enable better interoperability and scalability of DT systems. - Improving Data Security: Handling sensitive data in DT systems, especially in healthcare and smart city applications, requires robust security measures. - Integrating AI and ML: Future DTs could benefit from more advanced machine learning models that can adapt and evolve based on real-time data. - Addressing Cybersecurity Risks: Ensuring that DT systems are secure from external threats is critical as these systems grow in complexity and importance.

Merit of the paper by Semeraro et al. (2021)[259] is to recognize that significant research efforts need to be made on the application of a digital twin for improving the sustainability performances in each application context.

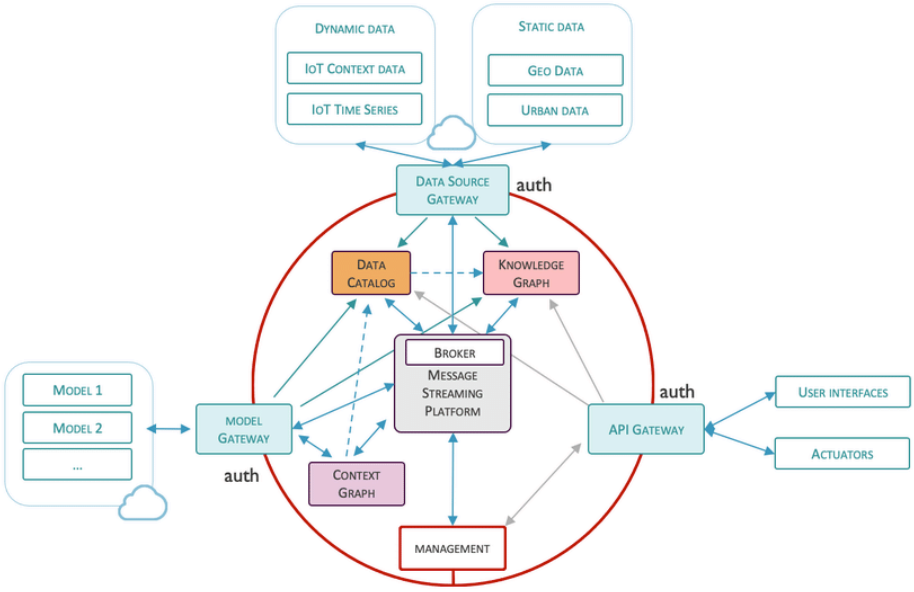
The research gap was partially addressed by the DUET project. Initially described in Par 3.1.4. of the present work, the DUET EU Horizon 2020 Project is extensively described in the paper "Open Urban Digital Twins – insights in the current state of play" (2021)[260].

It presented a Open Urban Digital Twin architecture, based on the architecture developed in the DUET EU Horizon 2020 project.

[258] See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[259] See C. Semeraro, M. Lezoche, H. Panetto, and M. Dassisti. "Digital Twin Paradigm: A Systematic Literature Review", *Computers in Industry* 130, 2021: 103469. https://doi.org/10.1016/j.compind.2021.103469.

[260] see T. Coenen, N. Walravens, S. Lefever, P. Michiels, B. Otjacques, and G. Degreef. "Open Urban Digital Twins – Insights in the Current State of Play", 2021.



- Figure 3: The visual scheme in question represents a cross-domain decision support system, composed of both static and dynamic urban data across domains (such as mobility, air quality, and infrastructure) and utilizes real-time data from IoT devices. The architecture can be understood through several core layers:

a. Data Sources

- Static Data: Includes geospatial data (like 3D models of buildings or roads) and demographic information (e.g., age distribution, socio-economic profiles). Static data represents fixed aspects of the city's structure and its population.
- Dynamic Data: Sourced primarily from IoT sensors embedded within the city infrastructure. This real-time data (e.g., traffic flow, air quality measurements) is crucial for monitoring and reacting to the city's evolving conditions.
- Context Data: Meta-information about the dynamic data, such as sensor calibration settings, time stamps, and geographic location. This contextual information ensures that raw data is accurately interpreted within its specific environment.

b. Models

- Process-Centric Models: These are based on traditional, well-established knowledge of physical processes. For example, air quality

prediction models that use wind speeds and traffic patterns to estimate pollution levels in real-time.
- Data-Centric Models: Built on machine learning and artificial intelligence, these models adapt and learn from the massive datasets generated by IoT sensors. Unlike process-centric models, they can update and refine their outputs based on new data, increasing predictive accuracy over time.

c. Brokers

- Data Broker: A critical middleware component that collects, processes, and redistributes the diverse datasets across the system. It ensures communication between different models and data sources, allowing seamless cross-domain decision making.
- Context Broker: Ensures that all data exchanged within the system is enriched with appropriate metadata. This component was initially developed under the FIWare framework and helps contextualize IoT data in urban environments.

d. Actuators

- Actuators are mechanisms or devices that can enact changes in the physical environment, such as traffic lights responding to real-time traffic data or autonomous vehicles adjusting their routes based on real-time conditions. They are crucial for the "digital-to-physical" interaction within a UDT.

e. Decision Support Layer

- UDT provides both short-term operational support (e.g., adjusting traffic lights to improve traffic flow) and long-term strategic planning (e.g., determining the optimal locations for flood-prevention infrastructure). It does so by integrating both human and automated decision-making processes.

The scheme showcases UDT's capacity to function as a composite system, where multiple individual twins of urban entities (e.g., buildings, streets, or vehicles) combine to create a broader urban-scale twin. The architecture is highly modular and extensible, allowing new models, datasets, and decision-making algorithms to be plugged into the system over time.

- Cross-Domain Integration: A key feature of UDT is its ability to integrate and align data from previously siloed domains like traffic management and air quality monitoring, enabling comprehensive analysis and improved decision making.

- Interoperability: The architecture emphasizes the use of open standards and APIs to ensure interoperability between data sources, models, and actuators across different urban domains.

In cities such as Antwerp and Bruges, this architecture has been applied to integrate traffic and air quality models. Here, traffic models predict the flow and types of vehicles in certain areas, while air quality models estimate pollution levels. UDT links these models, enabling city managers to visualize how changes in traffic patterns affect air quality and to make data-driven decisions to mitigate pollution.

The architecture of the Open Urban Digital Twin (UDT), as derived from the DUET EU Horizon 2020 project, represents a sophisticated integration of cross-domain data systems aimed at enhancing urban decision-making processes through real-time interaction between physical and digital environments, but some consideration can already be made.
The UDT framework connects static datasets, such as geospatial and demographic information, with dynamic data collected via IoT sensors, enabling continuous monitoring and simulation of urban systems. Central to the architecture is the data broker, which serves as the backbone for the collection, processing, and redistribution of diverse datasets, while ensuring semantic interoperability across different urban domains.
Data brokers are regulated in the Data Act, but it is interplay with GDPR and AI Act is yet to be tested in practice[261].

This facilitates the interaction between process-centric models, grounded in established human knowledge, and data-centric models, which leverage machine learning to adapt to evolving real-world conditions. The UDT's ability to support both short-term operational decisions (such as traffic management through real-time adjustments of traffic signals) and long-term strategic planning (for instance, optimising urban infrastructure to mitigate flood risks) could exemplify its versatility, but possibly at a cost of pursuing a clear goal.

Moreover, the architecture is designed for scalability, incorporating advanced brokers and message queue systems to manage growing data volumes, and it adheres to open standards for future extensibility. The scalability, however, must also be intended in the city size, with systems designed for high quantities of data that could struggle with lower quantities of them (not enough data for valuable analyses).

Coming back to the intended project, the UDT not only supports human decision-makers but also enables automated decision-making processes, further enhancing urban governance by integrating predictive models with actu-

[261] See H. Ruschmeier, "Data Brokers and European Digital Legislation". European Data Protection Law Review 9, no. 1, 2023: 27–38. https://doi.org/10.21552/edpl/2023/1/7.

ators that can directly influence the physical environment. This innovative system represents a significant advancement in urban informatics, offering a framework for cities to dynamically evolve alongside their digital counterparts.

The model shows similarities in Europe with the case of Zurich, which is worth citing its advancement and for its attention on the 3D spatial data. As a classical DTC:

The 3D spatial data are the basis for linking further spatial data or other data. Where appropriate, elements from reality are linked to the digital world in real time. The processes for digitizing reality are extended by the third dimension.[262]

The case is particularly interesting because of important tradition on Spatial Data Infrastructure and the importance highlighted in the project of the Federal Act on Geoinformation (GeoIG 2007), which defines the standards for spatial data and metadata in Switzerland. The digital twin's compliance with the European INSPIRE Directive (Infrastructure for Spatial Information in the European Community) is highlighted:

Spatial data, spatial data models, and spatial metadata are defined by the Federal Act on Geoinformation (GeoIG 2007), and have been described in detail. The Act is fully "Infrastructure for Spatial Information in the European Community" (INSPIRE) compliant and even goes beyond the INSPIRE Directive, although it is not an actual transpo- sition of the Directive, since Switzerland is not an EU Mem- ber State. Compared to other European countries there was a formal Spatial Data Infrastructure in place in Switzerland before the implementation of INSPIRE (Crompvoets et al. 2018) and based upon the Federal Act on Geoinformation a solid governance framework has been developed.[263]

The INSPIRE Directive will be analysed later in this work (see Chapter 4). Although Switzerland is not a member of the European Union, GeoIG exceeds the standards set by the EU's INSPIRE Directive (Infrastructure for Spatial Information in the European Community), which aims to create a standardized spatial data infrastructure across Europe.

As written in the paper, *The Act on Geoinformation describes 3D spatial data as the extension and characteristics of certain spaces and objects, in particular their location, condition, use and legal relationships, with a certain*

[262]See G. Schrotter, C. Hürzeler, "The Digital Twin of the City of Zurich for Urban Planning", *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

[263]See G. Schrotter, C. Hürzeler, "The Digital Twin of the City of Zurich for Urban Planning", *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

reference to time. The spatial data models are representations of reality, which determine structure and content independent of a specific spatial data system. The formal descriptions of the characteristics of spatial data are based on metadata, such as origin, content, structure, validity, timeliness, accuracy, usage rights, access options or processing methods. Metadata are an essential component for establishing and operating a geodata infrastructure. Without metadata no valid decisions and actions can be derived from geodata. Even a proper search for spe- cific geodata cannot be done without proper metadata. Are important considerations (and limitations) that constitute part of the state of the art in term of DTCs.

A deeper analysis on the 3D images is described again in Deng et al. (2021): *The DTC focuses on instantaneity and accuracy, which requires highly automated mapping and surveying technology. Surveying and mapping in a DTC are the fundamental technologies that make it possible to deliver data integrated holo-graphic results (2D/3D, aboveground/underground and indoor/outdoor) in real-time. Surveying and mapping technology in cities has two segments: surveying the topography, environment, and spatial structure of the city; and mapping this information into an integrated system based on geographic information system (GIS). In the surveying part, four technologies are considered: tilt photography, unmanned aerial vehicle (UAV), 3D laser scanning, and global positioning system (GPS). In the mapping part, two technologies are considered: real-world 3D reconstruction technology and multi-source geographic data processing technology.*[264]

In the context of Digital Twin Cities (DTC), the process of capturing and representing urban environments is divided into two primary segments: surveying and mapping.

The surveying segment involves the detailed examination of the city's topography, environment, and spatial structure. This is achieved through the application of four key technologies: tilt photography, which offers oblique aerial images for better perspective; unmanned aerial vehicles (UAVs), which provide flexible and efficient data collection from the air; 3D laser scanning, which captures precise three-dimensional data of physical structures; and global positioning systems (GPS), which ensure accurate geolocation data. Together, these technologies enable comprehensive data acquisition necessary for creating a digital representation of the city.

The second segment, mapping, involves integrating the surveyed information into a cohesive system using geographic information systems (GIS). This integration is facilitated by two advanced technologies: real-world 3D

[264]See T. Deng, K. Zhang, and Z-J. (Max) Shen. "A Systematic Review of a Digital Twin City: A New Pattern of Urban Governance toward Smart Cities". *Journal of Management Science and Engineering* 6, no. 2 (June 2021): 125–34. https://doi.org/10.1016/j.jmse.2021.03.003.

reconstruction technology, which converts collected data into detailed three-dimensional models; and multi-source geographic data processing technology, which synthesizes various data inputs to create a unified spatial dataset. These technologies collectively enable the real-time delivery of integrated holographic results that encompass both 2D and 3D perspectives, covering aboveground, underground, indoor, and outdoor environments.

Already the problem of surveying and mapping opens further considerations. In the article about the DTC of Zurich, for example, the Authors engage critically on the problem of the updates of a DTC, referencing the important article by Batty (2018)[265] on the High-Frequency and Low-Frequency City (in dialogue with Wildfire (2018)[266]).

In the description of Batty:

High-Frequency Cities Models

- High-Frequency Cities operate on short time scales that align with human experiences, such as seconds, minutes, hours, days, and months. These cities are characterised by processes that are highly dynamic and require continuous, real-time adjustments. The concept of high-frequency cities relates to models or digital twins that provide reactive feedback and visualisations, enhancing real-time or near real-time interventions to improve the daily functioning of urban environments.
- In practical terms, high-frequency cities rely on digital twins that focus on immediate data processing and responsive decision-making. These models are often used to monitor and manage urban systems such as traffic flow, energy usage, and public transport operations. They help city managers respond swiftly to changing conditions, such as adjusting traffic signals based on real-time congestion data or dynamically managing energy distribution during peak usage times.
- High-frequency models are critical for day-to-day operations, offering predictive insights that allow city operators to preemptively address issues. For example, these systems can predict the impact of an incoming storm on city infrastructure, enabling pre-emptive action like adjusting flood relief systems to minimize damage and disruption.

Low-Frequency Cities Models

[265]See M. Batty, "Digital Twins", *Environment and Planning B: Urban Analytics and City Science* 45, no. 5, 2018: 817–20. https://doi.org/10.1177/2399808318796416.

[266]See C. Wildfire, "How can we spearhead city-scale digital twins?" *Infrastructure Intelligence*, 2018. Previously available at link: http://www.infrastructure-intelligence.com/article/may-2018/how-can-we-spearhead-city-scale-digital-twins, then available here https://www.mottmac.com/views/how-can-we-spearhead-city-scale-digital-twins (last accessed 19.09.2024).

- Low-Frequency Cities operate on longer time scales, often spanning years, decades, or even centuries. These cities focus on slow-changing aspects of urban life, including infrastructure development, long-term urban planning, and strategic investment decisions. Low-frequency cities are concerned with predictive modelling that aids in scenario planning and future-proofing city systems against various socio-economic and environmental changes.
- Models for low-frequency cities do not function in real-time but instead provide simulations based on extensive historical data, helping guide decisions that affect the city's future. These predictive models inform infrastructure investments, urban expansion, and resilience planning. For instance, by simulating the impact of different urban growth scenarios, city planners can evaluate the potential long-term effects of new policies, such as zoning changes or public transport expansion, on the urban landscape.
- While high-frequency models aim to enhance immediate urban operations, low-frequency models are geared towards guiding policy and strategic decisions that shape the city's evolution over extended periods. This dual approach allows cities to address both the urgent and the enduring aspects of urban management, using digital twins to inform interventions across vastly different temporal scales.

Michael Batty introduced the distinction between high-frequency and low-frequency cities to highlight the differing temporal scales at which urban systems operate and are managed. This distinction helps to clarify how digital twins and models can be effectively employed to address both immediate, short-term urban issues and long-term strategic planning needs. By doing so, Batty aimed to emphasize the importance of developing appropriate models that are tailored to specific urban challenges rather than using a one-size-fits-all approach.

Key Reasons for introducing the distinction are:

1. Understanding the Temporal Dynamics of Urban Systems: Cities are complex entities with processes that operate across a wide range of time scales. High-frequency processes, such as traffic flow and energy consumption, demand real-time adjustments, while low-frequency processes, like infrastructure planning and policy development, require long-term analysis and projections. Batty's distinction helps frame these dynamics in a way that aligns digital twin technologies with the appropriate time scales.

2. Differentiating Model Applications: Batty pointed out that digital twins and models are not uniform; they must be adapted to fit the specific needs of either short-term or long-term urban management. High-frequency models are suited for reactive, real-time operations, en-

hancing the daily functioning of a city. In contrast, low-frequency models focus on predictive, long-term planning, allowing cities to prepare for future scenarios and make informed investment decisions. This distinction helps urban planners and technologists better understand which type of model is needed for specific applications.

3. Clarifying the Role of Digital Twins in Urban Management: Batty used the distinction to clarify misconceptions about digital twins, emphasising that not all digital models operate as true real-time replicas of physical systems. High-frequency digital twins might attempt to closely mirror real-time operations, but low-frequency models are decoupled and operate in a different context, focusing more on long-term scenarios rather than continuous real-time feedback. This nuance helps manage expectations about what digital twins can achieve at different scales.

4. Addressing the Complexity of Urban Integration: By separating high and low-frequency models, Batty highlighted the challenge of integrating these different approaches into a cohesive urban management strategy. High-frequency interventions may need to be rapidly responsive, whereas low-frequency interventions require careful planning and policy alignment. Understanding these distinctions allows for a more strategic approach to using digital twins, where the strengths of each can be effectively leveraged without overreaching their capabilities.

5. Facilitating Multidisciplinary Collaboration: The distinction also underscores the need for collaboration between disciplines that traditionally operate in separate silos—like real-time operations and strategic urban planning. By framing the urban environment through these two lenses, Batty encourages a holistic approach that combines immediate, data-driven decision-making with long-term planning to address the interconnected challenges of modern cities.

Overall, Batty's introduction of high-frequency and low-frequency cities still serves to create a more precise language and framework for discussing digital twins, enhancing their relevance and application in the context of urban management and planning.

The Batty's contribution posed itself into a debate interest in the imaginary evoked by the possibility to predict future scenarios and outcomes. As critically noted in Schrotter, Hürzeler (2020):

Updates may happen in short intervals and this may, but does not have to, be related to the so-called High-Frequency and Low-Frequency City (Batty 2018; Wildfire 2018). Even in a Low-Frequency City, elements which in reality undergo rapid changes and contain time-critical information (e.g. by

means of real-time sensors) are to be linked to the digital world.[267]

They cited the construction and real estate sectors, in which DTs can simulate both existing building and ones proposed/planned or under construction. In this case *The digital prototype is built before reality and thus enables predictive modelling. The predictive modelling and the reactive modelling, immediate action in both digital and real space, are described in Wildfire (2018).*[268]

Wildfire[269] made the analysis: *opportunities for massive scale digital twins are significant*, if we accept that benefits fall into two categories:

1. Reactive: Feedback and visualisations enhance real-time or near real-time interventions and improve the smooth day-to-day running of the city or asset;

2. Predictive: Interdependency modelling based on accurate input data is used to improve longer-term scenario planning to steer appropriate (and equitable) investment decisions. For example, if one item is changed then the impacts can be modelled for all other items in the model to enable testing of:

   - Iterative/feedback loops and responses: For example, we could predict how an impending storm detected from weather data would affect flood relief systems in the city and the activities that are dependent on their smooth operation, enabling informed decisions to be made about pre-emptive action if required.

   - Sandbox scenario testing: Taking the flood risk scenario above this could include predictive analysis of road locations and flood risk areas for new urban zones. Another example is impact testing of different charging scenarios for a city's transport network, in order to optimise effective future use of road and public transport assets.

To comment with Schrotter, Hürzeler:

In predictive modelling, a distinction is made between iterative feedback and sandbox testing. This means that the most diverse simulations and scenarios

[267]See G. Schrotter, C. Hürzeler. "The Digital Twin of the City of Zurich for Urban Planning". *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

[268]See G. Schrotter, C. Hürzeler. "The Digital Twin of the City of Zurich for Urban Planning". *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

[269]See C. Wildfire, "How can we spearhead city-scale digital twins?" *Infrastructure Intelligence*, 2018. Previously available at link: http://www.infrastructure-intelligence.com/article/may-2018/how-can-we-spearhead-city-scale-digital-twins, then available here https://www.mottmac.com/views/how-can-we-spearhead-city-scale-digital-twins (last accessed 19.09.2024)

in the digital world can be enriched, created and analysed with empirical values from reality. This is described in Grieves (2014) under the term of digital prototypes and the environment of the digital twin.[270]

The problem of prediction requires further consideration and is one of the main directions for future research. If simulation technology is at the basis for policy support, planning, and early warning mechanisms, it is also true that this constitutes an experimentation on the city we never experienced before.

3.4.3. Maturity Models and Levels

In literature, the topic of a Digital Twin City is underrepresented. it is understudied the relationship between a maturity models and the law. However, to shape a correct analysis of a DTC seems important to start from the study of the maturity levels The maturity models, also called maturity levels, help assess their development stages and capabilities.

The maturity level of Digital Twin technologies varies significantly across different European cities.

In 2018 the Gemini Principles proposed a specific approach to assessing the "level of maturity" of Digital Twins (DTs) for cities, though they didn"t use a formalized scale with numerical ratings. Instead, the assessment is qualitative and based on how data integration is handled within the DT implementation.

The study introduced three levels of maturity related to data integration methods:

1. Conceptual Schema Model-Based Level:
    - Description: At this level, data integration occurs at the highest conceptual level by extending existing data schema models to cover new features or themes. This involves modifying or enhancing the existing data models (e.g., CityGML extensions) to incorporate additional datasets and attributes that are necessary for a broader range of urban simulations.
    - Examples: Integration methods that adjust data schemas to support new urban applications, such as adding new types of environmental data to an existing city model.
2. Database-Based Level:
    - Description: Data integration at this level involves direct interaction with databases, where data is updated or fed into specific

[270] See G. Schrotter, C. Hürzeler. "The Digital Twin of the City of Zurich for Urban Planning". *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

attributes or classes within the database systems that support the DT. This level is more focused on how data is stored, managed, and accessed, rather than how the data is structured conceptually.
    - Examples: Linking city models with real-time sensor data to update specific classes, such as traffic flow or energy consumption attributes in the database.
3. Application-Based Level:
    - Description: This is the most applied and often visible level of data integration, where data is integrated within specific applications, primarily for visualisation and interaction purposes. This level usually handles data integration at the viewer or user interface level, allowing end-users to interact with the DT through platforms such as web interfaces or simulation tools.
    - Examples: Integration of data in visualisation platforms like Cesium or VirtualCitySystems to render real-time city models for public use or specific simulations (e.g., flood risk assessments, air quality monitoring).

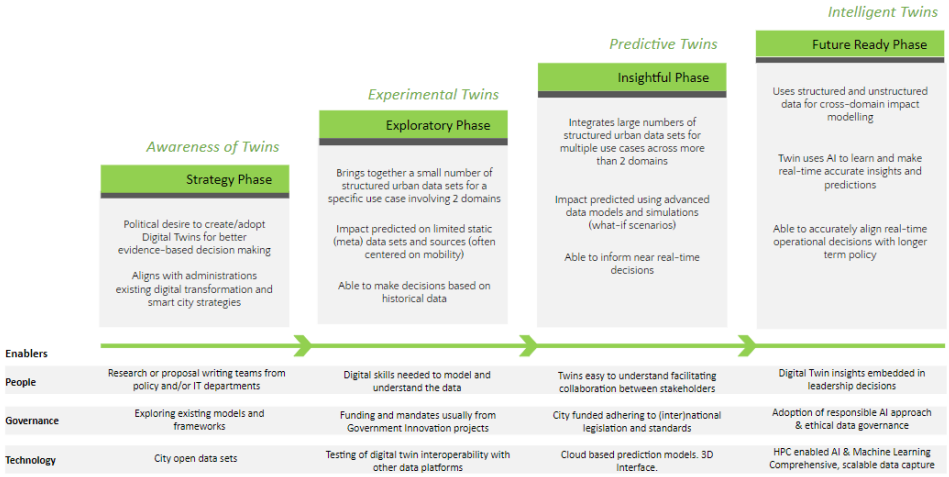
The Assessment is then based on Integration Complexity

- Maturity Evaluation: The maturity of a DT is assessed based on how comprehensively it integrates data across these levels. DTs that integrate data only at the application level are considered less mature than those that incorporate data at the schema or database level, where the integration impacts the underlying structure and functionality of the DT.
- Indicators of Higher Maturity: A highly mature DT would exhibit multi-level data integration—conceptually adjusting models, managing data effectively at the database level, and providing user-friendly application interfaces. Additionally, the ability to support real-time updates, complex simulations, and predictive analytics indicates a higher level of maturity.

The Gemini Principles highlighted how differences in integration methods reflect varying levels of maturity. The lack of a formal, quantitative scale means that maturity assessments are somewhat subjective but provide a clear guideline for identifying advanced versus basic DT implementations.

Following attempts closed this gap, for example in the DUET project.

The DUET (Digital Urban Twins) maturity model categorizes digital twins into three types based on their development stage:



- Figure 4: DUET maturity model.

- Level 0 – No Integration: At this stage, urban data is managed in silos, and there is little or no integration of data sources for holistic insights. Traditional methods of urban management and planning are still dominant.
- Level 1 – Initial Integration: Basic data integration begins. Cities start developing simple digital representations using limited data streams, but they may still rely on manual data collection and processing.
- Level 2 – Data-Driven Decision Support: This level involves more comprehensive integration of various data sources, enabling data-driven insights. Cities begin to use simulation models and real-time data for more informed decision-making.
- Level 3 – Advanced Urban Twin: The city has a well-functioning digital twin that includes real-time data, advanced simulations, and predictive analytics. It can model complex urban systems and help city officials test different scenarios (such as traffic flow optimisation or emergency response planning).
- Level 4 – Fully Integrated Digital Twin Ecosystem: The Digital Twin is fully integrated across various domains of urban management, including transportation, environment, energy, public safety, and healthcare. It functions autonomously in some cases, providing continuous feedback loops to enhance urban performance and citizen well-being.

The DUET model was designed to be inclusive and adaptable, linking to other existing models and facilitating local digital twin discussions. It served as a diagnostic tool that helps cities identify their current state and plan for

future advancements[271].

Two of the most advanced Maturity Levels, already a result of an analysis and an integration of existing maturity models, are: - TOGI - Weß Maturity Model (year 2023) - CITYSTEPS Maturity Model (year 2024)

The first is the maturity model presented by TOGI (at least in the present work, the TOGI Maturity Model)[272], from a monograph titled "How can digital twins change the way German municipalities perform their tasks?" by Sophia Weß, published as Volume 24 of the TOGI series by The Open Government Institute at Zeppelin University.

It explores the concept of digital twins in the context of German municipalities, analysing their potential applications, impacts, and the necessary conditions for their effective implementation. This model is a framework that classifies the development and capabilities of digital twins based on their functionality and performance. This model is crucial for understanding how well digital twins can replicate and interact with physical systems, particularly in the context of municipal management and urban development.

Definition and Overview: The maturity levels of digital twins represent a "maturity functionality":

1. *Representative: Virtual spatial mapping of physical objects.* The most basic level, where digital twins provide a virtual spatial mapping of physical objects. This level primarily focuses on creating a digital representation without any real-time interaction or data integration.

2. *Simulator: Virtual spatial mapping with unidirectional communication starting from the physical object.* Builds on the representative level by enabling unidirectional communication from the physical object to the digital twin. This allows for some level of simulation, where the digital twin can model scenarios based on data from the physical object.

3. *Monitor: Unidirectional communication for monitoring and visualization of physical objects in real time (primarily through generated sensor data).* Introduces real-time monitoring and visualisation through unidirectional communication. Sensor data from the physical object is

[271] See "DUET's Digital Twin Maturity Model Supports Cities in Their Digital Transformation", a link: https://www.digitalurbantwins.com/post/duet-s-digital-twin-maturity-model-supports-cities-in-their-digital-transformation (last accessed 09.02.2025)

[272] See S. Weß, *Wie können digitale Zwillinge die Aufgabenerledigung deutscher Kommunen verändern? eine Analyse von Einsatzbereichen, Veränderungspotenzialen und Rahmenbedingungen* (How can digital twins change the way German municipalities perform their tasks?), edited by Jörn von Lucke. TOGI Schriftenreihe (The Open Government Institute), Vol. 24. Berlin: epubli, 2023.

used to update the digital twin, allowing for real-time observation of the physical object's status.

4. *Smart Monitor: Linking of received data with gained insights and their visualization in real time ("Smart Data").* Enhances the monitoring capabilities by linking real-time data with insights, often referred to as "Smart Data." This level allows for more advanced visualisation and begins to integrate some predictive capabilities based on the data.

5. *Digital Twin: Bi-directional communication between visualized "smart data" and effects on the physical object in real time, data-based simulation and prediction with automated reaction based on artificial intelligence (AI), if necessary.*. The highest maturity level, featuring bi-directional communication. The digital twin not only simulates and predicts outcomes based on real-time data but also interacts with the physical object, potentially altering its state based on automated decisions driven by artificial intelligence (AI). This level represents a fully integrated system capable of real-time adaptation and response.

As mentioned before, these maturity levels reflect the increasing complexity and capability of digital twin systems. As cities progress through these levels, their digital replicas are supposed to become more sophisticated, enabling more advanced applications such as real-time traffic management, predictive maintenance, emergency response simulations, and integrated urban planning.

The TOGI model originates in the context of German municipalities, where the strategic implementation and progression through the maturity levels of digital twins are seen as crucial for optimising resources and enhancing service delivery. The maturity model provides a structured framework that enables municipalities to assess their current digital capabilities and strategically plan for the integration of more advanced functionalities over time.
Initially, a municipality may start with a "Monitor" level digital twin, which facilitates real-time tracking of infrastructure status. This level serves as a foundational step, allowing municipalities to gather data and insights into their existing systems without significant disruption. As municipalities become more familiar with the technology and its potential benefits, they can progress to higher maturity levels. For instance, advancing to a "Digital Twin" level enables systems to autonomously manage and adjust city services based on real-time data analysis and predictive modelling. This evolution not only enhances operational efficiency but also improves the municipality's ability to respond swiftly and effectively to urban challenges such as traffic congestion, energy consumption, and emergency management.
It can provide better planning security and reduce risks associated with urban development projects, producing and integrating valuable insights that can inform policy decisions and operational strategies.

It requires, as argued since the beginning of the present work, a better understanding of the existing legal framework, to design the system in a way that doesn't backlash.

The concept and classification of this maturity model are derived from a comprehensive synthesis of insights from various authoritative sources. Specifically, it draws on research from Detecon International GmbH (2019a), Fraunhofer IESE (2021), The Institution of Engineering and Technology (2019), Wang et al. (2023), and a seminar paper by Weß (2022). These sources collectively contribute to a nuanced understanding of digital twin technologies and their application in urban settings. By leveraging this synthesised knowledge, German municipalities can effectively navigate the complexities of digital transformation, fostering sustainable urban development and enhancing the quality of life for their residents.
The relevance of this maturity model lies in its ability to guide municipalities through a phased approach to digital transformation. By aligning their digital twin strategies with these maturity levels, municipalities can ensure a gradual yet impactful integration of technology that is tailored to their specific needs and capacities. This approach minimises risks associated with rapid technological adoption while maximising the benefits of improved service delivery and resource management. A practical use case in the mobility sector demonstrated the benefits and challenges of implementing a digital twin for traffic and mobility management in the city of Friedrichshafen.

The importance of this model relies not only on its design, in fact similar to other models, but on the associate initial legal analysis.

One of the most pressing legal struggles recognised by the TOGI paper involves ensuring data privacy and security. As digital twins integrate vast amounts of real-time data, including potentially sensitive personal information, municipalities must establish robust legal frameworks to protect individual privacy and secure data against breaches. Compliance with regulations such as the General Data Protection Regulation (GDPR) is essential but can be complex and resource-intensive, requiring municipalities to invest in legal expertise and technological safeguards.

Another significant challenge lies in navigating public procurement laws. The adoption of digital twin technologies often necessitates lengthy and stringent procurement processes, which can delay implementation and increase costs. These processes must align with existing public sector regulations, adding layers of complexity to the already challenging task of integrating new technologies into municipal operations. Implementing digital twins requires significant investment in technology and infrastructure, which can be a barrier for smaller municipalities, also considering the need to access to specialized expertise and training programs to effectively develop and manage digital twin systems.

Furthermore, the current legal frameworks, overall considered, may not fully accommodate the advanced capabilities of digital twins. There is a pressing need for updating these frameworks to support the deployment and operation of digital twins effectively. This includes developing standardised data formats and ensuring interoperability between different systems, which are crucial for maximising the benefits of digital twins across various municipal functions.

The monograph also highlights several key legal findings that underscore the complexity of integrating digital twins within German municipalities.
One such finding is the critical role played by municipal councils, composed of elected members who set financial frameworks and allocate resources. These councils are instrumental in determining the legal and financial viability of adopting digital twins, emphasising the need for informed decision-making at the governance level.
Decentralisation of decision-making within municipalities is another important finding. While this decentralisation can facilitate quicker implementation of digital twin technologies by granting more autonomy to lower management levels, it also requires careful legal oversight to ensure compliance with overarching regulations. This balance between autonomy and oversight is crucial for successful integration. Moreover, the impact of New Public Management (NPM) principles has encouraged municipalities to adopt business management approaches, including digital innovations like digital twins. However, this shift necessitates navigating legal frameworks originally designed for more traditional administrative processes, highlighting the need for legal adaptability and innovation. Finally, establishing clear framework conditions for the use of digital twins is essential. This involves creating supportive legal environments that enable standardized data platforms and interoperability between systems. Such frameworks not only facilitate the effective use of digital twins but also ensure that their deployment aligns with ethical standards and public interest goals.

The monograph provides a comprehensive framework and practical guidance for municipalities to navigate these challenges and leverage digital twin technologies effectively. The monograph provides eight actionable recommendations for municipalities, focusing on political, legal, and management strategies to promote the adoption and effective use of digital twins. Recommendations include fostering inter-municipal cooperation, securing funding, developing standardized data platforms, and investing in training and capacity building.

While the monographs doesn't enter into legal details, it suggests however a to update existing legal frameworks to support the deployment and operation of digital twins in municipalities. This is seen as a critical step towards harnessing their full potential.

This involves a comprehensive approach to modernising data governance, which is essential for ensuring privacy, security, and ethical data use. Robust data governance frameworks are crucial not only for compliance with regulations such as the GDPR but also for building public trust in how data is managed and utilized. Furthermore, creating standards for interoperability is vital to facilitate the development of data formats and interoperable systems, enabling seamless integration of data from diverse sources and ensuring consistency across platforms. This interoperability is key to the effective functioning of digital twins, allowing for comprehensive data analysis and decision-making.

In addition to these technical considerations, legal structures should be adapted to facilitate innovation by reducing bureaucratic hurdles. Streamlining public procurement processes and providing clear legal guidelines for the use of new technologies within public administration can significantly enhance the adoption of digital twins. This legal clarity not only accelerates innovation but also ensures that municipalities can effectively integrate cutting-edge technologies into their operations without unnecessary delays.

Moreover, ensuring compliance and accountability is paramount. Updated legal frameworks must establish clear guidelines on data usage, system interoperability, and public procurement to maintain accountability and ensure that digital twins operate within legal boundaries. These guidelines help safeguard against misuse and ensure that all stakeholders adhere to established standards.

Overall, these updates aim to create a supportive legal environment that enables municipalities to fully leverage digital twin technologies, which is seen as challenging in the European context.

The integration of digital twins in urban environments marks a pivotal shift from reactive to proactive public service management, leveraging advanced technologies to forecast and optimize urban functions.
By incorporating real-time data from various sources, such as sensors and IoT devices, digital twins provide an up-to-date virtual representation of the city, enabling city planners to simulate and test different urban scenarios. This capability allows for strategic planning in areas like traffic management, energy consumption, and disaster response, offering a virtual testing ground for policies before real-world implementation. Predictive analytics, powered by advanced AI and machine learning algorithms, further enhance this proactive approach by analysing historical and real-time data to forecast future events and trends. Such predictive capabilities can significantly improve urban management by anticipating maintenance needs, optimising resource allocation, and supporting automated decision-making processes, such as adjusting traffic signals to alleviate congestion.

However, while the enthusiasm for predictive capabilities in digital twin cities is warranted, it must be tempered with critical safeguards. The complexity of urban environments means that digital twins cannot capture every aspect of reality, such as interpersonal relationships and cultural nuances. This limitation underscores the importance of viewing digital twins as valuable tools rather than comprehensive solutions. Ethical considerations and data security are paramount, as the extensive use of personal and urban data raises concerns about privacy and cybersecurity. Ensuring robust data governance frameworks is essential to mitigate these risks.

Moreover, the initial investment required for implementing digital twins can be substantial, posing challenges for smaller municipalities. Therefore, these technologies should be aligned with clear goals and practical needs to ensure they deliver tangible benefits. The accuracy of predictions depends on high-quality data; thus, municipalities must prioritise robust data collection and integration practices to avoid unreliable forecasts that could misguide decision-making.

Scalability and interoperability are also critical factors. Digital twin systems must be capable of handling large volumes of data from diverse sources while ensuring seamless integration across different platforms. This is particularly challenging in municipalities with historically fragmented data systems. Finally, public engagement and transparency are vital in fostering trust and collaboration. Citizens should be actively involved in the planning process, with clear communication about how predictive models impact social and environmental factors.

A second maturity model that worth analyse is the CITYSTEPS Maturity Model[273]. The concept is detailed in the article "Assessing governance implications of city digital twin technology: A maturity model approach" by Masahiko Haraguchi, Tomomi Funahashi, and Filip Biljecki, published in *Technological Forecasting & Social Change* (2024).

According to the Authors, the CITYSTEPS Maturity Model is a framework specifically designed to assess the development stages of City Digital Twins (CDTs). This model aims to evaluate the current state of CDTs and their potential impact on urban governance, addressing issues such as transparency, accountability, and public participation. Context: As cities increasingly adopt digital twin technologies, there is a growing need to understand their implications for governance. CDTs represent virtual replicas of urban environments that enable simulations and analyses for better decision-making in city planning. However, the integration of CDTs into urban governance

[273]see M. Haraguchi, T. Funahashi, and F. Biljecki, "Assessing Governance Implications of City Digital Twin Technology: A Maturity Model Approach", *Technological Forecasting and Social Change* 204, 2024: 123409. https://doi.org/10.1016/j.techfore.2024.123409.

raises challenges related to data management, public participation, transparency, and social inclusion. The CITYSTEPS Maturity Model was developed to systematically assess these challenges at different stages of CDT development. The model comprises the following eight stages:

1. *Stage 1: Preparation and Planning Stage. Focuses on the initial framework and planning for a digital twin, with no data included.* This initial stage involves planning and creating a framework for a digital twin. During this phase, no data is included. This stage includes deciding where a completed CDT will be open to the public or used only by policy-makers (D'Hauwers et al., 2021).

2. *Stage 2: 2D Stage. Reconstructs a physical city into a 2D model, integrating essential land information.* The second stage focuses on the reconstruction of a physical city into a 2D model, incorporating essential land information and integrating various map types.

3. *Stage 3: 3D Static Stage: Develops a digital city within a 3D model using static data, enabling historical and present situation analyses.* Using static data, the third stage builds a digital city within a 3D model. These data include building information details from Building Information Modeling (BIM) and infrastructure data for existing structures. At this stage, the digital twin evaluates both historical and present situations, predicting impacts using 3D static data. For example, it assesses the built environment, such as shades and landscapes. The 3D BAG project in the Netherlands can be classified as Stage 3 as it aims to create a 3D model that includes geography, elevation, and building features (3D Geoinformation Research Group, 2022).

4. *Stage 4: 3D Dynamic Stage. Incorporates dynamic data, such as human mobility, for simulations and predictions.* This stage equips the model with 3D structured and dynamic data, including human mobility, transportation, and the flow of goods. The model integrates large amounts of urban data to facilitate predictions and simulations. For example, a model can simulate building electricity usage, traffic congestion, or urban air circulation patterns. A prime example is the OnDijon project in Dijon, France, which aligns with Stage 4 in our framework. The project uses integrated dynamic data to conduct impact simulations, incorporating data from all public utilities and services to analyze the present environment (Dijon Metropole).

5. *Stage 5: Dynamically Integrated 3D Stage. Integrates 3D dynamic data and IoT, providing recommendations for decision-making.* In this phase, a CDT model evolves to incorporate 3D dynamic and IoT data. This indicates a shift from earlier stages, where the digital city replicated its physical counterpart. From Stage 5 onwards, the model

can include virtual structures or buildings that do not have physical counterparts. Furthermore, it begins to provide recommendations to aid human decision-making processes. A notable example of this is a project in the City of Zurich in Switzerland, which involves simulation analysis based on already collected data[274]. It simulates urban environmental phenomena, including noise, air pollution, and solar potentials, by integrating and analysing geometric data with various planning parameters, such as building utilisation, floor space, and number of inhabitants and workplaces. The City Information Model (CIM) contributes to this stage, extending the BIM concept to cover the entire city, transforming static CDTs into dynamic ones (Cureton and Dunn, 2021; Wu et al., 2021).

6. *Stage 6: Real-time Decision-making Stage. Analyzes integrated 3D data in real-time to offer decision-making insights.* At this stage, CDTs gain the capabilities to analyse dynamic and integrated 3D data, offering accurate insights and real-time alternative options for decision-making. They can also simulate impacts across different domains. Among European projects, the National Digital Twin program (NDTp) exemplifies this stage for its prioritisation of the real-time data processing, focusing on real-time analysis and reactive event processing (Cambridge Living Laboratory Research Facility, 2022). Similarly, DUET utilises ten data sources and 18 simulation models to inform planning decisions (DUET, 2022a). Both projects can be classified as Stage 6 in our framework, presenting the capabilities to derive optimal solutions through real-time analysis using dynamic and integrated data.

7. *Stage 7: Autonomous Decision-making Stage. CDTs use AI to make decisions and execute actions independently.* At this stage, the digital twin use autonomous reasoning and artificial intelligence to make decisions independently and execute actions based on 3D predictions and simulations. Currently, there are no known existing projects that have reached this stage.

8. *Stage 8: Real-time Synchronization and Autonomous Implementation Stage. Achieves full real-time synchronization between physical and digital environments, with autonomous decision-making.* This stage sees CDTs achieve full, bidirectional, continuous, real-time synchronisation between the physical reality and the digital counterpart. During this phase, CDTs autonomously implement decisions, guided by insights from simulations.

[274]See G. Schrotter, C. Hürzeler. "The Digital Twin of the City of Zurich for Urban Planning". *PFG – Journal of Photogrammetry, Remote Sensing and Geoinformation Science* 88, no. 1, 2020: 99–112. https://doi.org/10.1007/s41064-020-00092-2.

The CITYSTEPS Maturity Model could be crucial for guiding the development and governance of CDTs. By mapping the maturity of CDT initiatives, it could help stakeholders identify and address governance challenges, such as transparency and inclusion, at each stage of technology development. The model promotes a structured and adaptive approach to integrating CDTs into smart city governance, ensuring that these technologies are used responsibly and inclusively. Merit of this model is that it specifically discusses governance matters, even if not by a fully legal point of view. The paper addresses the underexplored governance aspects of city-scale digital twins (CDTs). The model, which partially include the expertise from the DUET project seen before, evaluates the existing governance structures and processes related to the implementation of digital twins in urban settings with a questions-oriented approach that aims to help cities understand how well they are currently managing their digital assets. The model not only looks at the present capabilities but also anticipates future needs and challenges, allowing cities to plan governance strategies that align with technological advancements. By highlighting governance implications, the model encourages cities to adopt best practices in managing digital twin technologies, ensuring that they can leverage these tools for better urban planning and management.

In par 5.3. the described framework explicitly tackle the problem of "Inclusion", in these terms:

Inclusion refers to the equitable presence of all citizens, including marginalized and disadvantaged groups, in the benefits and opportunities provided by CDT initiatives (van Gils and Bailey, 2021). It means that every citizen has an equal opportunity to access and participate in the services and infrastructure provided by CDT. Through our investigation of existing projects, inclusion is barely discussed in the context of CDT, as claimed by Tzachor et al. (2022). We will discuss this issue later in Section 7.

The CITYSTEPS Maturity Model commendably addresses the critical issue of inclusion in the context of city-scale digital twins (CDTs). However, it is important to distinguish between two concepts the paper highlights: "equitable presence in the benefits and opportunities" and "equal opportunity to access and participate in services and infrastructure". The former implies a broader, more systemic integration of all citizens into the benefits of CDT initiatives, while the latter focuses on individual access and participation. This distinction is crucial, from a legal point-of-view, as the paper rightly acknowledges that "participation" is not synonymous with inclusion.

However, it falls short by not fully exploring how the majority of the projects equate participation with individual engagement, whether digital or in-person. While digital participation indeed transcends spatial and temporal barriers, it often remains an isolated interaction between the

citizen and administration. This focus on individual participation can inadvertently perpetuate "relational inequality," where individuals must first overcome social and relational barriers before effectively engaging in public discourse. It is correct that digital participation overcomes the barrier of space and time, but seems to remain an individual experience of the citizen in front of the administration.
For example, the assertion that citizen-led data collection enhances community engagement overlooks the necessity of pre-existing community structures. Despite it is not an uncontested truth, citizens are more likely to feel a sense of community when they are part of smaller, familiar groups before engaging with the broader citizenry. Even the mentioned: "This data collection by the citizens themselves can enhance their engagement, increase the sense of community, and empower them to contribute to the CDT initiative." (pag. 11) does not explore the need to be in an existing community before the possibility of feeling a community with all the other citizens.

Furthermore, while visualisations can aid in demonstrating potential policy outcomes, relying solely on citizens' intuition raises concerns about media literacy[275] and the potential for misleading representations.

The paper argues:

"city authorities can enhance the inclusivity of their data by fostering collaborations with human rights organizations, legal entities, and city government offices, such as human rights and customs".

The consideration is certainly sharable, but while fostering collaborations with human rights organisations and legal entities can enhance data inclusivity, it is imperative to address data protection concerns.

Authorities must ensure that data shared by citizens is not misused or disclosed to entities like law enforcement for purposes contrary to the primary interest, serving the citizens in need.

For example, an organisation like an NGO can share its data about with city authorities to enhance services for vulnerable populations. However, it is imperative that these authorities ensure strict respect of the finality of this sharing activity. Mapping vulnerabilities should prioritize the needs of the people rather than serve the interests of data controllers. Using data from NGOs to persecute individuals in need is fundamentally contrary to public interest and undermines trust in digital governance. Safeguarding

[275]May be allowed the reference to G. Suffia, "Per una partecipazione qualificata nella società iper-veloce", *Ciberspazio e diritto*, Mucchi Editore, no. 2, 2020; G. Suffia "Smart cities e digital divide : una proposta di analisi". *Ciberspazio e diritto*, Mucchi Editore no. 2, 2021, https://doi.org/10.53148/1081. The relevance of media literacy, declined as "AI literacy", is also fundamental in EU's AI Act - Regulation (EU) 2024/1689, Article 4.

data integrity and ensuring ethical use are essential to maintaining public confidence and promoting equitable outcomes in digital twin initiatives.

3.4.4. The Laboratory and The City

In the light of what has been seen in the previous paragraphs, it clearly emerges how, at least for a substantial part of computer science literature, the city is seen and described more as an observable mechanism, composed of sophisticated systems but reducible to atomic components, rather than as a complex and elusive organism, a social construct with an elusive form and even more ancestral origins.

The implications regarding the discernment of the city as a mechanism rather than an organism would deserve more space[276]. After what has already been mentioned above (cf. Par. 3.2.), for the purposes of this work it is worth noting the analysis of that part of the literature that critically questions the computer science literature, with the result of highlighting an important point: in smart cities projects, the city is not only the observed computer, but also the large laboratory, in which it is therefore possible to conduct experiments. Experimentation, therefore, is both the object of the experiment and the analytical category of it.
In the discussion by Laurent et al. (2019), the authors write:

The omnipresence of the vocabulary of experimentation is an invitation to theorise the notion and turn it into an analytical category. This approach draws its inspiration from work in human geography and urban planning on experimentation as a novel mode of governance [1], and from analyses of the conditions of scientific experimentation, its systems of proof and the practices of testing and demonstration, developed in the study of science and technology [2] in order to describe the simultaneous transformations in the state of knowledge and the social and political order.[277]

[276] may be allowed the reference to G. Suffia. "How to Regulate a Digital Twin City? Insights from a Proactive Law Approach". In Proceedings of the 24th Annual International Conference on Digital Government Research, 122–28. Gdañsk Poland: ACM, 2023. https://doi.org/10.1145/3598469.3598482. Some considerations were later incorporated in M. Haraguchi, T. Funahashi, and F. Biljecki, "Assessing Governance Implications of City Digital Twin Technology: A Maturity Model Approach", *Technological Forecasting and Social Change* 204, 2024: 123409. https://doi.org/10.1016/j.techfore.2024.123409.

[277] see Laurent et al., in A. Courmont, P. Le Galès, *Gouverner la ville numérique*. La vie des idées. Paris: la Vie des idées.fr PUF, 2019, pag. 52, translation by the author - in the original footnote: [1] James Evans, Andrew Karvonen, Rob Raven (dir.), "The Experimental City", Londres, Routledge, 2016; Harrier Bulkeley, Vanesa Castán Broto, "Gouvernment by Experiment? Global Cities and the Governing of Climate Change", in Transactions of the Institute of British Geographers, 2013, vol. 38, n. 3, p. 361-375. [2] Simon Shapin, Steven Schaffer, "Léviathan et la pompe à l'air, Hobbes et Boyle entre science et politique", Paris, La Découverte, 1993; Andrew Barry, "Demonstrations, Sites and Sights of Direct Action", in Economy and Society, 1999, vol. 28, n. 1, p. 75-94.

According to the Authors, the literature on experimental urbanism invites the analysis of experiments as empirical and theoretical entry points to study the transformations of contemporary urban spaces. "The vocabulary of experimentation has become an omnipresent trope in contemporary urban planning discourse". They cite the term "test-bedded" in this regard. The simulated environment can be used to test "possible" scenarios or to virtually explore the consequences of a particular situation. They pointed out that urban experiments serve as sociotechnical devices designed to facilitate collective learning through demonstration practices[278]. These experiments aim not only at the collective production of knowledge but also at enabling new forms of governance.
They explore scenarios and address specific problems by orchestrating a combination of technologies and stakeholders positioned in relation to one another. Furthermore, these experiments are inherently multidisciplinary, intersecting technical, scientific, political, and economic domains. They function as economic and political experiments by simultaneously fostering market development and defining the appropriate modes of public intervention in urban contexts. This multifaceted analysis opens intriguing questions about the broader implications of urban experimentation, particularly concerning the evolving dynamics of urban governance and market interactions. Such inquiries invite further scholarly investigation into how these experimental practices might reshape our understanding of urban development and policy-making in an increasingly complex world.

Page 52 notes the dual nature of these experiments:

- on the one hand, they are intended to carry out experiments on urban infrastructures and environments, which may also impact on citizens.
- on the other, they are themselves experiments that bring into play the capacity of these platforms to intervene on the urban.

It is important to note (p. 59) how they attempt to adopt a scientific approach, but with an important *caveat*: contrary to the closed and controlled environment of scientific laboratories, urban laboratories are themselves part of the experimentation being tested, the "laboratory" (= the city) being itself part of the experimentation and in the experimentation. The result is a true "Laboratorisation du monde".

The analysis primarily focuses on the example of Virtual Singapore, which is frequently cited throughout this work. Cited by the Authors (Laurent et al., p. 47) as an example of "Expérimentations urbaines", it is described as a "dynamic virtual 3D model" and a "collaborative data platform". Developed by Dassault Systèmes (a private company) and the National Research

[278]see Laurent et al., in A. Courmont, P. Le Galès, *Gouverner la ville numérique*. La vie des idées. Paris: la Vie des idées.fr PUF, 2019, pag. 53.

Foundation (Singapore)(a public body), the platform allows users to develop tools and applications to test solutions and services, plan decisions, and conduct research to address emerging and complex challenges for Singapore[279]. It presents itself as a 3D graphical representation of the city, with information sourced from both public and private sectors. Defined (p. 48) as a *"double numérique" of the city, custom-designed to meet the expectations of the NRF, the centrality of testing is explicitly assumed as an experimental approach to develop novel scenarios. The Virtual Singapore platform is thus expected to contribute to risk evaluation and management, such as fires, natural disasters, or crowd movements.*

On page 64, it is further presented as *a digital platform for testing scenarios and innovations for housing.* It is acknowledged that Virtual Singapore is itself an experiment, as its components are subject to experimentation. Unlike other contexts (e.g., San Francisco), experimentation seems to be a condition of Singapore's identity (and geopolitical survival) itself (p. 65).

The questions arising from this analysis are, however, numerous:

- *If a dispute arises, how does the fact that Virtual Singapore is an experiment affect the situation?* This raises concerns about the legal and operational frameworks governing experimental urban platforms[280].
- *Experimentation is part of Singapore's very identity:* While this approach may be suitable for Singapore, other cities might not embrace the same "mission". Insights from the smart cities perspective suggest the need to have both the "Political Wheel", and the "Governance Wheel" involved and committed to these experimentations. This implies that without political leverage, governance alone is insufficient.

[279]see at the website: https://www.nrf.gov.sg/programmes/virtual-singapore, link consulted on 19.11.2022).

[280]see Italian Data Protection Authority, "Provvedimento dell'11 gennaio 2024", n. 5, against the Municipality of Trento. The Italian Data Protection Authority (Garante per la Protezione dei dati personali) sanctioned the municipality for having conducted two research projects (Marvel and Protector) that was found in violation of data protection regulations for collecting footage from existing surveillance cameras for urban security purposes, as well as audio from microphones installed in public areas. The data was analyzed using artificial intelligence techniques to automatically detect events posing risks to public safety. The municipality claimed that the data would be anonymized immediately after collection. The goal was to detect negative emotions and process information of interest to law enforcement agencies to identify risks and threats to places of worship. Both projects, funded by European funds, aimed to develop technological solutions to enhance urban safety within the "smart cities" framework. According to the Authority, the Municipality of Trento, whose institutional purposes do not include scientific research (the municipality couldn't be classified as a "research institute or entity" under the relevant legal framework), failed to demonstrate a legal framework justifying the processing of personal data, including data related to offences and special categories. The sharing of data with third parties, including project partners, rendered the processing unlawful. Additionally, gaps in the data protection impact assessment were contested.

> Without the governance leverage, politics is ineffective. This highlights the necessity of integrating both political and governance strategies to ensure the successful implementation and sustainability of urban experiments.

Another relevant example cited by Laurent et al. is MuniMobile (San Francisco). Cited by the Authors (p. 48) as an example of *Expérimentations urbaines (Laurent et al.)*, this mobility app is utilized by the SFMTA (San Francisco Municipal Transportation Authority) to provide information and incorporates a system of "Gamification." Gamification involves integrating playful elements into a procedure or product (e.g., an app) and is identified by Zuboff as a tool for "behaviours' changing"[281] through rewards. The app is expressly dedicated to experimenting with and developing solutions.
The foundation of the app highlights that experiments are costly, and the partnership method offers a good compromise. They open, however, a larger debate on the Public-Private relationship, which will be addressed later.

A key premise in the context of urban experimentation is the integration into and support of real-time administration[282]. According to the Authors (p. 60), by transforming into a laboratory of experimentation and a city managed "in real-time," San Francisco focuses on optimising performance as a political tool. However, *This perspective, often presented as an alternative to costly investments in transportation infrastructure, does not provide resources for long-term planning and could render it obsolete*[283].
Again (p. 63): the whole system lends itself to making *real-time adjustment the central task of urban governance*[284].
This approach highlights the tension between immediate, data-driven decision-making and the need for sustainable, long-term urban planning. While real-time management offers agility and responsiveness, it may lack the foresight necessary for enduring infrastructural development. This raises critical questions about how cities can balance short-term efficiency with long-term strategic goals, ensuring that technological advancements do not overshadow foundational urban planning principles.

[281] see S. Zuboff, *Il capitalismo della sorveglianza il futuro dell'umanità nell'era dei nuovi poteri*. Roma: LUISS University Press, 2019.

[282] see the description of the "Real-Time Democracy" of San Francisco, as in Laurent et al., in A. Courmont, P. Le Galès, *Gouverner la ville numérique*. La vie des idées. Paris: la Vie des idées.fr PUF, 2019.

[283] see Laurent et al., in A. Courmont, P. Le Galès, *Gouverner la ville numérique*. La vie des idées. Paris: la Vie des idées.fr PUF, 2019 - citing B. Laurent, F. Talvard, "Real-Time Democracy. Imagining the City of Permanent Innovation", i3 Working Papers Series, 2017, 17-CSI-01.

[284] see A. Courmont, P. Le Galès, *Gouverner la ville numérique*. La vie des idées. Paris: la Vie des idées.fr PUF, 2019 - Laurent et al - quoting Brice Laurent, Félix Talvard, "Real-Time Democracy. Imagining the City of Permanent Innovation", i3 Working Papers Series, 2017, 17-CSI-01).

This "Laboratorisation du monde"[285] necessitates reflections on the Public-private relationship discussed by many authors, including the French geographer M. Lussault. In discussing *iper-localisation*, Lussault observes that: *At different times, there are specific relational modes between public and private actors that must be recognized and respected.*[286]

He cites Manuel Appert as an example, who in his work "Politique du Skyline. Shard et le débat sur les tours à Londres" (Métropolitiques, 2011), observed in London the formation of complex, "ago-antagonistic" alliances among local and foreign economic operators, architects and designers, public authorities, and civil society actors. These latter groups, particularly through their contestation actions, contribute to the evolution of projects.

This analysis underscores the intricate dynamics between public and private sectors in urban experimentation. It highlights the importance of acknowledging and respecting these relationships to foster successful collaborations. The example from London illustrates how diverse stakeholders can engage in complex alliances that drive urban development while also accommodating contestation and negotiation, ultimately shaping more resilient and adaptive urban projects.

Returning to experimentation as a defining category for today's smart city projects, the authors write (p. 49)[287]:

This expression refers to situations in urban life where experiments, tests or pilots are deployed that affect the nature of the city itself.

The aim is to achieve *a new understanding of how to act on the city by targeting key issues and finding solutions.*

Further elaboration reveals that, according to the Authors (p. 54-55), the definition of "experiments" emphasizes that projects are explicitly intended to test and try solutions, including organisational ones, to *produce new knowledge that remains, at least in part, uncertain and linked to public demonstrations.* Thus, *all urban experimentation, whether deployed in a physical location or through simulation and digital modelling technology, contains, more or less explicitly, a singular vision of the future, including a reordering (social, economic, political) of urban spaces.*[288]

[285] See A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019.

[286] see M. Lussault. *Iperluoghi. La nuova geografia della globalizzazione.* Milano: Franco Angeli, 2019.

[287] see A. Courmont, P. Le Galès, *Gouverner la ville numérique.* La vie des idées. Paris: la Vie des idées.fr PUF, 2019, pag. 49, anticipated at page 24.

[288] see concordant doctrine in M. Lussault. *Iperluoghi. La nuova geografia della globalizzazione.* Milano: Franco Angeli, 2019. In the conclusion to his book "Hyperplaces", after discussing the "Regimes of Human Spatialities", Prof. Lussault writes (p. 256): *None of these* (places)*, here is my main thesis, turns out to be politically neutral, although some*

If the platform itself is an experiment, *how can experiments be tested within an experiment?* Part of the answer lies in recognising that:

- Experiments are neither micro nor macro but are *situé dans un territoire dont certains paramètres sont contrôlés*, meaning they are situated within a territory where certain parameters are controlled.
- The sites, actors, and networks are reorganized to enable its validation.
- Experimentation *ne peut être comprise comme un expérimentation sans tenir compte de l'écologie des acteurs impliqués dans la conception de l'application* — it cannot be understood as an experiment without considering the ecology of actors involved in the application's design. This includes the power dynamics between elected officials, the positions of major mobility companies, private partners and the distinct publics gathered by the test.

The authors propose a "*Grille de valutation*" (Laurent et al. - p. 55) where the overall experimentation is broken down into elementary units, consisting of the following questions, each of them briefly analysed for the purposes of the present work:

- *qui sont les expérimentateurs?* To analyse the question, it is necessary to explore several key aspects that are crucial for a comprehensive understanding. The experimenters may come from various academic, professional, or institutional backgrounds. Understanding their identities is essential for grasping the scope and credibility of the experimentation. The distribution of experimenters across different regions can influence the experimentation process. Regional diversity might bring varied perspectives but also pose challenges in terms of coordination and standardisation. Experimenters often require academic backing to access private data. This necessity highlights the role of academic institutions as gatekeepers in research, ensuring ethical standards and data integrity. The relationship between experimenters and academic entities can shape the methodology and outcomes of the research. It underscores the importance of establishing trust and credibility. Establishing who is included or excluded as an experimenter is a critical

are intentionally political (urban street struggles, ZADs, the creations of alternative localities) and others incidentally (the "flânerie" in the "mall," the entrance to a station). And he points out: *The "politicity" of places results from the fact that in them there is always flagrantly stated, for each protagonist, the problem of regulating this space that is "between" realities, to which he must, inevitably, bring a concrete response.* Because: *We must, therefore, always master what comes from acceptable proximities, from good placements, from limits and thresholds to be recognized and crossed, from the ability to make pathways./ Even more: in all these aspects, one must know how and be able to make the best choice, and to do this, one must continually mobilize "elementary skills of spatiality"* (quoting the earlier book "L'Avènement du Monde") - Reconstruction and translation by the Author.

step. This involves setting clear criteria that may be based on expertise, institutional affiliation, or other relevant factors. The inclusion or exclusion of certain actors can significantly affect the research's scope, focus, and potential biases. It is vital to articulate these boundaries transparently to maintain the study's integrity.

- *quelles sont les entités expérimentales et qu"est-ce qui est testé en pratique?* To analyse the question, we must consider the nature and scope of the experimental entities and the practical aspects of what is being tested. The attempt to standardise experimental entities is crucial for ensuring that they can be compared effectively. Standardisation allows for consistent measurement and evaluation across different experiments, facilitating broader generalisations and insights. While standardisation aids comparability, it may also impose constraints that limit the diversity of experimental approaches. Balancing uniformity with flexibility is a key consideration. Technical Systems can include data production systems, which are often tested for efficiency, accuracy, and scalability. Understanding how these systems operate under various conditions can inform improvements in technology and data management. Experimental entities may also involve economic models or pricing strategies. Testing these mechanisms can reveal insights into market dynamics, consumer behaviour, and economic efficiency. Experiments often focus on human behaviour, examining how individuals or groups respond to different stimuli or environments. This aspect is critical for fields such as psychology, sociology, and behavioural economics. In initiatives like Virtual Singapore, all citizens become part of the experimentation process. This raises important questions about consent and participation. A critical issue is whether individuals have the option to opt-out of such experiments. Ensuring that citizens have the choice to not participate respects personal autonomy and addresses ethical concerns related to involuntary involvement.

- *dans quel(s) site(s) et quelles conditions les tests sont-ils conduits?*, and the following *quels sont les objectifs de l'expérimentation?* To analyze the questions, it is crucial to consider the contextual and strategic dimensions of experimentation. The notion of "Laboratorisation du Monde," as discussed by Courmont and Le Galès, suggests that the world itself is increasingly being treated as a laboratory. This perspective emphasizes the pervasive nature of experimentation across various domains and geographies. However, experiments are conducted in a wide range of sites, from controlled laboratory settings to complex urban environments. Each site presents unique conditions that can influence the outcomes and applicability of the research. In urban contexts, experiments often focus on real-time reorganisation, where the urban space is continuously reshaped through optimisation operations.

This dynamic approach reflects the fluid nature of modern cities and their capacity for constant adaptation. Conducting experiments in such dynamic environments poses challenges related to data accuracy, system responsiveness, and the ability to predict long-term impacts. A common objective in many experiments is the optimisation of existing strategies, aiming for greater efficiency in processes and systems. However, this focus on efficiency may overshadow other potential goals. There is often a lack of clarity regarding objectives beyond mere optimisation. It is crucial to articulate broader goals, such as social equity, environmental sustainability, or innovation, to ensure that experiments contribute meaningfully to societal progress. Experiments should align with larger strategic objectives, whether they pertain to urban development, technological advancement, or policy innovation. Clear articulation of these goals enhances the relevance and impact of the research. Regular evaluation of experimental outcomes against stated objectives allows for adaptive strategies that can better address emerging challenges and opportunities.

- *à quelles audience est-elle adressée?* To analyze the question, the role and significance of the audience in the context of experimentation must be clarified. The audience plays a crucial role in attesting to the value of experimental results. This underscores the importance of public engagement and validation in the success of urban experiments. The statement *Il n"y a pas d"expérimentation urbaine sans démonstration et sans public* highlights that urban experimentation inherently involves showcasing results to an audience, which in turn legitimizes and amplifies the impact of the findings. It is essential to ensure that experimentation is not merely a marketing exercise. Authentic engagement with the audience requires transparency and genuine intent, rather than superficial displays aimed at promoting specific agendas. For experiments to be meaningful, they must address real-world issues and provide tangible benefits. This authenticity helps in building trust and credibility with the audience. The focus on audience engagement allows experiments to transcend debates about scale—whether they are micro or macro, local or global. By creating "espaces ad hoc," experiments can cater to diverse audiences who expect valuable outcomes. These tailored spaces enable experiments to resonate with different publics, ensuring that they are perceived as valuable regardless of their scale or scope.

- *qui est censé en attester les résultats?* To analyze the question, it is necessary to explore the complexities surrounding the certification of experimental results. The question of who certifies results is often overlooked in smart cities literature. This gap indicates a need for more explicit discussions about accountability and validation in urban

experimentation. The notion that "citizens will certify the results" is frequently presented as self-evident. However, this assumption may serve as a convenient way to sidestep deeper inquiries into the mechanisms of certification. Relying solely on citizens to validate results can be problematic. It assumes a level of engagement and understanding that may not always be present, and it risks oversimplifying the complexities involved in interpreting experimental outcomes. Unlike controlled laboratory settings, cities are dynamic and constantly evolving environments. Experiments conducted within them can alter the very fabric of the urban landscape, complicating the process of certifying results. As experiments modify urban spaces, distinguishing between experimental outcomes and broader urban changes becomes challenging. This complexity necessitates robust frameworks for certification that account for these interactions.

The methodologies articulated through these questions enabled the Authors to propose two significant key findings:

- *this approach connects numerous elements present in contemporary studies of urban innovations, yet it extends beyond them.*
- *It highlights a spectrum of actors that surpasses those typically visible in such analyses.* By employing this investigative methodology, in fact, the Authors uncovered the presence of "invisible actors," as noted on page 67. This revelation underscores the complexity and interconnectedness of urban systems, bringing to light the roles and influences of previously overlooked participants. This broader understanding enriches the discourse on urban innovation, offering a more comprehensive view of the dynamics at play.

Chapter 4

4.1. Reconstruct the Legal Framework

Summary: 4.1.1. Criteria for the Analysis - 4.1.2. Overview - 4.1.3. International and Supranational Level - 4.1.4. National and Local Level - 4.1.5. Conclusions

4.1.1. Criteria for the Analysis

In the pursuit of delineating the legal framework for Digital Twin Cities (DTC), this research embarks on a comprehensive analysis at the intersection of artificial intelligence (AI), big data, urban environments, and inequalities. This effort is both timely and essential, as the literature shows a considerable lack in efforts to blend these elements into a coherent legal structure.

Although numerous scholars focus on particular vertical areas, only a few have dived into a comprehensive analysis that offers the fundamental knowledge required for different industries to succeed in DTCs.

This study aims to fill that gap by focusing on legislative provisions with significant implications for AI, big data, urban development, and the multifaceted nature of inequalities —economic, cultural, and relational.

With AI and big data playing an increasingly important role in urban governance, there is a danger that these technologies may perpetuate current inequalities or generate new ones. For example, economic disparities could worsen if only specific socioeconomic groups have access to digital services or can join smart city projects. Inadequate representation of diverse communities on digital platforms may exacerbate cultural inequalities. Relationship disparities can occur when the use of surveillance technologies has a greater impact on marginalized communities.

The current legal landscape is fragmented and unevenly developed across different jurisdictions. While some areas, such as data protection and markets, have been extensively explored, others remain under-represented in legal debates. This study seeks to navigate through these complexities by examining the layers of norms—international, supranational (particularly within the EU context), national, and local regulations—that collectively shape the legal environment of DTCs in Europe (see Par. 1.3.2. for the

explained territorial limitation of the study).

To address these concerns, this research emphasizes the need for legal frameworks that are not only technologically informed but also socially conscious. By focusing on legislative provisions with significant implications for AI, big data, and urban development, this study aims to identify how laws interplay in their attempt to promote innovation, equity and inclusivity in cities.

The construction of a legal framework for DTCs necessitates consideration of multiple layers of norms, from the international to the local level:

1. International Law: International conventions and treaties play a crucial role in setting overarching principles that guide national policies on AI, data governance, and human rights. These instruments can provide a foundation for addressing global challenges related to inequalities in DTCs.

2. Supranational Law (EU): Within Europe, the European Union's regulatory landscape offers a unique context for examining how supranational norms influence national and local practices. The EU's emphasis on digital sovereignty and ethical AI provides critical insights into balancing technological innovation with social justice.

3. National Law: National legislation varies widely across countries, reflecting different priorities and capacities in addressing the challenges posed by DTCs. This layer involves analysing how national laws can be harmonised with international standards while addressing local needs.

4. Local Regulations: Cities themselves are key actors in shaping the legal environment for DTCs. Local regulations often determine how technologies are implemented on the ground, influencing their impact on urban inequalities.

This multi-layered approach reflects the complex and fragmented nature of the legal landscape surrounding DTCs. Some regulations are over-explored in existing literature, while others remain under-represented in legal debates. Therefore, this study will emphasize those under-represented areas to provide a more balanced understanding.

This study seeks to address the existing gap in the literature by concentrating on legislative provisions that have substantial implications for AI, big data, and urban development, while intentionally steering clear of technical sectors (like transports, infrastructures, energy performances, building construction, etcetera), which are already studied vertically, and sometimes in direct conjunctions, by separate literatures. Additionally, it steers clear of areas that are already extensively covered in European literature, such as data protection, privacy, markets, and competition.
To ensure the feasibility of this research, the focus will be directed toward

legislation that significantly influences Digital Twin Cities (DTC), as previously discussed and defined. This involves identifying specific legal articles or provisions that have a direct impact on AI, big data, and the broader context of urban development.

To define the legal framework of Digital Twin Cities in Europe it is necessary to consider multiple actors.
Legal pluralism is intended in the sense of a multi-level and multi-actor legal system. It is expressed in its empirical, socio-legal sense (on the way in which this plays out in a particular context)[289]. The actors involved in this framework can be equally diverse:

- States: National governments play a pivotal role in setting policies that influence how cities adopt AI and big data technologies.
- Regions and Provinces: Sub-national entities can tailor policies to address regional disparities and specific local challenges.
- Cities: As primary sites for implementing DTC initiatives, cities have significant autonomy in crafting local regulations that reflect their unique contexts. Cities, here, become shorthand for local government, which in turn stands for the lowest tier of public administration within a given state (UN 2015).
- Public Actors: Universities, public research institutes, and public companies contribute to knowledge production and policy development.
- Private Actors: Companies and software providers drive technological innovation but must be held accountable for their impact on urban inequalities.
- NGOs and Civil Society: These groups advocate for marginalized communities and ensure that diverse voices are included in policy discussions.
- Citizens: Ultimately, citizens are both beneficiaries and stakeholders in DTC initiatives; their engagement is crucial for ensuring equitable outcomes.

A critical aspect of this research involves examining the rights and duties established by various laws across these actors. This includes analysing specific articles or provisions that directly impact AI, big data, urban development, and inequalities within DTCs.
The subsequent paragraphs will dive into these layers of norms and actors in detail, where the goal is to provide a valid way of comprehensive analysis (in

[289]see B. Oomen, E. Durmus, "Cities and Plural Understandings of Human Rights: Agents, Actors, Arenas", *The Journal of Legal Pluralism and Unofficial Law* 51, no. 2, 2019: 141–50. https://doi.org/10.1080/07329113.2019.1596731.

the field of legal informatics, as mentioned in Chapter 2) instead of focusing on specific territories or problems. The following paragraphs will offer an exploration of how legal frameworks can be designed, or reformed, to foster environments where technology serves as a tool for social justice rather than an amplifier of existing disparities.

By illuminating pathways for integrating technological advancements with urban planning in a legally coherent manner, this research aims to provide insights into how digital twin cities can evolve sustainably across Europe. Through this analysis, we hope to offer guidance for future research and policy-making that addresses both the opportunities and challenges presented by the emergence (and legal consolidation) of digital twin cities.
Crafting a legal framework for Digital Twin Cities requires a careful balance between technological innovation and social equity. By focusing on underrepresented areas within the legal landscape —particularly those related to inequalities— this study seeks to contribute meaningfully to the ongoing discourse on smart cities. It underscores the importance of inclusive policy-making that considers diverse perspectives and prioritizes equitable outcomes for all urban residents.

4.1.2. Overview

In the contemporary digital age, as previously noted in section "3.3. Reflection in the Law", the increasing complexity of digital technologies, particularly their integration into public governance, presents unprecedented challenges for lawmakers, courts, and scholars alike[290].
These technologies are not merely tools of administration but are rapidly transforming the social, economic, and legal landscapes, necessitating a comprehensive re-evaluation of existing legal frameworks to ensure their alignment with the evolving digital context.
This effort of understanding is essential to ensure that legal decisions are informed and adapted to the changing context.

Urban Digital Twins (UDTs), which serve as virtual representations of cities and their ecosystems, represent a prime example of such transformative potential. Unlike conventional technologies employed by public administrations, it is questionable if UDTs should be considered mere digital assets, as linked databases or administrative software for visualising the municipal area. This reductive view may not fully grasp the transformative potential of the Digital Twin Cities, as highlighted in Chapter 3.
In fact, they introduce novel, dynamic forms of civic engagement, fostering digital spaces where citizens, public authorities, and private entities can

[290] see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica.* Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020, p. 41

interact and collaborate. There is a broader perspective that sees these digital cities as much more than mere tools; they could constitute new virtual public spaces where citizen participation is not only desired but sometimes necessary for the very functioning of the system.

For the consideration expressed, the legal qualification of Digital Twin Cities can represent a fundamental and complex area of debate.
These platforms are transforming, evolving through different "maturity levels", moving forward into new layers of integration. They"re changing nature requires a legal framework that recognizes their dual nature as both tools for urban management and as spaces for democratic participation. Only in this way they will serve the development of human constructs, and cities *in primis*.

One critical legal question centers on the classification and regulation of these digital constructs. Should UDTs be treated only as administrative property under public law, or as emerging public spaces, related to traditional urban commons, where citizen participation is integral to the system's function? The latter perspective calls for an evaluation of how laws governing civic participation, privacy, and public-private interactions must adapt to ensure that UDTs remain inclusive and democratic.

Developing a legal framework for UDTs requires a multi-level approach, starting from supranational regulations and extending to national and local laws. This process must take into account, in Europe, primarily the complex relationship between the competences of the European Union, Member States and Regions/Local Authorities. The European Union, with its wide range of regulations and directives, plays a key role in defining the minimum standards that Member States must meet.
This interplay between EU and national regulations is essential to understand the flexibility and constraints in managing UDTs across different jurisdictions.

Moreover, the role of public-private partnerships in managing UDTs presents a set of complex legal challenges. While such collaborations can drive technological advancement and urban innovation, they must be carefully regulated to avoid disproportionate power imbalances and ensure equitable distribution of benefits.

A comprehensive legal analysis of UDTs should also consider human rights principles as articulated in the European Convention on Human Rights (ECHR), or the fundamental rights articulated in the Charter of Fundamental Rights of the European Union (CFR).
These principles, especially those related to privacy, non-discrimination, and freedom of expression, must be integrated into any regulatory framework governing the deployment and operation of UDTs. As UDTs increasingly

mediate essential aspects of urban life, from transportation to housing, it is imperative that they contribute to reducing, rather than exacerbating, social inequalities.

In conclusion, the legal regulation of UDTs requires an integrated approach that considers multiple layers of governance—supranational, national, and local—while addressing emerging challenges such as data privacy, cybersecurity, and social equity. Mapping relevant legislation in Europe concerning Digital technologies, Cities, and Inequalities requires the exploration of specific regulations and broader legal frameworks affecting these areas. This approach is complex but possible and allows the identification of key regulations and interactions between different levels of governance that influence the development and management of cities. Furthermore, it is important to consider how these regulations can be adapted to address emerging challenges[291] in upcoming years.
Regulations must be designed not only to facilitate technological innovation but also to promote social justice and inclusion. Through an integrated approach that involves all relevant actors -from supranational institutions to local governments- it is possible to develop policies that ensure that Digital Twin Cities contribute positively to collective well-being in Europe.

4.1.3. International and Supranational Level

a. UN Level The foundations of the legal framework relevant to the present work reside at the international and supranational level much more on the side of inequalities, in the present work understood mainly in their urban dimension as explained in Section 2. This is largely due to the era in which the principles were elaborated, although there has been no lack of attempts in recent years to also regulate the technological aspect at the international and supranational level (attempts of which we will give ample account). That said, the first foundations for the present work can be found in the Universal Declaration of Human Rights (UDHR), 1948[292].
Adopted by the United Nations General Assembly in 1948, it provides a foundational framework for human rights protections worldwide. While it asserts principles of formal equality in terms of equal treatment before the law (legal equality), it also hints at substantive equality by emphasising economic, social, and cultural rights. Article 7 states:

All are equal before the law and are entitled without any discrimination to equal protection of the law. All are entitled to equal protection against any

[291] in other words, being resilient. For a legal point of view on "legal resilience", see A. Sari, "Hybrid CoE Trend Report 3. Hybrid Threats and the Law. Concepts, Trends and Implications", Trend Report. European Centre of Excellence for Countering Hybrid Threats, 2020.
[292] see Source: UDHR, 1948.

discrimination in violation of this Declaration and against any incitement to such discrimination.

This provision reflects the notion of formal equality—equal treatment and non-discrimination before the law. However, the UDHR does not stop at this level of protection. In fact, Article 25, paragraph 1 recognises:

Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.

This recognition of economic and social rights empowers the first provision (legal equality), offering tools for the protection of more formal and substantive levels of equality in diverse and inspired legislations worldwide. The individual-oriented approach highlights that certain material conditions must be met for individuals to exercise their rights fully. However, referring to *standard of living* and especially to *social services*, the UDHR implies that states must actively work to create conditions that promote true equality, beyond the mere absence of discrimination. It is a nuanced offshoot of what can be defined as substantive equality.

The UDHR is completed by the International Covenant on Economic, Social and Cultural Rights (ICESCR), 1966[293], which emphasizes more on the state's role in ensuring that individuals can exercise their rights by addressing socio-economic inequalities. This international treaty embodies substantive equality by recognising that achieving real equality often requires affirmative state action to rectify imbalances. Article 2 mandates that:

1. *Each State Party to the present Covenant undertakes to take steps, individually and through international assistance and co-operation, especially economic and technical, to the maximum of its available resources, with a view to achieving progressively the full realization of the rights recognized in the present Covenant by all appropriate means, including particularly the adoption of legislative measures.*
2. *The States Parties to the present Covenant undertake to guarantee that the rights enunciated in the present Covenant will be exercised without discrimination of any kind as to race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status.*
3. *Developing countries, with due regard to human rights and their national economy, may determine to what extent they would guarantee the economic rights recognized in the present Covenant to nonnationals.*

[293]see Source: ICESCR, 1966.

The formulas adopted are clear in suggesting the adoption of legal measures to achieve the full protection of rights, and in mandating *the maximum of its available resources* for each state party.
While this reflects formal equality in terms of non-discrimination, the Covenant's substantive equality is repeated in other articles.
Article 11.1. recognises:

The States Parties to the present Covenant recognize the right of everyone to an adequate standard of living for himself and his family, including adequate food, clothing and housing, and to the continuous improvement of living conditions. The States Parties will take appropriate steps to ensure the realization of this right, recognizing to this effect the essential importance of international cooperation based on free consent.

This provision requires states to take positive measures to ensure that individuals can enjoy an adequate standard of living, showing an explicit commitment even to the *continuous improvement of living conditions.*

In the United Nations (UN) framework, the United Nations Sustainable Development Goals (SDGs) the United Nations Sustainable Development Goals (SDGs) serve as a significant point of reference for sustainable urban development.
The Sustainable Development Goals (SDGs) are an extension of the continuous global effort (1992-2015)[294] led by the United Nations, particularly through its Department of Economic and Social Affairs.
It aims at achieving sustainable development by the year 2030. The 2030 Agenda[295] for Sustainable Development was unanimously adopted by all UN Member States in 2015, marking a global consensus on a path towards peace and prosperity. It underscores the necessity for a global partnership, urging collaborative efforts among all nations and serving as a comprehensive call to action for countries around the world, whatever is their developmental status.

It is centered around 17 Sustainable Development Goals (SDGs) that address a wide range of global challenges, including poverty, inequality, climate change, environmental degradation, peace, and justice[296].
The agenda seeks to integrate and balance the three dimensions of sustainable development: economic, social, and environmental. To do so, it is

[294]see https://sdgs.un.org/goals (link consulted on 03.04.2024).
[295]see https://eurocities.eu/latest/local-digital-twins-empower-urban-planners-for-informed-decisions/ (link consulted on 02.02.2025).
[296]see P. Kuenkel, A. Gruen, "Co-Creation for Sustainability as a Societal Learning Journey". In Lifelong Learning and Education in Healthy and Sustainable Cities, edited by U.M. Azeiteiro, M. Akerman, W. Leal Filho, A.F.F. Setti, and L.L. Brandli, 377–93. World Sustainability Series. Cham: Springer International Publishing, 2018. https://doi.org/10.1007/978-3-319-69474-0_22.

articulated in goals that cover diverse areas such as ending poverty, ensuring quality education, promoting gender equality, ensuring clean water and sanitation, affordable and clean energy, and fostering innovation and infrastructure[297]. The importance of collaboration among countries is not limited to their level, but vertically involves stakeholders from different sectors like governments, the private sector, civil society, and individuals working together[298].

The goals emphasise the need for integrated solutions to achieve an harmonizes socio-economic advancements with environmental sustainability, ensuring the well-being of the planet and its inhabitants for current and future generations. While economic growth is seen as essential for achieving the goals, there is also a need to consider cultural and non-economic values. This includes recognising the importance of arts and culture in human development, which may not always align with market-driven approaches[299].
The agenda also encourages the use of technology and innovation to drive sustainable development[300].

Agenda 2030 is highly relevant and interesting for cities, primarily due to its focus on sustainable urban development. One of the key Sustainable Development Goals (SDG Goal 11) specifically targets making cities inclusive, safe, resilient, and sustainable.
Another Goal, (SDG Goal 10), explicitly addresses inequalities and focuses on reducing inequalities within and among countries.

The close consequentiality of these two articles cannot be accidental, but suggests the scope of exploration itself of the present work. The focus on reducing inequalities through leveraging sustainable cities is integral to achieving sustainable development overall and improving the quality of life for all individuals.

Starting from the first, in order of appearance in the Agenda 2030, the Goal 10 is titled "Reduce inequality within and among countries". it is structured

[297] see J. Brodny, M. Tutak, "The Level of Implementing Sustainable Development Goal 'Industry, Innovation and Infrastructure' of Agenda 2030 in the European Union Countries: Application of MCDM Methods", Oeconomia Copernicana 14, no. 1 (25 March 2023): 47–102. https://doi.org/10.24136/oc.2023.002.

[298] see R. Pärli, M. Fischer, "Implementing the Agenda 2030 – What Is the Role of Forums?", *International Journal of Sustainable Development & World Ecology* 27, no. 5 (3 July 2020): 443–57. https://doi.org/10.1080/13504509.2020.1719546.

[299] see T. Barrantes-Fernández, E. Cruz-Hidalgo, J. Francisco Rangel-Preciado, and F. M. Parejo-Moruno, "Decommodify the 2030 Agenda: Why and How to Finance What Is Not Profitable?" *Sustainability* 15, no. 5 (22 February 2023): 3966. https://doi.org/10.3390/su15053966.

[300] For instance, smart and sustainable hotels are being promoted within the tourism sector to enhance operational efficiency and sustainability. See B. Casais, L. Ferreira. "Smart and Sustainable Hotels: Tourism Agenda 2030 Perspective Article", *Tourism Review* 78, no. 2, 2023: 344–51. https://doi.org/10.1108/TR-12-2022-0619.

in Target and Indicators[301], as it follows:

- *Target 10.1.: By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average*
  - *Indicators 10.1.1.: Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population*
- *Target 10.2.: By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status*
  - *Indicators 10.2.1: Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities*
- *Target 10.3: Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regarg*
  - *Indicators 10.3.1: Proportion of population reporting having personally felt discriminated against or harassed within the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law*
- *Target 10.4: Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality*
  - *Indicator 10.4.1: Labour share of GDP*
  - *Indicator 10.4.2: Redistributive impact of fiscal policy*
- *Target 10.5: Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations*
  - *Indicators 10.5.1: Financial Soundness Indicators*
- *Target 10.6: Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions*
  - *Indicators 10.6.1: Proportion of members and voting rights of developing countries in international organizations*
- *Target 10.7: Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies*
  - *Indicators 10.7.1: Recruitment cost borne by employee as a proportion of monthly income earned in country of destination*
  - *Indicator 10.7.2: Number of countries with migration policies that facilitate orderly, safe, regular and responsible migration and*

[301] see https://sdgs.un.org/goals/goal10#targets_and_indicators (link consulted on 03.04.2024).

mobility of people
    - *Indicator 10.7.3: Number of people who died or disappeared in the process of migration towards an international destination*
    - *Indicator 10.7.4: Proportion of the population who are refugees, by country of origin*
- *Target 10.a: Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements*
    - *Indicators 10.a.1: Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff*
- *Target 10.b: Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes*
    - *Indicators 10.b.1: Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment and other flows)*
- *Target 10.c: By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent*
    - *Indicators 10.c.1: Remittance costs as a proportion of the amount remitted*

For the purposes of this work, SDG Goal 10 gives fundamental guidelines on where to point the attention on inequalities. Mentioning age, sex[302], disability, race, ethnicity, origin, religion, or economic or other status, it focuses primarily on the individual level, without forgetting the importance of addressing socioeconomic inequalities, which are prevalent in various regions, including the European Union. Many studies have shown that achieving the targets of SDG Goal 10 requires concerted efforts and policies to address these disparities[303]. It emphasizes the need for policies that promote social, economic, and political inclusion for all[304].

[302]Agenda 2030 also highlights gender equality as a crucial component, with SDG 5 focusing on achieving gender equality and empowering all women and girls. This includes addressing gender disparities in health, education, and economic opportunities. See for example in G. N. Shava, N. Mkwelie, M. Jasper Ndlovu, and E. Zulu. "Higher Education Institutions' Sustainable Development towards Agenda 2030: A Global Goals in Policy and Curriculum". *International Journal of Research and Innovation in Social Science* VII, no. IV (2023): 1320–36. https://doi.org/10.47772/IJRISS.2023.7510.

[303]see in A. Szymańska, "Reducing Socioeconomic Inequalities in the European Union in the Context of the 2030 Agenda for Sustainable Development", *Sustainability* 13, no. 13 (2 July 2021): 7409. https://doi.org/10.3390/su13137409.

[304]see in Europe in T. M. Cojocaru, G. H. Ionescu, D. Firoiu, L. M. Cismaș, M. D. Oțil, and O. Toma. "Reducing Inequalities within and among EU Countries—Assessing

The intersection between SDG Goal 10 and cities offers opportunities to derive concrete actions for the development of cities:

1. Urban Planning and Zoning Laws:
    - Implementing inclusive urban planning and zoning laws that prevent segregation and ensure diverse communities have equitable access to services and opportunities.
    - Developing legal frameworks that promote mixed-use development to reduce spatial inequalities and ensure all residents have access to essential services.
2. Affordable Housing:
    - Enacting and enforcing laws and regulations that promote the development of affordable housing to ensure that low-income and marginalized groups can live in safe and affordable homes within the city.
    - Legal measures to protect tenants' rights and prevent predatory practices by landlords.
3. Public Transportation and Accessibility:
    - Developing comprehensive legal frameworks that ensure public transportation systems are affordable, reliable, and accessible to all, including those with disabilities, to reduce inequalities in mobility and access.
    - Legal mandates for the development of pedestrian and cycling infrastructure to promote inclusive mobility options.
4. Inclusive Public Services and Infrastructure:
    - Enforcing laws that mandate the inclusive design of public spaces and infrastructure, ensuring that they are accessible and usable by all, including the elderly, children, and persons with disabilities.
    - Legal frameworks to ensure equitable distribution of and access to public services like education, healthcare, and recreational facilities.
5. Economic Opportunities and Employment:
    - Implementing legal initiatives to promote economic opportunities in cities, including support for small businesses, skills training, and access to microfinance, with a focus on marginalized and underserved communities.
    - Enforcing labor laws that ensure fair employment practices and protect the rights of workers in urban settings, including informal

the Achievement of the 2030 Agenda for Sustainable Development Targets (SDG 10)". Sustainability 14, no. 13, 2022: 7706. https://doi.org/10.3390/su14137706. See, with reference to Big Data, in H. Hassani, Hossein, X. Huang, S. MacFeely, and M. Reza Entezarian. "Big Data and the United Nations Sustainable Development Goals (UN SDGs) at a Glance". *Big Data and Cognitive Computing* 5, no. 3 (28 June 2021): 28. https://doi.org/10.3390/bdcc5030028.

sector workers.

6. Social Inclusion and Anti-Discrimination:
    - Enacting anti-discrimination laws that protect minorities, migrants, and other vulnerable groups from exclusion and marginalisation in urban settings.
    - Legal measures to ensure the participation and representation of all groups in urban governance and decision-making processes.
7. Safety and Security:
    - Strengthening legal and policy frameworks to enhance safety and security in urban areas, with a focus on preventing crime and violence against vulnerable populations.
    - Legal reforms to ensure that law enforcement practices are fair, non-discriminatory, and respect human rights.
8. Urban Environmental Justice:
    - Developing legal measures to address environmental inequalities in cities, ensuring that all residents have access to clean air, water, and green spaces.
    - Laws to prevent and mitigate the adverse environmental impacts of urban development on marginalized communities.

By addressing these aspects through legal and policy frameworks, cities can play a crucial role in reducing inequalities and creating inclusive urban environments where everyone has the opportunity to thrive.

SDG Goal 10 has, furthermore, significant intersection also with the law. It highlights the role of legal reforms in achieving a more equitable world, underlining the necessity for legal systems that promote equality and justice, in several directions:

1. Legal Frameworks and Equality:
    - Implementing comprehensive anti-discrimination laws that cover all forms of discrimination, including race, gender, sexual orientation, disability, and socioeconomic status.
    - Enacting and enforcing laws that ensure equal opportunity in employment, education, and access to services.
2. Property Rights and Access to Resources:
    - Strengthening legal frameworks to ensure equal rights to land and property, which are critical for reducing economic inequalities.
    - Implementing legal measures that support the inheritance rights of women and marginalized groups.
3. Legal Aid and Access to Justice:
    - Ensuring that legal aid services are available and accessible to all, particularly the poor and marginalized, to enhance access to justice.
    - Developing legal systems that are responsive to the needs of dis-

advantaged groups, thereby reducing barriers to justice.

4. International Law and Global Inequality:
    - Leveraging international legal instruments and agreements to address global economic disparities and unfair trade practices that exacerbate inequality.
    - Promoting legal frameworks that regulate and ensure responsible business practices by multinational corporations in host countries.
5. Labor Laws and Workers' Rights:
    - Strengthening labor laws to protect workers from exploitation and ensure fair wages, safe working conditions, and the right to unionize.
    - Enacting legal measures to eliminate forced labor, child labor, and human trafficking.
6. Legal Systems and Social Protection:
    - Developing legal frameworks that support comprehensive and inclusive social protection systems, ensuring that vulnerable populations are protected against economic shocks and downturns.
    - Legal recognition and support for community-based social safety nets.
7. Migration and Legal Protections:
    - Establishing legal protections for migrants and refugees to ensure their rights are respected and they are protected from exploitation and abuse.
    - Creating legal pathways for migration that respect human rights and reduce the vulnerability of migrants to inequality.
8. Taxation and Fiscal Policies:
    - Implementing progressive tax systems through legal means to ensure a fair distribution of wealth and reduce income inequality.
    - Enacting laws that close loopholes, prevent tax evasion, and ensure that corporations and the wealthy contribute their fair share to the economy.
9. Gender Equality and Legal Systems:
    - Strengthening legal frameworks to eliminate gender-based discrimination and violence, ensuring women and girls have equal rights in all aspects of society.
    - Legal measures to support women's economic empowerment, such as equal pay for equal work laws.
10. Legal Education and Awareness:
    - Promoting legal education and awareness programs to inform citizens of their rights, thereby empowering them to demand justice and equality.
    - Training for legal professionals on issues related to inequality and discrimination to ensure they are equipped to address these issues

effectively.

By integrating these legal considerations and reforms, the objectives of SDG Goal 10 can be substantially supported, moving societies toward greater equality and justice, both within countries and globally.

The following Goal, SDG Goal 11, is titled "Make cities and human settlements inclusive, safe, resilient and sustainable". it is again structured in Target and Indicators[305], as it follows:

- *Target 11.1: By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums*
  - *Indicators 11.1.1: Proportion of urban population living in slums, informal settlements or inadequate housing*
- *Target 11.2: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons*
  - *Indicators 11.2.1: Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities*
- *Target 11.3: By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries*
  - *Indicators 11.3.1: Ratio of land consumption rate to population growth rate*
  - *Indicator 11.3.2: Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically*
- *Target 11.4: Strengthen efforts to protect and safeguard the world's cultural and natural heritage*
  - *Indicators 11.4.1: Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)*
- *Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations*
  - *Indicators 11.5.1: Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population*

[305] see https://sdgs.un.org/goals/goal11#targets_and_indicators (link consulted on 03.04.2024).

  - *Indicator 11.5.2: Direct economic loss attributed to disasters in relation to global domestic product (GDP)*
  - *Indicator 11.5.3: (a) Damage to critical infrastructure and (b) number of disruptions to basic services, attributed to disasters*
- *Target 11.6: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management*
  - *Indicators 11.6.1: Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities*
  - *Indicator 11.6.2: Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)*
- *Target 11.7: By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities*
  - *Indicators 11.7.1: Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities*
  - *Indicator 11.7.2: Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months*
- *Target 11.a: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning*
  - *Indicators 11.a.1: Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and (c) increase local fiscal space*
- *Target 11.b: By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels*
  - *Indicators 11.b.1: Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030*
  - *Indicator 11.b.2: Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies*
- *Target 11.c: Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials*
  - *No Indicators*

The intersection between SDG Goal 11 and Inequalities offers opportunities to derive concrete actions for the development of cities[306]:

Direct Address of Inequalities:

- Inclusivity: SDG 11 emphasizes the need for cities and human settlements to be inclusive. This means ensuring that all residents, regardless of their socio-economic status, gender, age, race, ethnicity, or disability, have equal access to urban resources, services, and opportunities. Legal frameworks supporting SDG 11 must address inequalities by ensuring non-discriminatory access to housing, public spaces, and urban services.
- Access to Basic Services: The goal stresses the importance of universal access to safe, affordable housing, and basic services. This directly targets economic inequalities by ensuring that even the poorest urban dwellers have access to essential services such as clean water, sanitation, and waste management systems.
- Public Spaces: SDG 11 advocates for the provision of universal access to safe, inclusive, and accessible green and public spaces. This is crucial for reducing social inequalities, as it ensures that all city residents, regardless of their economic background, have spaces for recreation and socialisation.

Indirect Impact on Inequalities:

- Resilience and Safety: By focusing on making cities resilient to disasters and creating safer urban environments, SDG 11 indirectly addresses inequalities. Vulnerable populations are often the most affected by urban disasters and crime. Enhancing urban resilience and safety helps protect these groups, thereby reducing their vulnerability and addressing inequalities.
- Sustainable Transportation: The goal's emphasis on providing access to safe, affordable, efficient, and sustainable transport systems has implications for inequalities. Efficient public transport systems ensure that all residents, including those from lower socio-economic backgrounds, can access employment, education, and other services, thereby reducing economic and social inequalities.
- Economic Opportunities: By promoting inclusive and sustainable urbanisation, SDG 11 can foster economic opportunities and job creation,

[306]see D. Soeiro, "Smart Cities, Well-Being and Good Business: The 2030 Agenda and the Role of Knowledge in the Era of Industry 4.0", *Knowledge, People, and Digital Transformation*, edited by Florinda Matos, Valter Vairinhos, Isabel Salavisa, Leif Edvinsson, and Maurizio Massaro, 55–67. Contributions to Management Science. Cham: Springer International Publishing, 2020. https://doi.org/10.1007/978-3-030-40390-4_5.

particularly for the marginalized and vulnerable. This can help bridge economic inequalities within cities.

The implementation of SDG 11 requires legal and policy frameworks that explicitly address inequalities. This includes various actions, from zoning laws that prevent segregation, to policies that ensure affordable housing. A broader exploration might involves:

Legal Frameworks and Urban Development:

- Inclusivity in Urban Legislation: Legal systems can promote inclusivity in urban areas by enforcing anti-discrimination laws, ensuring equal access to housing, public spaces, and services, and protecting the rights of marginalized groups. This involves the enactment of laws that prevent segregation and discrimination in urban areas, ensuring all citizens, regardless of their background, have access to the benefits of urban living.
- Safety Regulations: The law plays a crucial role in making cities safe through regulations that govern building codes, fire safety, public space design, and crime prevention. Legal frameworks can enforce standards for the construction of resilient infrastructure, regulate hazardous materials, and establish law enforcement protocols to ensure public safety.
- Resilience and Environmental Legislation: To enhance the resilience of cities to natural disasters and climate change, legal measures are necessary. This includes zoning laws that prevent construction in high-risk areas, regulations that mandate the integration of climate resilience into urban planning, and laws that promote sustainable resource management.
- Sustainable Urban Planning Laws: Sustainable development in urban areas is supported by legal frameworks that encourage green building practices, efficient public transportation systems, and the preservation of green spaces. Laws that incentivize renewable energy use, waste reduction, and water conservation contribute to the sustainability of cities.
- Public Participation and Governance: Legal mechanisms can ensure that urban development is a participatory process. This involves laws that guarantee public access to information, enable community involvement in planning decisions, and establish transparent governance structures.
- Implementation and Enforcement: For SDG 11 to be realized, not only must appropriate laws be enacted, but their implementation and

enforcement must also be ensured. This requires a robust legal system capable of holding individuals and entities accountable for non-compliance.

- International Cooperation and Legal Harmonisation: Given the global nature of urban challenges, international legal frameworks and cooperation play a vital role. This includes treaties, agreements, and partnerships that facilitate the exchange of best practices, technical assistance, and financial support for sustainable urban development.

Many challenges and opportunities arise:

- Adapting Legal Systems to Rapid Urbanisation: As cities grow rapidly, legal systems must be adaptable to address emerging challenges, including housing shortages, infrastructure strain, and environmental degradation.
- Balancing Development and Conservation: Legal frameworks must find a balance between facilitating urban development and protecting the environment, ensuring that growth does not come at the expense of ecological and social sustainability.
- Inequality and Access to Justice: Ensuring that all urban residents, especially the most vulnerable, have access to justice is crucial for addressing inequalities in cities. Legal aid, community legal services, and inclusive legal processes are essential components.
- Innovation in Urban Legislation: The dynamic nature of urban development demands innovative legal solutions. This includes leveraging technology in governance, adopting flexible zoning laws, and exploring new models of public-private partnerships.

Achieving this goal has the potential to significantly reduce various forms of inequalities within cities by ensuring inclusivity, safety, resilience, and sustainability. However, the complexity of the interventions seems to pose important questions on how effectively translate into practical actions its noble principles. This struggle is the same struggle UDTs might find in dealing with the topic of the present work.

The Agenda 2030 benefits cities in various ways[307], at the same time high-

[307] Agenda 2030 encourages cities to adopt sustainable practices that improve the quality of life for their residents. This includes initiatives to manage contaminated areas, which can lead to revitalisation and increased availability of safe properties. The framework also supports enhancing cultural attractiveness in cities, which can boost tourism and contribute to sustainable urban development. The Cultural Attractiveness Index (CAI) is an example of a tool developed to help cities evaluate and improve their cultural appeal in alignment with sustainable development goals. See in H. Zhang, X. Yu Leung, and B. Bai. "Cultural Attractiveness Index for Sustainable Cities: Tourism Agenda 2030". *Tourism Review* 78, no. 2 (7 April 2023): 411–26. https://doi.org/10.1108/TR-05-2022-0255.

lighting the critical role that Big Data plays in monitoring and achieving the Sustainable Development Goals. As seen in the Indicators, Big Data are crucial for tracking progress towards the 17 SDGs and the 169 associated targets. The United Nations Statistical Commission has developed a Global Indicator Framework with 232 indicators to help countries implement and monitor their development strategies[308]. However, while Big Data offers numerous possibilities for compiling SDG indicators, it also presents challenges such as legal, ethical, technical, and reputational issues[309]. These challenges need to be addressed to maximize the benefits of Big Data in supporting sustainable development.

Specific papers, like "Enabling Digital Twins to Support the UN SDGs"[310], review the current trajectory of digital twin applications in supporting general sustainability, strengthening the links within the 17 UN SDGs through the data.

Overall, Agenda 2030 represents a transformative vision for a better world, requiring concerted efforts and innovative solutions to address complex global issues. The importance of the UN SDG Goals, however, is not limited to their aspirations, as they are noted by several legislative acts worldwide. To remain at the UN level, a recent UN General Assembly Resolution (11.03.2024 on "Seizing the opportunities of safe, secure and trustworthy artificial intelligence systems for sustainable development") explicitly recognises that AI systems can, potentially, accelerate and enable progress towards reaching the 17 Sustainable Development Goals.
This is significant in the light of the mentioned SDG Goal 10 and Goal 11.
The US-led draft resolution[311] was "co-sponsored" or backed by more than 120 other Member States, including European Countries and the United States of America, and was adopted without a vote[312].
The resolution marked a pioneering move by the Assembly to establish

[308]see C. Wang, Y. Tang, H. Zhang, B. Zhang, F. Wu, and L. Xu. "Synthetic Aperture Radar for SDGs in Big Data Era". In 2021 SAR in Big Data Era (BIGSARDATA), 1–4. Nanjing, China: IEEE, 2021. https://doi.org/10.1109/BIGSARDATA53212.2021.9574431. For instance, several countries have prioritized Big Data Analytics as a key component of their national development plan to support the SDGs.

[309]see S. MacFeely, "The Big (Data) Bang: Opportunities and Challenges for Compiling SDG Indicators". *Global Policy* 10, no. S1 (January 2019): 121–33. https://doi.org/10.1111/1758-5899.12595.

[310]see H. Hassani, X. Huang, and S. MacFeely. "Enabling Digital Twins to Support the UN SDGs". *Big Data and Cognitive Computing* 6, no. 4 (16 October 2022): 115. https://doi.org/10.3390/bdcc6040115.

[311]see UN's "Seizing the opportunities of safe, secure and trustworthy artificial intelligence systems for sustainable development", available at link: https://undocs.org/A/78/L.49 (link consulted on 02.02.2025).

[312]see at link: https://news.un.org/en/story/2024/03/1147831 (link consulted on 02.02.2025).

regulatory measures in the nascent domain of AI, emphasising the imperative of upholding human rights throughout the lifecycle of AI, including its design, development, deployment, and utilisation.
The Assembly called on all Member States and stakeholders "to refrain from or cease the use of artificial intelligence systems that are impossible to operate in compliance with international human rights law or that pose undue risks to the enjoyment of human rights" and to respect that "The same rights that people have offline must also be protected online, including throughout the life cycle of artificial intelligence systems". The Assembly further recognised the "varying levels" of technological development between and within countries. This mention is particularly important in the topic of inequalities, recognising that the so-called "digital divide" is not only a matter of access to technology, but also a matter of digital literacy (a sort of meaninghful access to technology)[313].

b. Supranational Level - Transnational Law At the Supranational Level, International Human Rights Law (IHRL) is a complex and evolving field, drawing from a variety of sources and shaped by numerous actors across global and regional frameworks.
Article 38(1) of the International Court of Justice (ICJ)[314] articulates the formal sources of International Human Rights Law, including international conventions, international custom, and general principles of law recognised by civilised nations. Despite the debate about its adequacy in today's context, where multiple actors operate within a diverse array of institutions (starting from the UN Charter of 1945), it is true that the sources of IHRL are varied and include influences from religious creeds, natural law, and the nature of society itself. The interplay between formal legal structures and these broader ethical considerations continues to shape the development and implementation of international human rights norms. As the global landscape evolves, so too does the framework of IHRL, requiring ongoing dialogue and adaptation to address new challenges and ensure the protection and promotion of human rights worldwide[315].

In the European context, the European Convention on Human Rights (ECHR) protects human rights and fundamental freedoms. Established in 1950 and into force since the 1953, the ECHR is an international human rights treaty by the Council of Europe, which includes 46 member states.

[313]see G. Suffia, "Smart cities e digital divide: una proposta di analisi" (Smart cities and digital divide: a proposal for analysis), in *Ciberspazio e diritto* (ISSN 1591-9544) n. 2, Stem Mucchi Editore, Modena, 2021.

[314]see International Court of Justice, Statute, at link: https://www.icj-cij.org/statute (link consulted on 02.02.2025).

[315]see C. Chinkin, "Normative Development in the International Legal System". In Commitment and Compliance, edited by Dinah Shelton, 1st ed., 21–42. Oxford University PressOxford, 2003. https://doi.org/10.1093/acprof:oso/9780199270989.003.0002.

As well known, all European Union (EU) countries are members of the ECHR. Moreover, the EU itself, through the Treaty of Lisbon, is required to accede to the ECHR, aligning its legal framework with the human rights standards set by the ECHR[316].

The jurisprudence of the European Court of Human Rights (ECHR) only started to pay significant attention to the Internet after 2010. This delay, as documented by Perri (2020)[317], is due to the novelty of the issues and by the fact that appeals to the Court can only be lodged when all national remedies and degrees of adjudication have been exhausted. However, this condition has allowed the Court to approach digital issues with a more mature and informed perspective, as cases that reach Strasbourg are often those that have already gone through a lengthy judicial process in their respective countries. This process ensures that the issues brought to the Court's attention are substantive and not merely theoretical.

The Court tends to reject appeals based on abstract violations of law, and requires that the case be based on a present and concrete injury to the individual interests of the applicant, as pointed out by Perri (p. 59). This pragmatic approach ensures that the Court focuses on issues that have a real and tangible impact on people's lives, rather than on mere legal assumptions. However, this need for concreteness has not prevented the Strasbourg judges from reflecting on the peculiarities of the digital world and the Internet[318].

Thanks to their privileged position as a supra-governmental organisation encompassing a wide range of states and jurisdictions, the judges of the ECHR have had the opportunity to consider the impact of the digital on the fundamental rights enshrined in the European Convention on Human Rights. In particular, the right of access to the Internet has been a crucial reference point. Through Internet access, it is possible to safeguard other fundamental rights, such as freedom of expression and information, which are essential in today's digital society. This right in many countries is now considered a fundamental right, protected by constitutional guarantees[319].

Over the years, numerous problems related to the regulation and evaluation

[316] see at link: https://www.bmeia.gv.at/en/human-rights-and-the-eu (link consulted on 02.02.2025).

[317] see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica*. Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020.

[318] see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica*. Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020.

[319] This recognition implies that any intervention that might restrict access to the Internet must be viewed with extreme caution. Internet access is not only a means to exercise freedom of expression and information, but also a facilitator for access to a wide range of other rights and opportunities, from education to employment to political participation. Therefore, limitations to this right can have significant and far-reaching consequences. see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica*. Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020.

of technological phenomena have emerged. These problems often require the updating of established legal categories and a reinterpretation of norms in light of the changed reality, as pointed out by Perri (p. 44). Indeed, rapid technological change has made it necessary to continuously adapt existing laws to ensure that they remain relevant and effective. This adaptation process is not without its challenges, as it requires a balance between legal innovation and the protection of human rights.
Moreover, the Court must be able to anticipate future legal challenges that may arise with the evolution of the digital, ensuring that its rulings remain relevant and enforceable. In this context, the ECHR plays a key role in promoting a coherent and uniform approach to digital regulation among the various member states. Through its decisions, the Court can influence national policies and encourage the adoption of common standards that respect human rights. This is particularly important at a time when digital technologies are rapidly transforming the way we live and interact.

Articles 8 and 10 of the European Convention on Human Rights are of crucial importance in the context of surveillance, as they respectively address respect for private and family life, including the protection of personal data, and freedom of expression. These articles are the foundation on which many of the European Court of Human Rights (ECtHR) decisions on surveillance and privacy are based.

Article 8 ECHR states:

1. Everyone has the right to respect for his private and family life, his home and his correspondence.

2. There shall be no interference by a public authority with the exercise of this right except such as is in accordance with the law and is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others.

Although there is a margin of appreciation, i.e. a certain discretion that may be exercised by individual states in identifying a measure as necessary, this margin is always open to review by the ECHR. The Court has the task of assessing whether the measures taken are excessive or disproportionate to the aims pursued (Perri, p. 49). This judicial review is essential to ensure that states do not abuse their discretionary power to the detriment of citizens' fundamental rights.

In the context of a hypothetical digital twin, it is crucial to assess whether such technology could constitute state interference in citizens' private lives and whether such interference is "necessary" or pursues a legitimate interest. The question becomes particularly complex when considering the so-called

"substantive test", which requires determining how interference by the digital twin is necessary in a democratic society. Although the right to privacy is not an absolute right, it remains one of the fundamental rights recognised by the Convention.

Although the Court rarely rejects a declared purpose of the state for adopting intrusive measures, it does not exclude the possibility of restricting the use of digital twins if they do not meet the criteria of necessity and proportionality. The lack of a precise definition of "democratic society" further complicates the assessment. However, as Prof. Perri points out, it is clear that balancing the rights of individuals against the public interest is crucial, and the application of the principle of proportionality takes centre stage (Perri, p. 54).

The principle of proportionality, which permeates the entire Convention, has different definitions depending on the context in which it is applied. In one of the best known pronouncements, the Court stated that: *89. (…) Furthermore, inherent in the whole of the Convention is a search for a fair balance between the demands of the general interest of the community and the requirements of the protection of the individual's fundamental rights. (…)*[320]

This principle requires that any limitation of fundamental rights must be appropriate, necessary and proportionate to the legitimate objectives pursued.

In the context of digital twins, the application of the proportionality principle becomes particularly complex. These technologies, which aim to digitally replicate aspects of physical reality, can offer significant advantages in terms of efficiency and innovation. However, they also entail potential risks to privacy and individual freedom. It is therefore essential that any implementation of digital twins is accompanied by a rigorous assessment of the impact on fundamental rights.

Furthermore, it is important to consider how the use of digital twins may affect freedom of expression, guaranteed by Article 10 of the Convention. This freedom is fundamental to the functioning of a democratic society and must also be protected in the digital context. Any restriction must be justified by a legitimate interest and must meet the criteria of necessity and proportionality.

In this context, the protection of privacy and personal data emerges as a key priority. However, the digital reality requires exceptions to this protection, but these exceptions must be strictly regulated[321]. They must only occur in

[320] see Soering v. UK of 7 July 1989, App. No. 14038/88, para. 89, Perri, p. 54, available at link: https://hudoc.echr.coe.int/eng?i=001-57619 (link consulted on 02.02.2025).

[321] see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica.* Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020.

exceptional circumstances, clearly defined by law. This means that exceptions cannot be applied arbitrarily, but must be justified by concrete and clearly defined needs. Furthermore, it is essential that people are adequately informed about these exceptions. Information must be accessible, clear and precise, enabling citizens to fully understand the legislation or rules in force and their rights in this respect. This principle is well illustrated in Council of Europe Recommendation Rec(2014)6[322], which emphasises the importance of transparency and accessibility of information as pillars of rights protection in a technological context.
The importance of these measures cannot be underestimated. In a world where personal data are collected, analysed and used on an unprecedented scale, citizens' trust in digital institutions and systems depends on their ability to ensure that fundamental rights are respected. Transparency in exceptions and limitations is crucial to maintaining this trust. Citizens need to know when and why their data can be used in ways that go beyond the norm, and they must be able to challenge such uses if they feel they are unjustified.

To ensure the rule of law also online, it is not sufficient to rely only on the European Convention on Human Rights. It is crucial to also consider all the other conventions of the Council of Europe that set regulatory standards concerning freedom of expression, access to information, freedom of assembly, protection against cybercrime, and the right to privacy and personal data protection (Perri, p. 45). These conventions work together to create a legal framework that can address the challenges posed by rapid technological change, ensuring that fundamental rights are also protected in the digital context.

A recent update is the Council of Europe's Framework Convention on Artificial Intelligence (CETS 225), signed in September 2024, which establish a legal framework to ensure that the development and use of AI systems respect human rights, democracy, and the rule of law. It addresses potential risks posed by AI, including discrimination, privacy violations, and threats to democratic processes, while also promoting transparency, accountability, and fairness:

1. Protection of Human Rights: AI systems must comply with international human rights standards.
    - Article 4 of the convention explicitly requires that AI activities respect and protect human rights, consistent with international and domestic laws[323].

[322]see P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica.* Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020.
[323]see Council of Europe's Framework Convention on Artificial Intelligence (CETS 225), signed in September 2024.

2. Democratic Integrity: AI should not undermine democratic institutions or processes.
    - Article 5 addresses the risks AI poses to democratic processes, including threats to democratic institutions, separation of powers, and public trust[324].
3. Transparency and Accountability: Clear, understandable governance of AI systems is required, including mechanisms for oversight.
    - Article 8 covers transparency and oversight, requiring openness in AI decision-making processes, and Article 9 emphasizes accountability for adverse impacts on human rights and democracy[325].
4. Equality and Non-Discrimination: AI systems must be designed to avoid discrimination and promote fairness.
    - Article 10 ensures that AI systems respect equality, including gender equality, and prohibits discrimination based on applicable legal frameworks[326].
5. Privacy and Data Protection: Individuals' privacy rights and personal data must be safeguarded.
    - Article 11 mandates that AI systems protect privacy and personal data, following international and domestic privacy laws and standards[327].

The Convention covers the entire lifecycle of AI systems —from design to decommissioning— and mandates regular risk assessments (see Chapter V – Assessment and mitigation of risks and adverse impacts) to mitigate adverse impacts. They include (Article 16):

2. Such measures shall be graduated and differentiated, as appropriate, and: a. take due account of the context and intended use of artificial intelligence systems, in particular as concerns risks to human rights, democracy, and the rule of law; b. take due account of the severity and probability of potential impacts; c. consider, where appropriate, the perspectives of relevant stakeholders, in particular persons whose rights may be impacted; d. apply iteratively throughout the activities within the lifecycle of the artificial intelligence system; e. include monitoring for risks and adverse impacts to human rights, democracy, and the rule of law; f. include documentation of risks, actual and potential impacts, and the risk management approach; g. require, where appropriate, testing of artificial intelligence systems before

[324]see Council of Europe's Framework Convention on Artificial Intelligence (CETS 225), signed in September 2024.

[325]see Council of Europe's Framework Convention on Artificial Intelligence (CETS 225), signed in September 2024.

[326]see Council of Europe's Framework Convention on Artificial Intelligence (CETS 225), signed in September 2024.

[327]see Council of Europe's Framework Convention on Artificial Intelligence (CETS 225), signed in September 2024.

making them available for first use and when they are significantly modified.

The Convention does not deviate from the ECHR, but clarifies its approach in relation to IA. It is worth mentioning the explicit mention of inequalities, motif of concern:

Concerned about the risks of discrimination in digital contexts, particularly those involving artificial intelligence systems, and their potential effect of creating or aggravating inequalities, including those experienced by women and individuals in vulnerable situations, regarding the enjoyment of their human rights and their full, equal and effective participation in economic, social, cultural and political affairs.

And later in Article 10, "Equality and non-discrimination":

1. *Each Party shall adopt or maintain measures with a view to ensuring that activities within the lifecycle of artificial intelligence systems respect equality, including gender equality, and the prohibition of discrimination, as provided under applicable international and domestic law.*

2. *Each Party undertakes to adopt or maintain measures aimed at overcoming inequalities to achieve fair, just and equitable outcomes, in line with its applicable domestic and international human rights obligations, in relation to activities within the lifecycle of artificial intelligence systems.*

In ECtHR judgements, can be highlighted some cases with the potential to be relevant for groups of individuals, as the nature of UDTs and the primary focus of the present work:

- Liberty and Others v. the United Kingdom (2008)[328]: This case dealt with the interception of communications by the UK Ministry of Defence. The ECHR found a violation of Article 8, noting the lack of clarity in the law regarding how intercepted data could be used. The ruling is relevant to concerns about how data collected in UDTs may be used and the need for transparent legal frameworks.

- Shimovolos v. Russia (2011)[329]: This case concerned the use of a "surveillance database" to track an activist's movements across Russia by train and plane. The ECHR ruled that such databases, which collect information about individuals" movements without clear legal safeguards, violated the right to respect for private life under Article

[328]see "Mass surveillance factsheet" by European Court of Human Rights, available at https://www.echr.coe.int/factsheets (link consulted on 05.02.2025).

[329]see "New Tech factsheet" by European Court of Human Rights, available at https://www.echr.coe.int/factsheets (link consulted on 05.02.2025).

8 of the Convention. The connection to inequalities lies in how individuals, especially those engaging in activism or challenging authority, may face disproportionate surveillance, an issue compounded in smart cities with extensive data-tracking infrastructure. Such surveillance may disproportionately affect certain demographics, including political dissidents and marginalized groups.

Other cases involved the use of digital technologies for policing, criminal investigations and public safety, partially acquitted because of sufficient safeguards[330]. Due to the specific nature of these claims (related to criminal cases and not involving Big Data), they are not presented in detail in the present work.

Could be noted, however, that despite the UDTs are proven to be used for safety reasons, they might not have a sufficient legal basis to operate invasive data collection of personal data.

For the present analysis, it is relevant an analysis of the Article 14, "Prohibition of discrimination", of the ECHR.

The enjoyment of the rights and freedoms set forth in this Convention shall be secured without discrimination on any ground such as sex, race, colour, language, religion, political or other opinion, national or social origin, association with a national minority, property, birth or other status.

The principle expressed aligns with the idea of formal equality, with the ECHR opening to more positive obligations on the state in cases involving vulnerable groups. The article doesn"t allow the ECHR to be invoked for a general non-discrimination right, as stated in a 1968 case (Case "relating to certain aspects of the laws on the use of languages in education in Belgium" - ECH-1968-S-003 23.07.1968):

The Convention does not provide for a general non-discrimination right. Equality of treatment is violated only when the distinction has no objective and reasonable justification, the existence of which is to be assessed in relation to the aim and effects of the measure under consideration, having regard to the principles normally prevailing in a democratic society. A treatment is also discriminatory whenever it is clearly established that there is no reasonable relationship of proportionality between the means employed and the legitimate aim sought to be realised.

Other cases, like Arnar Helgi Lárusson v. Iceland (ECH-2022-2-007 31.05.2022), gave the ECtHR the possibility to rule in favour of *"reasonable accommodation" – understood as "necessary and appropriate modification*

[330]see for example Uzun v. Germany (2010), Weber and Saravia v. Germany (2006) and other from the "New Technologies factsheet" by European Court of Human Rights, available at https://www.echr.coe.int/factsheets (link consulted on 05.02.2025).

and adjustments not imposing a disproportionate or undue burden, where needed in a particular case", and that *Such reasonable accommodation helps to correct factual inequalities which are unjustified and which therefore amount to discrimination.*

Also Article 2, "Right to life", ECHR can be relevant for the present analysis, since the relevance it acquired in relation with a "safe environment":

1. *Everyone's right to life shall be protected by law. No one shall be deprived of his life intentionally save in the execution of a sentence of a court following his conviction of a crime for which this penalty is provided by law.*

2. *Deprivation of life shall not be regarded as inflicted in contravention of this article when it results from the use of force which is no more than absolutely necessary: a) in defence of any person from unlawful violence; b) in order to effect a lawful arrest or to prevent the escape of a person lawfully detained; c) in action lawfully taken for the purpose of quelling a riot or insurrection.*

In the ECtHR ruling, can be highlighted these cases:

- Öneryıldız v. Turkey (2004): This case concerned the death of several individuals in an explosion at a waste tip in Istanbul, illustrating how poor urban planning and management of risks in urban areas can lead to tragedies that disproportionately affect the poor. The Court found violations of Article 2 (right to life) and Article 1 of Protocol No. 1 (protection of property). This is relevant for discussions of how smart cities can use AI to prevent such incidents and address urban inequalities. (source: "Environment factsheet")

- Budayeva and Others v. Russia (2008): This case involved a mudslide that devastated the town of Tyrnauz, with the ECHR finding Russia in violation of Article 2 for failing to implement safety measures. The case highlights how urban planning failures and environmental hazards can disproportionately impact vulnerable communities, creating a social inequality issue that could intersect with the implementation of smart city technologies designed to mitigate such risks. (source: "Environment factsheet")

c. In EU (AI/Big Data, Cities, Inequalities) The EU's commitment to human rights is also reflected in its internal legal order and the EU Char-

ter of Fundamental Rights, which is legally binding[331][332].
The European Court of Justice (ECJ) considers the ECHR as a guiding principle in its case law, ensuring that EU institutions and member states respect fundamental rights as defined by the ECHR[333]. However, the EU Charter of Fundamental Rights, despite the similarities, is a different document and requires a specific analysis.

The EU Charter of Fundamental Rights is a pivotal document within the European Union's legal architecture, enshrining a comprehensive array of fundamental rights and freedoms that are crucial for interpreting legislation in the face of new and emerging challenges. Signed as soft law in 2000 and becoming legally binding with the Treaty of Lisbon in 2009, the Charter consolidates and reaffirms rights derived from the European Convention on Human Rights, European constitutional traditions, and various EU treaties and international agreements. Its significance lies not only in the breadth of rights it encompasses but also in its role as a guiding framework for EU institutions and Member States.

After a Preamble which sets the vision for a united Europe committed to human dignity, freedom, democracy, equality, the rule of law, and human rights, the Charter is structured into 54 articles divided across seven main chapters, each addressing distinct categories of rights.

- Title I: Dignity: Protects rights such as human dignity, the right to life, and the prohibition of torture and inhuman or degrading treatment.
- Title II: Freedoms: Covers various freedoms including respect for private and family life, freedom of thought, conscience, and religion, and the right to education.
- Title III: Equality: Includes rights related to equality, such as non-discrimination, gender equality, and the rights of children and the elderly.
- Title IV: Solidarity: Focuses on social and workers' rights, including the right to fair working conditions and social security.
- Title V: Citizens' Rights: Establishes rights related to EU citizenship, such as the right to vote in EU elections and the right to good administration.
- Title VI: Justice: Provides for rights related to access to justice, including the right to a fair trial and the presumption of innocence.
- Title VII: General Provisions: Governs the interpretation and appli-

[331]see T. Ahmed, I. De Jesus Butler. "The European Union and Human Rights: An International Law Perspective". European Journal of International Law 17, no. 4 (1 September 2006): 771–801. https://doi.org/10.1093/ejil/chl029.

[332]see at link: https://www.bmeia.gv.at/en/human-rights-and-the-eu (link consulted on 02.02.2025).

[333]see at link: https://www.bmeia.gv.at/en/human-rights-and-the-eu (link consulted on 02.02.2025).

cation of the Charter, ensuring its coherence with other EU and international laws.

The Charter serves as a benchmark for assessing the compatibility of national laws with EU values. By applying primarily to EU institutions and Member States when implementing EU law, as it is explicitly evoked in primary EU legislation like the AI Act[334] (see later Par. 4.3). It plays a crucial role in ensuring that human rights principles are embedded within EU policies across various domains.

For the present analysis, two aspects worth highlighting (before spending more words on the so-called FRIA - Fundamental Rights Impact Assessment, see Par. 4.3): - the difference between Article 8 ECHR and Article 7 CFR - the role of Equality and Solidarity

As Prof. Perri notes (p. 47), Article 8 of the Convention differs significantly from Article 7 of the Nice Charter.

The latter Article 7, "Respect for private and family life", CFR states:

Everyone has the right to respect for his or her private and family life, home and communications.

It seems offering a more absolute vision of the right to privacy. However, this vision is tempered by Article 52 of the Charter, which provides that certain limitations are only possible if they are necessary and aimed at protecting general interests recognised by the Union or the rights and freedoms of others[335].

About Equality and Solidarity (Title III and Title IV), the Charter enshrines the principle of equality before the law (Art. 20) and explicitly prohibits all forms of discrimination (Art. 21), including those based on gender, race, ethnicity, religion, disability, age, or sexual orientation. It also highlights specific protections for vulnerable groups, such as the rights of children (Art. 24) and older persons (Art. 25). Title III further emphasizes gender equality (Art. 23), ensuring that men and women are treated equally across all social and economic domains. The section reflects the EU's commitment to fostering an inclusive society where everyone enjoys equal rights, protection, and opportunities, regardless of their personal characteristics.

Despite not explicitly mentioning inequalities, the Charter adopt the perspective of Solidarity (Articles 27-38) to point out social and economic rights, highlighting the principle of solidarity between workers, employers, and the broader society. It guarantees key rights related to employment, such as

[334]see EU's AI Act - Regulation (EU) 2024/1689.

[335]See P. Perri. *Sorveglianza elettronica, diritti fondamentali ed evoluzione tecnologica.* Informatica giuridica 10. Milano: Giuffrè Francis Lefebvre, 2020.

the right to fair and just working conditions (Art. 31), collective bargaining and action (Art. 28), and protection against unjustified dismissal (Art. 30). Title IV also extends to broader social welfare, including the right to social security and assistance (Art. 34), healthcare (Art. 35), and environmental protections (Art. 37). This title reinforces the EU's commitment to ensuring that economic progress goes hand in hand with social justice, providing safeguards for workers and promoting the welfare of all citizens.

The role of solidarity on Urban Digital Twins was already noted in (Suffia, 2023)[336].

Moving to the direct legislation, the granularity of it suggests a thematic recognition divided in three main fields: AI and Big Data; Cities; and Inequalities.

i. AI and Big Data The European Union has been proactive in crafting a comprehensive legislative framework to govern the rapidly evolving fields of Artificial Intelligence (AI) and Big Data, reflecting its commitment to fostering innovation while safeguarding fundamental rights and ethical standards. At the heart of this regulatory landscape is the proposed Artificial Intelligence Act, introduced by the European Commission in April 2021. This landmark proposal seeks to establish a structured legal framework by categorising AI systems into four distinct risk levels: unacceptable, high, limited, and minimal. The aim is to ensure that AI technologies are not only safe but also aligned with European values, particularly in terms of respecting human rights and ensuring public trust in AI systems. This risk-based approach[337] underscores the EU's nuanced understanding of AI's potential benefits and challenges.

In parallel, the General Data Protection Regulation (GDPR) serves as a critical pillar in both AI and Big Data regulation. While its primary focus is on data privacy and protection, GDPR's implications for AI are profound, especially concerning automated decision-making and profiling. By setting stringent rules on data processing and individual consent, GDPR ensures that personal data is handled responsibly, thereby mitigating risks associated with AI applications that rely heavily on data analytics. Moreover, the Ethics Guidelines for Trustworthy AI, developed by the European Commission's High-Level Expert Group on AI, although not legally binding, provide essential ethical principles for AI development. These guidelines emphasize

[336]see G. Suffia, How to regulate a Digital Twin City? Insights from a Proactive Law approach: How "human in the loop" and "precautionary principles" can serve policymakers in their attempt to incorporate respect of rights and solidarity in the smart city, in DGO '23: *Proceedings of the 24th Annual International Conference on Digital Government Research*, pp 122–128, https://doi.org/ 10.1145/3598469.3598482 (open access)

[337]See Recital 26, EU's AI Act - Regulation (EU) 2024/1689..

human agency, fairness, transparency, accountability, and robustness, offering a moral compass for developers and policymakers alike.

In addressing liability issues arising from AI systems, the EU is updating the Product Liability Directive to ensure that existing legal frameworks adequately cover the complexities introduced by AI technologies. Additionally, the Digital Services Act (DSA) and Digital Markets Act (DMA) play pivotal roles in regulating the broader digital ecosystem in Europe. These acts address challenges posed by digital platforms, including those driven by AI, ensuring fair competition and protecting consumers within digital markets.

Turning to Big Data, GDPR remains central by establishing rigorous standards for personal data collection, processing, and storage. Its impact on Big Data analytics is significant as it mandates transparency and accountability in handling vast datasets. The Data Governance Act, adopted in 2022, complements GDPR by facilitating cross-sectoral data sharing across EU member states. This regulation aims to create a harmonized legal framework that encourages data access and reuse while ensuring data sovereignty and security.

Furthermore, the proposed Data Act seeks to regulate access to and use of data generated by Internet of Things (IoT) devices. It aims to ensure a fair allocation of data value among stakeholders, thus promoting innovation while safeguarding consumer rights. The ePrivacy Directive, often referred to as the "Cookie Law," directly impacts Big Data usage by regulating privacy in electronic communications. This directive ensures that individuals' online activities are protected from unwarranted surveillance or exploitation.

Lastly, the Open Data Directive encourages the availability of public sector information for reuse, promoting transparency and fostering innovation in Big Data applications. By making public sector data more accessible, this directive supports the development of new services and solutions that can drive economic growth and societal benefits.

Together, these legislative measures reflect the EU's holistic approach to regulating AI and Big Data. They demonstrate a commitment not only to technological advancement but also to upholding ethical standards and protecting individual rights in an increasingly digital world. This comprehensive framework positions the EU as a global leader in responsible technology governance.

The approach is complemented by policy programs and project, like the "European Local Digital Twin Toolbox Project", which supports the adoption

and implementation of digital twins across EU cities[338][339], or the European Commission Initiatives: "Digital Decade Policy Programme 2030", "European Green Deal", "Digital Europe Programme".

Further developments can come from the "Research and Innovation Data Space"[340]: in particular the European Open Science Cloud (EOSC) is identified as a pivotal data space for research and innovation.

ii. Cities The European Union's approach to urban development and the evolution of smart cities is characterized by a strategic blend of initiatives and directives aimed at fostering sustainable, efficient, and technologically advanced urban environments. Central to this framework is the Urban Agenda for the EU, which, although not legally binding, provides a comprehensive policy framework guiding urban development across member states. This agenda emphasizes the integration of smart city concepts, sustainable development practices, and digital transformation, reflecting the EU's commitment to creating resilient and livable urban spaces. It encourages collaboration among cities, member states, and EU institutions to address urban challenges through innovative solutions.

A key legislative component supporting these objectives is the Energy Performance of Buildings Directive (EPBD). This directive plays a crucial role in promoting energy efficiency within the built environment, a fundamental aspect of smart city initiatives. By setting standards for energy performance in buildings, the EPBD contributes to reducing carbon footprints and enhancing sustainability in urban areas. This aligns with broader EU goals for climate action and energy transition.

The Smart Cities and Communities European Innovation Partnership (EIP-SCC) further advances these efforts by fostering the deployment of smart city solutions across Europe. This initiative encourages the integration of cutting-edge technologies such as AI and Big Data into urban settings, facilitating improvements in areas like mobility, energy management, and public services. By promoting collaboration between public authorities, businesses, and citizens, the EIP-SCC aims to create more efficient, inclusive, and responsive urban environments.

In addition to these initiatives, several related regulations play supportive

[338]see "Digital Twins in Europe: Insights into the European Commission's report", 2024, at link: https://vc.systems/en/digitale-zwillinge-in-europa-einblicke-in-den-bericht-der-europaeischen-kommission/ (link consulted on 06.02.2025).

[339]see "European Local Digital Twin Toolbox project" at link: https://oascities.org/european-local-digital-twin-toolbox-project/ (link consulted on 06.02.2025).

[340]see "Common European Data Spaces" at the EU Commission website: https://digital-strategy.ec.europa.eu/en/policies/data-spaces (link consulted on 06.02.2025).

roles in shaping smart cities. The INSPIRE Directive establishes a spatial information infrastructure across Europe that is essential for effective urban planning and development. By standardising geospatial data access and interoperability, this directive supports informed decision-making processes crucial for smart city projects.

The Trans-European Transport Network (TEN-T) regulation is another vital component in this legislative landscape. It focuses on developing comprehensive transport infrastructures that are integral to smart city functionality. By enhancing connectivity and mobility within urban areas, TEN-T supports economic growth and improves quality of life for residents.

Together, these legislative measures underscore the EU's holistic approach to urban development. They reflect a commitment to leveraging technology and innovation to address contemporary urban challenges while promoting sustainability and inclusivity. Through these efforts, the EU aims to position its cities at the forefront of global urban innovation, setting benchmarks for smart city development worldwide.

Another data space, the "Public Administration Data Space", highlights the European Commission's commitment to establishing common European data spaces for public administration. These spaces aim to enable "gov tech," "reg tech," and "legal tech" applications. The goal is to support public services and practitioners by facilitating secure data sharing. These data spaces are distinctive as they often originate from public policies or EU legislation with the objective of creating public value. The interoperability-by-design approach ensures that these spaces will be interconnected, enabling cross-domain applications by reusing data across various domains[341].

Here are the relevant parts concerning smart cities, particularly focusing on public administration and the research and innovation data space, extracted from the document:

iii. Inequalities The European Union (EU) has developed a multifaceted approach to addressing urban inequalities, which intersect with social, economic, and environmental dimensions[342]. This approach is reflected in a variety of legislative measures and strategic initiatives designed to promote inclusive growth and reduce disparities across urban areas. A cornerstone of this effort is the EU Cohesion Policy, which serves as a primary tool for mitigating regional and urban inequalities. By channeling substantial funding into less developed regions, the policy aims to enhance infrastructure,

[341] see "Common European Data Spaces" at the EU Commission website: https://digital-strategy.ec.europa.eu/en/policies/data-spaces (link consulted on 06.02.2025).

[342] see M. Fermeglia, K. Pedrosa. "Planning for Citizens' Health: Towards an Integrated Approach to Air and Noise Pollution in the EU". *Journal for European Environmental & Planning Law* 19, no. 1–2, 2022: 9–30. https://doi.org/10.1163/18760104-19010003.

stimulate economic growth, and foster competitiveness, thereby addressing the root causes of socio-economic disparities.

Housing inequalities represent a significant challenge within European cities, often exacerbated by the economic potential of these urban areas. This issue particularly affects young people and is influenced by local and national housing policies that impact affordability and spatial segregation[343]. The EU supports research initiatives like the Horizon 2020 UPLIFT project to explore these dynamics and propose effective solutions. Additionally, gender equality in labor markets is a critical focus area for the EU. Through various directives aimed at ensuring equal opportunities and pay for men and women, the EU seeks to reduce social inequalities that manifest in urban settings.

Environmental inequalities also play a crucial role in shaping urban disparities. The EU has implemented directives such as Directive 2008/50/EC on ambient air quality and Directive 2002/49/EC on environmental noise to address these issues. These directives aim to mitigate air and noise pollution, which disproportionately affect densely populated urban regions and contribute to health inequalities. Furthermore, circular economy initiatives, while primarily targeting environmental sustainability, have implications for urban inequalities by promoting resource efficiency and reducing waste, thus supporting sustainable urban development[344].

Digital inequalities remain a significant barrier to achieving equality within the EU, particularly in education through e-learning platforms. The digital divide between more developed EU countries (EU-15) and others highlights disparities in technological access and usage. Addressing these digital inequalities is essential for ensuring equitable access to education and opportunities across urban areas[345].

The European Union's Cohesion Policy[346] is a pivotal instrument in its strategy to address regional and urban inequalities, reflecting a commitment to fostering balanced development across the continent. This policy aims to mitigate disparities between regions by promoting economic growth, job creation, and competitiveness, particularly in less developed areas. It involves substantial funding allocations designed to enhance infrastructure, stimulate innovation, and support sustainable practices. Through its various funds,

[343]see É. Gerőházi, N. Katona, and S. György Kollár. "Mechanisms Linking Economic Potential of European Cities to Housing Inequalities of Young People". *Frontiers in Sustainable Cities* 5, 2023: 1163984. https://doi.org/10.3389/frsc.2023.1163984.

[344]see EU's Directive 2008/50/EC on ambient air quality and Directive 2002/49/EC; EU's COM/2020/98 final on Circular Economy Action Plan.

[345]see B. Žmuk, F. Qureshi, and S. Khawaja. "Inequality in E-Learning in European Union Countries: Role of Gender Education and Urban Development", 2023.

[346]see M. Fermeglia, K. Pedrosa. "Planning for Citizens' Health: Towards an Integrated Approach to Air and Noise Pollution in the EU". *Journal for European Environmental & Planning Law* 19, no. 1–2, 2022: 9–30. https://doi.org/10.1163/18760104-19010003.

such as the European Regional Development Fund (ERDF) and the Cohesion Fund, the policy targets investments that improve transport links, boost research and development capacities, and enhance environmental sustainability.

A significant aspect of the Cohesion Policy is its focus on smart specialisation strategies. These strategies encourage regions to identify and develop their unique strengths and competitive advantages, thereby fostering innovation-driven growth tailored to local contexts. By supporting projects that align with these strategies, the EU aims to create more resilient economies capable of adapting to global challenges.

Moreover, the policy emphasizes social inclusion by funding initiatives that enhance access to education, healthcare, and social services. This approach not only addresses economic disparities but also tackles social inequalities that can exacerbate urban challenges. By improving living conditions and opportunities for disadvantaged groups, the Cohesion Policy contributes to more equitable urban environments.

However, implementing the Cohesion Policy across diverse member states presents challenges. Variations in administrative capacity, governance structures, and local priorities can affect the effectiveness of policy measures. To address these issues, the EU encourages capacity-building initiatives and fosters cooperation between regions through programs like INTERREG. These efforts aim to enhance regional capabilities in managing EU funds effectively and implementing integrated development strategies.

Overall, the EU's Cohesion Policy exemplifies a comprehensive approach to reducing urban inequalities by addressing economic, social, and environmental factors. It underscores the importance of tailored regional strategies and collaborative efforts in achieving inclusive growth across Europe. Despite challenges in implementation, the policy remains a cornerstone of EU efforts to promote cohesion and reduce disparities within its member states.

4.1.4. National and Local Level

a. States Each EU member state has strategies aligning with EU policies to support digital transformation. The national level is where "sovereignty" resides, and plays a crucial role in bridging the supranational and local dimensions. It holds the capacity to exert substantial control over both these levels and is responsible for resource allocation. This dual capability allows national legislation to act as a mediator and facilitator, ensuring coherence and integration across different governance layers. In the European context, the number of national legislations encompasses more than 30 countries, reflecting the complexity and diversity of the Continent. For the purpose of this analysis, only a few significant legislative initiatives, intersecting the

core themes of this study, will be cited. The aim is to highlight existing policies and legislation, other than the supranational ones, to provide more practical and useful tools for the forthcoming discussions.

The analysis will primarily consider countries that have been previously noted for their significant experiences with smart cities or Urban Digital Twins (UDTs). Additionally, countries will be considered by population and for having proposed innovative solutions for managing urban agglomerations through digital tools. This selection is based on the premise that these nations offer valuable case studies in leveraging technology for urban governance, providing lessons that can be applied more broadly.

At the national level, many European countries seem to have a more proactive approach to inequalities, sharing a common sensibility that see them actively recognise the duty to "remove obstacles" in achieving it.

Limiting the analysis to the most populated European countries, a leading position is for the Article 3 of the Italian Constitution, that clearly establish the principle of equality among citizens composed of two main parts:

3. Formal Equality: The first paragraph states that all citizens have equal social dignity and are equal before the law, without distinction of sex, race, language, religion, political opinions, personal and social conditions. This reflects the commitment to ensuring that no individual is discriminated against based on these characteristics.

4. Substantive Equality: The second paragraph emphasizes the role of the Republic in removing economic and social obstacles that limit the freedom and equality of citizens, thereby impeding their full development and effective participation in political, economic, and social life. This part underscores the proactive duty of the state to create conditions that allow for genuine equality among its citizens.

Despite being interpreted as a "programmatic provision", Article 3 not only enshrines formal equality but also mandates the state to actively work towards achieving substantive equality by addressing barriers that hinder individuals' full participation in society[347].

The Italian provision is similar in Spain. Article 9.2 of the Spanish Constitution obliges public authorities to promote conditions for real and effective freedom and equality and remove obstacles preventing its full realisation, both directed to individuals and groups. As in the Italian text, it describes the political, economic, cultural and social participation in public life as a way to "substantially" obtain the full realisation of the right. Article 14 guarantees the "formal equality", the equality before the law without

[347] see Italian Constitution.

discrimination based on birth, race, sex, religion, opinion, or any other personal or social condition. The same approach[348] of Italy and Spain is shared by Portugal (interestingly, Article 9 and Article 73 contain extensive provisions on fighting inequalities. Article 9 promotes the people's well-being and quality of life and real equality between the Portuguese, as well as the effective implementation of economic, social, cultural and environmental rights by means of the transformation and modernisation of economic and social structures; Article 73 promotes education, culture and science, stating a "the right to education and culture" and promoting the democratisation of education and the other conditions needed for an education conducted at school and via other means of training to contribute to equal opportunities, the overcoming of economic, social and cultural inequalities, the development of the personality and the spirit of tolerance, mutual understanding, solidarity and responsibility, to social progress and to democratic participation in collective life).

A similar approach is shared by the UK. Despite being a country of Common Law, the Equality Act 2010 ensures formal equality also supports substantive equality by allowing positive action to overcome disadvantages experienced by people with protected characteristics[349].

It is peculiar the case of France, where the Constitution asserts does "formal equality", but not explicitly mention substantive equality, despite France having a strong tradition of implementing policies to reduce social inequalities through various legislative measures. The same approach is shared by the Dutch Constitution.

Other countries seem to share a slightly different sensibility, more aligned oriented with the "formal equality". It is the case of Germany[350], which has constitutional provisions against the common forms of discrimination (Article 3 of the Basic Law for the Federal Republic of Germany states that all persons are equal before the law, and explicitly prohibits discrimination based on sex, parentage, race, language, homeland and origin, faith, or religious or political opinions), requiring explicit active measures only to promote actual equality, and take steps to eliminate existing disadvantages, between men and women. Many other European Countries, like Poland, the Netherlands and the Scandinavian Countries share the same approach.

As early as 2000 there have been numerous acts aimed at sanctioning the

[348] traces of it can be found, outside Europe, in South Africa and India.

[349] see A. Blackham, "Employment Discrimination Law in the United Kingdom: Achieving Substantive Equality at Work?", 2017.

[350] see C. D. Totten, "Constitutional Precommitments to Gender Affirmative Action in the European Union, Germany, Canada and the United States: A Comparative Approach", 2003. https://doi.org/10.15779/Z38JM1S.

transition to a digital economy[351], up to the Europe 2020 Strategy[352] and the Digital Agenda for Europe[353]. A framework is thus outlined in which, downstream of the principles and regulations of the sector, it is left to the states to transpose the indications formulated at supranational level, through the adoption of specific national strategies[354]. As Previti[355] notes, the idea of stimulating and coordinating the digitisation process through the Digital Agendas mechanism is based on the conviction that digital technologies are an important tool to implement the principles of the single market. With the establishment of the Single Market, a legal space is structured in which not only the respect of the fundamental freedoms recognised by the Treaties" is guaranteed, but also the removal of obstacles to access and the exercise of online activities by businesses, as well as a high level of protection of consumer rights and personal data[356].

The missing passage jumps to the eye, when the protection of rights is not accompanied by a similar provision in favour of the substantial removal of socio-economic conditions that hinder the full realisation of these rights, as instead evidenced by international legislations that express themselves in favour of greater substantive equality, and highlighted by several national Constitutions. This, however, does not prevent the administration and the digital world from finding innovative ways to work in this direction as well. This is the case of the so-called "proactive services"[357]. They refer to a shift in how public authorities interact with citizens, moving from reactive to anticipatory engagement. This concept is rooted in the idea that digital technologies can enable governments to anticipate citizen needs and deliver services before they are explicitly requested.

The confrontation with the administration has raised the issue of the framing of software within administrative procedures. AI and Big Data, an

[351]see European Council, 23-24 March 2000 (Lisbon, Portugal) as cited in L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022. pag 72 ff.

[352]see EU's COM(2010)2020 - in L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022 pag 72 and ff.

[353]see EU's COM(2010)245 - in L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022 pag 72 and ff.

[354]see L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022 pag 75-76.

[355]see COM(2015)192, as mentioned by L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022.

[356]see L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022

[357]see "Proactive Services" in H. Scholta, I. Lindgren. "Proactivity in Digital Public Services: A Conceptual Analysis", *Government Information Quarterly* 40, no. 3 (June 2023): 101832. https://doi.org/10.1016/j.giq.2023.101832.

innovative source of knowledge for the activity of public authorities[358] must, consequently, be qualified as: - a useful cognitive support to the further choices pertaining to the competent administrative authorities ("inquiry" function) - an instrument capable of elaborating the very content of the final determination of the procedural process ("decisional" function)[359].

It is not the task of this work to investigate the complex relationship between software, let alone AI, and administrative law, except to point out some continental orientations that are likely to direct the development of the theme in Europe for the coming years.

From a French matrix[360] there is emerging a principle of transparency of administrative action that in many respects turns out to be broader than the right of access hitherto known from continental practices. This right comes up against the problem of the explicability of the software and the measures that its deployer is called upon to put in place (in this case the public administration managing UDTs).

On the other hand, from a German matrix[361], AI systems have encountered the limitation of not being fully authorised (as a fully automated administrative act) for so-called "decisional" purposes, where the discretion of the administration is involved.

The theme of administrative discretion intersects several times with the development of digital at the service of the community, with certain principles that seem to be consolidated in the continental sphere, such as the adoption of a "digital first" for the administrative act, which must therefore be natively oriented towards its digital use.

It is interesting to note how there is, in European legal systems, a substantial demand for the administration to make an assessment of the software to be used, with a "preference" sometimes expressed for open source systems - this provision has recently been converted into a real legal obligation in Switzerland[362], where the new "Federal Law on the Use of Electronic Means for the Fulfillment of Government Tasks" (EMBAG) requires to the administration which has actively participated in the development of the software

[358] see L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022 pag 33.

[359] see L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022

[360] see L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022. See also the French law "LOI n° 2016-1321 du 7 octobre 2016 pour une République numérique", later updated in 2024.

[361] see L. Previti, *La decisione amministrativa robotica*. Percorsi di diritto amministrativo Monografie 67. Napoli: Editoriale scientifica, 2022 pag 125.

[362] see the Swiss law "Federal Law on the Use of Electronic Means for the Fulfillment of Government Tasks" (EMBAG - Bundesgesetz über den Einsatz elektronischer Mittel zur Erfüllung von Behördenaufgaben, vom 17. März 2023 (Stand am 1. Januar 2024).

to license it as open-source (the aim is to avoid public know-how being privatised behind a proprietary licence). This is a consistent application of the principle of "radical transparency" whose application is not yet debated in the EU, but which raises interesting questions about the development of increasingly powerful and potentially invasive digital tools in people's lives.

In any case, the administration in Europe must, even when using digital tools, ensure that the use is dictated by a "relevant public interest", and that a "satisfactory balance is struck between all the interests involved".

In many legal systems (and especially from Anglo-Saxon experiences) there is a call for the correct identification of data and parameters relevant to the specific purpose, without using proxies that take into consideration elements distant from the specific problem that the administration is called upon to solve, causing a distancing from the real and specific situation, with the risk of bias and inaccuracies.

These considerations apply directly to an urban digital twin that, as such, becomes an instrument of administrative decision-making and can have a great impact -for example, with the most advanced maturity levels- on the life of the city and its citizens.

In the realm of urban governance across Europe, cities find themselves navigating a multifaceted and intricate legislative environment. This landscape is characterized by its multi-layered nature, encompassing international, national, and local legal frameworks. European Union directives often set the stage with broad guidelines aimed at harmonising efforts across member states. However, these overarching strategies must be carefully adapted by individual cities to fit their specific circumstances and needs. This process of adaptation is not straightforward; it involves a delicate balancing act between maintaining local autonomy and ensuring compliance with higher-level mandates. The challenges associated with this adaptation are manifold. On one hand, there are technical difficulties in aligning diverse legislative requirements with existing urban infrastructures and capacities. On the other hand, these challenges are compounded by political and administrative considerations that can influence or even hinder the implementation process. Political agendas, resource allocation, and administrative inertia can all play roles in complicating or delaying effective policy execution, making the task of urban governance both demanding and complex.

The choices that local governments make in prioritizing certain rights to engage with and how, in turn, creates a growing body of different practices and interpretations concerning the realization of these rights, which pluralize the existing understandings of rights realization stemming from the practices of states or other traditional actors.[363]

[363]see B. Oomen, E. Durmus. "Cities and Plural Understandings of Human Rights:

Within this intricate legislative framework, one significant initiative is the promotion of Smart Cities procurement. This concept is integrated into public procurement processes and represents a strategic approach to modernising urban environments. The aim is to encourage cities to participate in national public tenders, allowing them to procure not only tangible products but also vital competencies and innovative methodologies from the market. This approach seeks to equip cities with the necessary tools and expertise to address contemporary urban challenges effectively. However, this strategy also brings to light a critical issue: while there is an abundance of advanced technologies available, they often lack direct applicability to existing urban problems, or they are not specifically tailored to the cities" needs. Conversely, many pressing urban issues do not yet have viable technological solutions. This disconnect necessitates a proactive stance from cities, which are increasingly driven to experiment autonomously. Such experimentation is often fueled by citizen expectations for improved quality of life and supported by legal mandates that encourage innovation[364]. Nevertheless, this drive towards experimentation underscores the need for cities to develop strategic procurement practices that go beyond mere acquisition of products, focusing instead on fostering holistic solutions that integrate technology with local needs. For example, popular solution seem to be:

- Smart Communities Network: Facilitates digital strategies and con-

Agents, Actors, Arenas". *The Journal of Legal Pluralism and Unofficial Law* 51, no. 2, 2019: 141–50. https://doi.org/10.1080/07329113.2019.1596731., pag. 145.

[364]The case of Barcelona con can interesting, as an example among many: Barcelona City Council is developing a strategy to promote ethical and responsible use of artificial intelligence (AI) in municipal management and public services. The goal is to align AI applications with human rights, transparency, and democratic values. This includes establishing governance structures, implementing pilot projects, creating an AI algorithm registry, reviewing regulatory frameworks, defining work methodologies, and promoting public awareness and engagement. The strategy emphasizes the importance of data privacy, algorithmic transparency, and accountability in AI development and deployment. The legal basis of the Barcelona's Digital Twin City are as follows: a) The Rules of Local Government, which establish that Barcelona City Council can promote every class of activities and provide all the public services that help to meet the needs of citizens which are not expressly attributed to other public authorities; b) The special system for the Barcelona Municipality (Act 1/2006, of 13 March), which establishes that Barcelona City Council can carry out complementary activities and services to those carried out by State and Regional authorities; c) The Government measure for open digitisation (2017), which aims for an improvement in the use of free software, open standards, data sovereignty, privacy and security by design; d) The Government measure for ethical and responsible data management (2018); e) The Institutional Declaration for technological humanism and trustworthy and ethical technologies in Barcelona City Council approved at the Full Municipal Council Meeting of June 2020. - All the information are available from: Barcelona City Council, "Govern measure for a municipal algorithms and data strategy for an ethical promotion of artificial intelligence", Deputy Mayor's Office for 2030 Agenda, Digital Transition, Sports and Territorial and Metropolitan Coordination, April 2021, availabe at www.barcelona.cat.

nectivity improvements at the regional level[365].

- Public-Private Partnerships: Collaboration between public entities and private companies to address data sharing and stakeholder interests[366][367].

The idea of "experimentation" is now a key focus in modern urban research, indicating a move towards more flexible and responsive strategies for managing cities. Cities are more commonly viewed as dynamic environments for testing new ideas and technologies in practical situations. Nevertheless, this experimental method does come with its own set of difficulties. One major challenge is the absence of a well-defined legal structure that actively promotes these efforts. Cities may face risk of innovative projects not following regulations without clear legal provisions for experimentation[368]. This uncertainty in the law can suppress innovation and discourage local governments from implementing innovative ideas that could greatly improve city living. In order to tackle these challenges successfully, there is a pressing necessity for stronger and more adaptable legal frameworks that offer precise instructions while still permitting creativity. Cities should be enabled by these frameworks to responsibly discover new solutions, making sure that any experimentation takes place safely and within the bounds of the law. By creating a legal environment that promotes innovation, cities can enhance their ability to address their individual challenges with creativity and foresight, ultimately resulting in urban environments that are more sustainable and enjoyable to live in.

4.1.5. Conclusions

The analysis presented in this chapter underscores the imperative of developing an integrated legal framework for Digital Twin Cities (DTCs) that is capable of addressing the multifaceted legal, social, and ethical challenges emerging at the intersection of technology and urban life. This framework cannot be overly localized; it must consider the international dimension, including the broader international legal framework, as the analysis has tried to show. Only by encompassing multiple levels of governance—international, supranational, national, and local—can we effectively regulate the interplay between digital technologies, urban development and addressing inequalities. Such an approach ensures that urban environments can evolve in a way that

[365] see "European Local Digital Twin Toolbox project" at link: https://oascities.org/european-local-digital-twin-toolbox-project/ (link consulted on 06.02.2025).

[366] see https://eurocities.eu/latest/local-digital-twins-empower-urban-planners-for-informed-decisions/ (link consulted on 02.02.2025).

[367] https://living-in.eu/taxonomy/term/284

[368] See Italian Data Protection Authority, "Provvedimento dell'11 gennaio 2024", n. 5, against the Municipality of Trento - more discussed in footnote 280.

supports both technological innovation and social equity, offering opportunities to bridge existing gaps in regulation and policy.
Building a DTC is a complex operation, which puts various levels of the legislation under stress.
A critical outcome of this analysis is the identification of significant gaps within current legal frameworks, particularly regarding the integration of AI and big data into urban spaces. One of the most notable gaps is the uncertain presence of a consistent idea of 'substantive equality', especially for groups, within the legislations of European countries. This inconsistency creates challenges in ensuring that technological advancements contribute to reducing effectively inequalities, rather than exacerbating them. Current legislation often fails to adequately address the risks of exacerbating social, economic, and cultural inequalities within cities, to the point that an "individual optimisation" of the legislative tools provided could come short in addressing the risks posed to groups by pervasive and digital tools. Therefore, there is an urgent need for laws that not only facilitate technological advancements for individuals alone, but also directly tackle collective issues of inequality. By emphasising legislative provisions that address underrepresented areas —such as social justice implications of technological deployment— this work will propose a more balanced and comprehensive legal framework for DTCs in Chapter 5.

4.2. Reflection on Social Scoring

Summary: 4.2.1. Extracting Data from the City - 4.2.2. Formalism vs Informality - 4.2.3. Legislation on Social Scoring - 4.2.4. Social Scoring, an Extended Analysis - 4.2.5. Conclusions on Social Scoring

4.2.1 Extracting Data from the City

The analysis conducted on the legislation showed a fundamental boundary in the setting of unacceptable risks in EU around AI systems. This provision is fundamentally relevant for the topic of UDTs, but to fully grasp its implications it seems necessary to spend some words on the idea of extracting data from the city, and why it is so popular in the core essence of smart cities projects.

As previously mentioned, understanding the city "as a computer" represented the label used to propose a real paradigm in urban management, shaping the government of the city on the extraction and analysis of data generated automatically by digital devices. When the urban management relies heavily on data generated by the digital interactions of its inhabitants, data is harvested almost passively through a wide array of digital devices, raising important questions about the ethics and implications of such pervasive extraction.

Despite this mechanism has proved effective for managing several layers of the city (from traffic management to energy consumption), the efficiency of managing more complex layers involving people is debatable.

In this framework, A well-known application of this model was contact tracing during the Covid-19 pandemic, which leveraged Bluetooth technology embedded in smartphones to monitor close interactions between individuals. While efficient for public health, this method exemplifies the ongoing tension between utility and privacy, as it highlights the extensive surveillance capabilities inherent in modern digital infrastructure. As Prof. Ferraris argues[369], the continuous recording of digital interactions is what constitutes the essence of digital communication, which has necessarily to be recorded before being sent (in that it is similar to writing but different from other forms of communication like speaking). In the analog world any behaviour has to be recorded to be analysed, but in the digital real every behaviour is recorded by default. It isn"t a surprise that many smart city projects aim to analyse this amount of (Big) data.

This "extraction" can be easy and cost effective. As said before, UDTs are emerging as one of the tools that public administrations can use to better

[369]see M. Ferraris. *Documanità: filosofia del mondo nuovo.* I Robinson. Bari: GLF editori Laterza, 2021; M. Ferraris, *Documentalità. Perché è necessario lasciar tracce.* Roma-Bari: Laterza, 2014.

understand urban dynamics. A city is a complex entity composed of several layers of data, and UDTs can help in being the collectors of both the static ("cold") data —such as statistical records and historical data— with dynamic ("hot") data, which reflects real-time, constantly changing information.
While cold data provides a foundation for long-term urban planning, hot data offers immediate insights into the city's day-to-day functioning. The challenge lies in integrating these data sources to form a comprehensive view of the urban landscape, acknowledging that cities are complex systems with human dimensions that defy purely quantitative analysis. Applying digital twins to cities requires the ability to integrate these different types of data to obtain a holistic and meaningful understanding of the urban environment.
The results can be partial and leave space for improvements, but a growing body of criticism targets the nature of such data extraction. This criticism is various and draws parallels to different cases and examples.
It refers to autocratic regime practices[370], or to illicit operations on social media platforms[371].

These concerns are correct, but they don"t underline an additional and more profound theme.
It is essential to recognise that while digital twins can offer powerful tools for urban management, they must be used in a way that respects and enhances the complexity and richness of the human experience.

The city, as a living organism, is characterised by a human dimension of "otherness" and "abundance", which cannot be fully captured through a purely quantitative approach. Indeed, the city is not simply a collection of sensors and data to be collected and analysed; it has a complexity that goes beyond what can be measured and quantified.
While the inner nature of data and big data can be described as "formality", this other area affers to what can be described as "informality".

4.2.2. Formalism vs Informality

The proliferation of sensors and digital devices in cities has transformed the urban environment into a "sensor society", as described by Professor Ziccardi. This phenomenon has led to an adaptation of cities and societies to make them comprehensible to machines. As Professor Floridi points out, the apparent intelligence of machines is largely due to the fact that we have

[370] see below the social scoring system experimented in China. For the social scoring as a prohibited practice under the EU's AI Act - Regulation (EU) 2024/1689, see Par. 4.2.3.

[371] see Cambridge Analytica scandal. For implications, may be allowed the reference to G. Suffia, G. Ziccardi, "Fake News, Guerra dell'informazione Ed Equilibri Democratici", *Federalismi.It* N. 11 - 24/04/2020, 2020. The situation is similar to that of social media, where users are referred to as "content creators", but in reality they continuously provide personal data to feed algorithms and maintain visibility.

adapted our behaviour and infrastructure to be recognised and interpreted by digital technologies. This adaptation raises ethical and social issues, as dependence on machines for understanding and controlling cities can lead to a loss of autonomy and increased surveillance.

The adaptation of cities to a machine-readable format, while offering numerous advantages in terms of efficiency and connectivity, is not without its limitations and challenges. As we dive deeper into this transformation, it becomes evident that there are theoretical and practical boundaries to how far this adaptation can go. One significant limitation arises when the adaptation process begins to encroach upon the intrinsic aspects of human nature. Humans are often described as "the animal who experiences the existence of more"[372], a phrase that encapsulates the complexity and depth of human experience, which cannot be fully captured or replicated by machines.

The essence of human experience includes emotions, creativity, spontaneity, and an awareness of existential dimensions that transcend mere data points. While machines excel at processing vast amounts of information and identifying patterns, they inherently lack the ability to understand or replicate the qualitative aspects of human life. For instance, the emotional resonance of a piece of art or the profound impact of a personal relationship cannot be reduced to algorithms or sensor data. Thus, when cities are overly optimized for machine readability, they risk becoming environments that prioritize efficiency over human richness and depth.This limitation becomes particularly apparent in areas such as art, culture, and personal interactions, where the inefficacy of a purely data-driven approach is most evident. In these domains, the reductionist nature of machine processing can strip away the layers of meaning that are essential to human experience. The challenge lies in finding a balance between leveraging technology for urban management and preserving the intangible qualities that make city life vibrant and meaningful.

Additionally, transforming cities to accommodate digital technologies may result in a substantial expense: the risk of losing what is fundamentally human and vibrant. As cities are more and more designed for machines, there is a risk of losing their natural characteristics that encourage community, creativity, and uniqueness. This change may result in cities that seem lifeless and lacking in personal connection, where interactions between people are through screens and algorithms instead of in-person meetings. The consequences go beyond just looks and social interactions; they also

[372]see S. Petrosino, M. Iofrida. *Contro il post-umano. Ripensare l'uomo, ripensare l'animale*. EDB, 2017. Partially discordant, according to the Author, is the position expressed by philosopher Luciano Floridi, who theorises that every problem can be treated as a computational problem (how many resources are needed to solve it), in L. Floridi, *Pensare l'infosfera*. Milano: Raffaello Cortina Editore, 2020.

raise important ethical issues. The push to make cities more easily understood by machines can result in more surveillance and data gathering, which brings up concerns about privacy and independence. As people increasingly depend on digital systems for everyday tasks, such as transportation and communication, their actions and whereabouts are continually monitored and evaluated. This monitoring could lead to a setting in which people feel under constant watch, possibly limiting their freedom and self-expression.

In order to tackle these obstacles, it is essential for urban planners, policymakers, and technologists to take on a comprehensive strategy that takes into account technological progress as well as human beliefs. This includes creating intelligent urban areas that improve efficiency while also supporting inclusivity, diversity, and well-being. One method to achieve equilibrium is by including participatory design methods that engage citizens in determining how technology is incorporated into their neighborhoods. By involving citizens in conversations about their needs and priorities, cities can make sure that technological solutions benefit people and not control them. Furthermore, creating areas in cities that prioritize the human touch over technology can also be beneficial. Parks, cultural hubs, and community centers can act as counterbalances to digital saturation, offering places where individuals can connect with nature and each other without technological mediation.

In the context of urban digitisation, Big Data can be seen as a form of "formality," representing structured, quantifiable, and predictable elements of city life. This formal approach is aligned with the notion of predictiveness, where data-driven models aim to anticipate and manage urban dynamics efficiently. However, this perspective often overlooks the "informality" inherent in cities—the living, dynamic, and inclusive aspects that define urban environments. Informality encompasses the spontaneous and organic interactions that occur within cities, which are not easily captured by data alone.

The speed at which digital technologies are evolving necessitates a flexible and critical approach that considers the social, ethical, and political implications of urban digitisation. A continuous dialogue between technology and society is essential to fully harness the potential of digital twins while respecting the values and dynamics that characterize our cities. This dialogue must bridge the gap between formality and informality, ensuring that technological advancements do not overshadow the human elements that make cities vibrant and diverse.

The knowledge pyramid, which distinguishes between data, information, knowledge, and wisdom, exemplifies a formal vision compatible with digital formalism. This structured approach aligns with the predictiveness associated with Big Data but often clashes with the informality inherent in societal and urban contexts. Cities are complex entities characterized by

social, cultural, and economic dynamics that cannot always be reduced to simple data points.

Digitisation, driven by major technology players, has promoted a vision of the city as a vast computer—a system that can be organised, understood, and controlled through digital means. Policy documents like those from Siemens in 2015 have theorised that cities can be managed as computer systems. However, this vision risks oversimplifying urban complexity by prioritising formality over informality. It is crucial to recognise that while formality offers predictiveness and control, informality fosters inclusivity and adaptability—qualities essential for thriving urban environments.

To truly benefit from digital advancements without compromising the essence of city life, it is vital to maintain a balance between these two dimensions. By embracing both formality and informality, cities can evolve into smart environments that enhance efficiency while preserving the richness of human experience.

Social scoring systems represent a problematic and potentially harmful attempt to extend formality into areas of city life and society that thrive on informality and inclusivity. These systems, often driven by the collection and analysis of vast amounts of personal data, aim to quantify and evaluate individual behaviours and social interactions through a formalized, algorithmic lens. By assigning scores to citizens based on their actions, social scoring seeks to predict and control behaviour, promoting conformity to predefined norms.

4.2.3. Legislation on Social Scoring

While the digitisation of cities offers significant opportunities to improve the management and understanding of urban dynamics, it is crucial to address the ethical and social issues associated with the extraction and use of data. Digital twins can become valuable tools for public administrations, but they must be integrated with an approach that recognises and respects the complexity of cities as living organisms. Only through a balance between technology and humanity will it be possible to exploit the full potential of digital twins while ensuring respect for the core values of our urban societies.

The use of digital tools to understand and manage cities has opened up new possibilities, going beyond the traditional management of technical flows such as energy, traffic and waste, typical of Smart Cities. Today, the focus is shifting towards the analysis of citizens' personal data to develop new forms of urban administration. This push towards a more sophisticated and personalised management of cities requires careful reflection by scholars, who have to deal with the ethical and legal implications of such practices. However, clear limits are emerging, particularly with regard to the extrapolation

and use of personal data.

Legislation, such as that of the European Union, places significant restrictions on the use of data and the regulation of artificial intelligence devices. The EU's Artificial Intelligence Regulation (AI Act), for instance, prohibits practices such as social scoring, despite without explicitly defining it, but with the intention of preventing abuses similar to those observed in other global contexts. Social scoring, which could theoretically improve urban management through in-depth knowledge of citizens, raises ethical concerns. In China, the social scoring system rewards or penalises citizens based on their behaviour, but this practice is controversial and difficult to implement fairly.

The Recital 31 says[373]:

AI systems providing social scoring of natural persons by public or private actors may lead to discriminatory outcomes and the exclusion of certain groups. They may violate the right to dignity and non-discrimination and the values of equality and justice. Such AI systems evaluate or classify natural persons or groups thereof on the basis of multiple data points related to their social behaviour in multiple contexts or known, inferred or predicted personal or personality characteristics over certain periods of time. The social score obtained from such AI systems may lead to the detrimental or unfavourable treatment of natural persons or whole groups thereof in social contexts, which are unrelated to the context in which the data was originally generated or collected or to a detrimental treatment that is disproportionate or unjustified to the gravity of their social behaviour. AI systems entailing such unacceptable scoring practices and leading to such detrimental or unfavourable outcomes should therefore be prohibited. That prohibition should not affect lawful evaluation practices of natural persons that are carried out for a specific purpose in accordance with Union and national law.

Then Article 5, "Prohibited AI practices", prescribes:

1. The following AI practices shall be prohibited:

(a) the placing on the market, the putting into service or the use of an AI system that deploys subliminal techniques beyond a person's consciousness or purposefully manipulative or deceptive techniques, with the objective, or the effect of materially distorting the behaviour of a person or a group of persons by appreciably impairing their ability to make an informed decision, thereby causing them to take a decision that they would not have otherwise taken in a manner that causes or is reasonably likely to cause that person, another person or group of persons significant harm;

[373]see Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 (AI Act - Regulation (EU) 2024/1689), Recital 31.

(b) the placing on the market, the putting into service or the use of an AI system that exploits any of the vulnerabilities of a natural person or a specific group of persons due to their age, disability or a specific social or economic situation, with the objective, or the effect, of materially distorting the behaviour of that person or a person belonging to that group in a manner that causes or is reasonably likely to cause that person or another person significant harm;

(c) the placing on the market, the putting into service or the use of AI systems for the evaluation or classification of natural persons or groups of persons over a certain period of time based on their social behaviour or known, inferred or predicted personal or personality characteristics, with the social score leading to either or both of the following:

(i) detrimental or unfavourable treatment of certain natural persons or groups of persons in social contexts that are unrelated to the contexts in which the data was originally generated or collected;

(ii) detrimental or unfavourable treatment of certain natural persons or groups of persons that is unjustified or disproportionate to their social behaviour or its gravity;

(d) the placing on the market, the putting into service for this specific purpose, or the use of an AI system for making risk assessments of natural persons in order to assess or predict the risk of a natural person committing a criminal offence, based solely on the profiling of a natural person or on assessing their personality traits and characteristics; this prohibition shall not apply to AI systems used to support the human assessment of the involvement of a person in a criminal activity, which is already based on objective and verifiable facts directly linked to a criminal activity;

(e) the placing on the market, the putting into service for this specific purpose, or the use of AI systems that create or expand facial recognition databases through the untargeted scraping of facial images from the internet or CCTV footage;

(f) the placing on the market, the putting into service for this specific purpose, or the use of AI systems to infer emotions of a natural person in the areas of workplace and education institutions, except where the use of the AI system is intended to be put in place or into the market for medical or safety reasons;

(g) the placing on the market, the putting into service for this specific purpose, or the use of biometric categorisation systems that categorise individually natural persons based on their biometric data to deduce or infer their race, political opinions, trade union membership, religious or philosophical beliefs, sex life or sexual orientation; this prohibition does not cover any labelling or filtering of lawfully acquired biometric datasets, such as images, based on

biometric data or categorizing of biometric data in the area of law enforcement;

(h) the use of "real-time" remote biometric identification systems in publicly accessible spaces for the purposes of law enforcement, unless and in so far as such use is strictly necessary for one of the following objectives:

(i) the targeted search for specific victims of abduction, trafficking in human beings or sexual exploitation of human beings, as well as the search for missing persons;

(ii) the prevention of a specific, substantial and imminent threat to the life or physical safety of natural persons or a genuine and present or genuine and foreseeable threat of a terrorist attack;

(iii) the localisation or identification of a person suspected of having committed a criminal offence, for the purpose of conducting a criminal investigation or prosecution or executing a criminal penalty for offences referred to in Annex II and punishable in the Member State concerned by a custodial sentence or a detention order for a maximum period of at least four years.

Point (h) of the first subparagraph is without prejudice to Article 9 of Regulation (EU) 2016/679 for the processing of biometric data for purposes other than law enforcement.

As seen, the AI Act does not provide an exhaustive definition of social scoring[374], but it explicitly targets systems that evaluate or score individuals based on their behaviour, personal characteristics, or socio-economic status to predict future behaviours. This includes state-sponsored social scoring systems (like the model sperimented in China[375]), where governments or entities assess individuals" trustworthiness based on behaviours such as debt repayment, compliance with laws, or even online activities. The AI Act prohibits such social scoring practices when they lead to:

[374]Traces on the concept of profiling, as a core element of social scoring, can be found in the recommendation CM/Re (2010)132, adopted by the Committee of Ministers of the Council of Europe, which can be considered a starting point also for the EU's legislation on the topic, as GDPR's Article 4. As in S. Abbady, *The EU Artificial Intelligence (AI) Act: A Commentary*. Edited by Ceyhun Necati Pehlivan, Nikolaus Forgó, and Peggy Valcke. Alphen aan den Rijn: Wolters Kluwer, 2025, p. 129.

[375]see K. Wong, L. Xan, and A. Shields Dobson. "We're Just Data: Exploring China's Social Credit System in Relation to Digital Platform Ratings Cultures in Westernised Democracies". *Global Media and China* 4, no. 2 (June 2019): 220–32. https://doi.org/10.1177/2059436419856090; D. Curran, A. Smart. "Data-Driven Governance, Smart Urbanism and Risk-Class Inequalities: Security and Social Credit in China". *Urban Studies* 58, no. 3 (February 2021): 487–506. https://doi.org/10.1177/0042098020927855; A. Knight, R. Creemers. "Going Viral: The Social Credit System and COVID-19". SSRN Electronic Journal, 2021. https://doi.org/10.2139/ssrn.3770208.

- Discriminatory treatment of individuals.
- Exploitation of vulnerabilities.
- Limiting individuals" access to essential services, education, or employment opportunities based on their scores.

The Act prohibits AI systems that evaluate natural persons based on their social behaviour, especially when these systems are applied by public authorities. The prohibition seeks to address ethical concerns about privacy violations, lack of transparency, and the risk of discrimination.

Social scoring raises significant ethical issues, such as privacy infringements and the potential for discrimination based on subjective or arbitrary criteria. The AI Act responds to these concerns by emphasising fairness, accountability, and transparency in AI systems. The idea is to prevent systems that could manipulate individuals by conditioning their access to services or social benefits based on biased or opaque algorithms.

However, it can be argued that a social scoring system that does not lead to discriminatory treatment or exploitation of vulnerabilities could potentially be authorized under certain conditions within the framework of the AI Act.

The AI Act is fundamentally concerned with preventing social scoring systems from leading to discriminatory outcomes, particularly those that impact individuals based on sensitive attributes (such as race, gender, socio-economic background, or health status). If a social scoring system were designed in a way that actively avoids discrimination —for example, by ensuring transparent algorithms, ethical data collection practices, and bias mitigation measures— it could be argued that such a system falls outside the strict prohibitions of the AI Act.

Further, the exploitation of vulnerabilities is another key concern that leads to the prohibition of social scoring systems. If a system is designed to respect the autonomy and dignity of individuals, it would need to ensure that it does not exploit groups that are vulnerable (due to factors such as age, economic status, or disabilities). This could mean that the system provides full informed consent to individuals, offers opt-out mechanisms, and ensures that no individual is unfairly disadvantaged based on their personal or socio-economic circumstances.

Social scoring systems could, theoretically, be justified if they provide positive societal benefits without imposing unfair burdens on individuals. For instance, if a social scoring system were implemented to promote environmentally responsible behaviour, public health, or community participation, and if it were applied uniformly without penalising or excluding individuals, it might be more favourably viewed within the framework of the AI Act. Such a system would need to be voluntary, transparent, and non-coercive,

ensuring it does not create a social divide between individuals based on arbitrary criteria.

The AI Act allows for high-risk AI systems to operate under strict conditions, one of which is human oversight. A social scoring system that includes robust oversight mechanisms, such as regular audits, appeal processes for individuals who feel unfairly treated, and transparency about how scores are calculated and used, might be viewed as compliant. Such a system would need to ensure that individuals fully understand the criteria used to assess their behaviour and have an opportunity to challenge decisions made based on their score.

While the above arguments present a pathway for authorising certain forms of social scoring, several legal and ethical concerns would still need to be addressed:

• Data Protection and Privacy[376]: Even if a social scoring system avoids discrimination and exploitation, it would still need to comply with strict data protection laws such as the General Data Protection Regulation (GDPR). The collection and use of personal data for social scoring would need to be justified on the grounds of legitimate interest or public good, and individuals would need to retain control over their personal data.

• Transparency and Accountability: Social scoring systems would have to be extremely transparent about how scores are calculated and how decisions are made based on those scores. There must be clear accountability mechanisms in place to prevent algorithmic opacity and ensure that individuals understand and can contest decisions made about them.

• Slippery Slope to Discrimination: Even if a system begins without overt discrimination, there is always a risk that unintended biases might creep into the scoring algorithms or that long-term societal impacts (such as reinforcing class or status divisions) could develop. As such, any social scoring system would need to be closely monitored to prevent it from becoming a tool of social control or exclusion. It's also the case to mention that the evaluation of the discriminatory treatment must be done *ex ante* (potential), and not only *ex post* (effective)[377].

While the AI Act prohibits certain types of social scoring, especially when they lead to discriminatory treatment or exploitation, it leaves room for high-risk AI systems that can be justified under strict regulatory conditions[378].

[376]See S. Abbady, *The EU Artificial Intelligence (AI) Act: A Commentary.* Edited by Ceyhun Necati Pehlivan, Nikolaus Forgó, and Peggy Valcke. Alphen aan den Rijn: Wolters Kluwer, 2025, p. 125.

[377]See Article 9.2(a) and 9.8, EU's AI Act - Regulation (EU) 2024/1689.

[378]And, in any case, respecting the principles and values of the EU, as expressed in many Recitals like n. 2, 7, 27, 28, 58.

One of the main difficulties in social scoring is defining "good behaviour" in objective and scientific terms. There is no consensus on what criteria should be used to measure people's behaviour, and people often rely on proxies, i.e. indirect indicators that may not accurately reflect reality. These proxies can be misleading and lead to incorrect assessments, as they do not capture the complexity of human actions and their motivations.

The implementation of advanced technologies for urban management must therefore be balanced by strict ethical and legal considerations. It is essential that cities adopt an approach that respects the privacy and rights of citizens, avoiding intrusive practices that could undermine public trust.

A carefully designed, transparent, and ethically sound social scoring system that avoids discrimination, protects vulnerable individuals, and promotes societal benefits could, in theory, be authorized. However, such a system cannot be drafted following only the "formality" of the digitisation, and need to be equilibrated with an equally important side of "informality".

Before moving on, some additional considerations must be made.

4.2.4. Social Scoring, an Extended Analysis

A dimension to consider is how the idea of social scoring intersects with the incentive theory. The incentive theory is a concept in economics and psychology that explores how incentives can motivate behaviour. It suggests that individuals are driven to act in certain ways by external rewards or incentives, which can be tangible, like money, or intangible, like praise or recognition. This theory is widely applied in various fields, including business, economics, and behavioural psychology.

The Key Aspects of Incentive Theory are:

1. Motivation Through Rewards: Incentive theory posits that behaviour is motivated by a desire for reinforcement or incentives. This contrasts with theories that emphasize internal drives or needs as primary motivators.

2. Applications in Economics: In economic contexts, incentive theory often deals with how financial rewards can influence decision-making and performance. For example, companies might use incentive programs to boost productivity among employees by offering bonuses or other benefits for meeting specific targets[379].

3. Principal-Agent Problem: The theory also addresses issues like the

[379]see M. Z. Hossain, U. Nusrat Urme. "Impact of Incentive Programs on Organizational Growth: A Case Study". ABC Research Alert 10, no. 1, 2022: 17–30. https://doi.org/10.18034/abcra.v10i1.600.

principal-agent problem, where there is a need to align the interests of different parties involved in a contract or agreement. This is particularly relevant in scenarios where one party (the agent) is expected to act in the best interest of another party (the principal), such as in employer-employee relationships[380].

4. Incentive Sensitisation Theory of Addiction: A specific application of incentive theory is found in the field of addiction studies, where it is used to explain how drug-induced changes in the brain can lead to heightened motivation for drug use. This is known as the incentive sensitisation theory of addiction, which suggests that addiction results from increased sensitivity to drug-related cues rather than just the pleasurable effects of drugs[381].

5. Game Theory and Incentives: Incentive mechanisms are also explored through game theory, where strategies are developed to optimize outcomes based on the incentives and actions of various stakeholders. This approach can be used to design policies and systems that encourage desired behaviours, such as energy conservation in public buildings[382].

Overall, incentive theory provides a framework for understanding how external factors can influence behaviour and decision-making across different domains, but the application of incentive theory to influence citizen behaviour in urban settings presents both opportunities and challenges.

While incentives can effectively motivate certain actions, they are not universally applicable or appropriate for promoting all types of "good behaviour." This critique explores the limitations of directly incentivising civic behaviours and emphasizes the importance of indirect incentives, such as systemic functionality and a sense of justice.

Civic behaviour is inherently complex and influenced by a multitude of factors, including cultural norms, personal values, and social influences. Direct incentives might oversimplify these motivations by reducing them to transactional exchanges. For instance, offering financial rewards for recycling

[380] see, for an initial exploration on the problem, J-J. Laffont, D. Martimort. *The Theory of Incentives: The Principal-Agent Model*. Princeton University Press, 2002. https://doi.org/10.1515/9781400829453.

[381] it is not the purpose of the present work, neither the expertise of the Author, but useful information can be found in T. E. Robinson, K. C. Berridge, "The Incentive Sensitization Theory of Addiction: Some Current Issues". P*hilosophical Transactions of the Royal Society B: Biological Sciences* 363, no. 1507 (12 October 2008): 3137–46. https://doi.org/10.1098/rstb.2008.0093.

[382] see H. Chen, Y. Xiao, Q. Liu, and G. Fu. "Incentive Mechanism and Subsidy Design for Continuous Monitoring of Energy Consumption in Public Buildings (CMECPB): An Overview Based on Evolutionary Game Theory". Buildings 13, no. 4 (7 April 2023): 984. https://doi.org/10.3390/buildings13040984.

might increase participation temporarily but could undermine intrinsic motivations for environmental stewardship over time[383].

Direct incentives can lead to unintended consequences, such as fostering dependency on rewards or encouraging minimal compliance rather than genuine engagement. For example, if citizens are rewarded for reporting neighbourhood issues, a potential risk is that they focus on quantity over quality. Some pivotal experiences seem to suggest this problem, for example, reporting trivial matters to gain rewards rather than addressing significant concerns. Citizens should be guided to consider the interests of others, and the common interest overall[384].

Incentive programs can inadvertently exacerbate social inequalities. Wealthier individuals might have more access to resources that allow them to take advantage of incentives, while marginalized groups could be left out. For instance, tax incentives for energy-efficient home upgrades primarily benefit homeowners with the financial means to invest in such improvements, leaving renters and low-income households at a disadvantage[385].

Indirect incentives focus on creating environments where good behaviour is naturally encouraged through systemic functionality. This approach involves designing systems that inherently promote positive outcomes without the need for explicit rewards. For example, urban planning that prioritizes pedestrian-friendly infrastructure can naturally encourage walking and reduce car dependency without needing to reward individuals for choosing sustainable transport options[386].

A sense of justice and community belonging can serve as powerful indirect incentives. When citizens perceive governance systems as fair and just, they are more likely to engage in cooperative behaviours. Participatory approaches in urban governance, where citizens have a voice in decision-making processes, can enhance their sense of ownership and responsibility towards communal goals[387].

[383]see R. Maleknia, J. ChamCham, "Participatory Intention and Behavior towards Riparian Peri-Urban Forests Management; an Extended Theory of Planned Behavior Application", *Frontiers in Psychology* 15 (26 March 2024): 1372354. https://doi.org/10.3389/fpsyg.2024.1372354.

[384]see J. Wu, J. Xiong. "How Governance Tools Facilitate Citizen Co-Production Behavior in Urban Community Micro-Regeneration: Evidence from Shanghai". Land 11, no. 8, 2022: 1243. https://doi.org/10.3390/land11081243.

[385]se A. G. Robertson, K. Hallinan, and J. Hoody. "Achieving Energy Justice in Low Income Communities: Creating a Community-Driven Program for Residential Energy Savings", 2019.

[386]see J. Wu, J. Xiong. "How Governance Tools Facilitate Citizen Co-Production Behavior in Urban Community Micro-Regeneration: Evidence from Shanghai", Land 11, no. 8, 2022: 1243. https://doi.org/10.3390/land11081243.

[387]see R. Maleknia, J. ChamCham, "Participatory Intention and Behavior towards Riparian Peri-Urban Forests Management; an Extended Theory of

Indirect incentives seem more effective in fostering long-term behavioural change compared to direct rewards. By embedding pro-social norms within the community culture, behaviours such as volunteering or participating in local governance become self-sustaining over time. This approach aligns with findings from studies on citizen participation in energy transitions, where long-term engagement is achieved through collective community efforts rather than individual rewards.

In addition to the limitations of direct incentives and the benefits of indirect incentives, it is crucial to consider the role of civic duty in promoting good behaviour among citizens. In a liberal democracy, duties are as important as rights, and recognising this balance is essential for fostering a well-functioning society.

In liberal democracies, the concept of duty complements individual rights. While rights empower citizens to pursue personal goals and freedoms, duties emphasise their responsibilities towards the community and the state. This duality ensures that personal liberties do not come at the expense of collective well-being.

Good behaviour should be viewed as a civic duty rather than merely a response to incentives. Duties such as obeying laws, participating in democratic processes, and contributing to community welfare are fundamental to maintaining social order and cohesion. When citizens perceive these actions as inherent responsibilities, they are more likely to engage in them consistently and voluntarily.

Promoting a sense of duty can be achieved through education and public discourse that highlights the importance of civic responsibilities. Schools and community programs can play a pivotal role in instilling values of citizenship and public service from an early age. By emphasising the moral and ethical dimensions of civic duties, societies can cultivate a culture where good behaviour is seen as an integral part of citizenship.

Balancing rights and duties involves ensuring that all citizens have equal opportunities to fulfill their responsibilities. This requires addressing systemic barriers that might prevent certain groups from participating fully in civic life. For example, providing accessible voting facilities and fostering inclusive public spaces can help ensure that everyone can exercise their rights and duties effectively.

Strong democratic institutions are essential for upholding both rights and duties. Transparent governance, accountability mechanisms, and participatory decision-making processes reinforce citizens' trust in the system. When

Planned Behavior Application", *Frontiers in Psychology* 15, 2024: 1372354. https://doi.org/10.3389/fpsyg.2024.1372354.

individuals feel confident that their contributions are valued and impactful, they are more likely to embrace their civic duties willingly.

Ultimately, rights and duties are interdependent in a liberal democracy. Rights provide individuals with the freedom to act, while duties remind them of their obligations towards others. This interdependence ensures that personal freedoms are exercised responsibly, contributing to a harmonious and just society.

4.2.5. Conclusion on Social Scoring

In conclusion, while the use of personal data and digital technologies offers significant opportunities to improve city management, it is crucial to address the ethical and legal challenges that come with it. Legislation such as the European Union's AI Act represent important steps towards regulating these practices, but an ongoing dialogue between technology, ethics and law is needed to ensure a sustainable and just urban future. Only through a balanced and conscious approach will it be possible to exploit the full potential of digital technologies while respecting the core values of our societies.

The reconstruction of reliability indices for neighbourhoods, areas, or entire cities is a promising application of digital twin technology. These indices can serve as proxies for various urban metrics, yet the further we extend this chain of proxies, the more tenuous our grasp on reality becomes. Digital twins, while not inherently designed for credit or social scoring, possess the potential to inadvertently harm certain individuals or groups, depending on their design and implementation. This risk arises from the selective focus of digital twins, which might overlook the nuanced dimensions of urban life. An alternative approach is to pursue datification in a more generative rather than extractive manner. However, this presents its own set of challenges, as the continuous and sustainable production of data requires adaptable tools.

The concept of open source and the importance of maintaining control over software are crucial in this context. Ensuring democratic control over the digital tools deployed in cities can be achieved through various means, including administrative and legislative interventions. It is imperative to scrutinise how data is collected and processed, particularly from a perspective of minimising these activities. Current regulations emphasise data minimisation, yet many contemporary practices lean towards massive data collection, driven by the demand for more data production. This trend inevitably clashes with privacy concerns and the ethical management of personal information.

The governance of these systems, whether public or private, is a critical issue. The formal nature of digital systems can lead to significant control over individuals, potentially managing, predicting, and directing their be-

haviour. This scenario risks creating what Professor Floridi terms "corporate populism," where the governance, having implemented a system, applies it without alternatives, resulting in a democratic deficit. This form of control by governance over the populace raises fundamental questions about the democratic principles at stake.

The debate surrounding what aspects of urban life should be digitalized is not as vigorous as it should be. While it is technically feasible to digitalize almost everything, this comes with significant costs. Deciding to digitize should be carefully considered, as it requires a careful balance of the benefits and possible societal and ethical consequences.

The conventional method of digitisation fails to grasp the intricate and ever-changing nature of human societies, where spontaneity, diversity, and adaptability play a crucial role. Casual conversations and connections are essential for lively communities, promoting imagination, originality, and unity among individuals. By inflexible structure applied to natural processes, social scoring may hinder the inclusiveness and resilience of urban areas.

Social scoring systems can exacerbate inequalities and infringe upon individual freedoms. By reducing human behaviour to numerical values, these systems often fail to account for the nuanced contexts in which actions occur. This reductionist view can lead to unfair penalisation of individuals who do not conform to the dominant cultural or social norms encoded within the scoring algorithms. It also raises significant ethical concerns regarding privacy, autonomy, and the potential for surveillance overreach.

In essence, social scoring represents an overextension of formality into realms where informality should prevail. To preserve the inclusivity and richness of city life, it is crucial to resist such attempts at over-formalisation and instead foster environments that celebrate diversity and support the complex realities of human interaction.

The challenge lies in determining which elements of urban life truly benefit from digitalisation and ensuring that the process is guided by principles that respect individual rights and promote social equity. The conversation must evolve to address these critical issues, fostering a more balanced and thoughtful approach to the integration of digital technologies in urban environments.

4.3. Assessments and DTCs

Summary: 4.3.1. Different Assessments - 4.3.2. Critical Consideration - 4.3.3. AI and Risk - 4.3.4. Closing Remarks

4.3.1. Different Assessments

The balance between fostering innovation and safeguarding fundamental rights is a central concern in the European Union's regulatory framework on digital technologies. This approach introduces various forms of impact assessments to address specific risks related to the areas of data protection, artificial intelligence (AI) and the use of big data.

This risk-based approach affects the most advanced UDTs.

Risk in EU legislation is generally defined in terms of potential harm to individual rights and freedoms, especially with regard to personal data and human dignity. Although neither the Treaty on European Union (TEU) nor the Treaty on the Functioning of the European Union (TFEU) provide an explicit definition of "risk," they form the constitutional basis for the protection of fundamental rights (Article 6 TEU) and the principle of proportionality (Article 5 TEU), both of which underpin the risk-based regulatory framework. This broad framework supports the creation of more specific instruments like the General Data Protection Regulation (GDPR) and the proposed Artificial Intelligence Act (AI Act), which operationalise risk management in the context of digital technologies.

The GDPR, for instance, explicitly requires organisations to conduct a Data Protection Impact Assessment (DPIA) when processing operations are "likely to result in a high risk to the rights and freedoms of natural persons" (Article 35 GDPR). This risk-based approach is designed to identify and mitigate risks associated with personal data processing, particularly where sensitive or large-scale data is involved, or where new technologies are used that could pose novel threats to privacy.

The GDPR outlines specific scenarios where a DPIA is required, including but not limited to: • Systematic and extensive profiling or monitoring of individuals (e.g., through large-scale surveillance), • Processing of special categories of data (such as health or biometric data), or • Large-scale processing that may significantly affect individuals, such as processing vast amounts of location or behavioural data.

It is important to note that not all digital technologies necessarily involve the processing of personal data. In the case of an Urban Digital Twin (UDT)—a virtual representation of a city's physical infrastructure—personal data

processing may not be directly involved. A UDT often focuses on modelling urban environments, optimising city planning, or improving public services through the aggregation of environmental, traffic, or energy data, which does not always implicate individual-level data.

However, if a UDT incorporates data from sources such as smart city sensors, surveillance systems, or mobile device tracking (e.g., for analysing pedestrian movements), and if this data can be linked to individuals, a DPIA may be required. The key determinant is whether the UDT processes personal data —defined by the GDPR as any information relating to an identifiable individual.

In the context of an Urban Digital Twin (UDT), the possibility to fall into the cases regulated by Article 35 GDPR might depend on the effectiveness of the anonymisation techniques, which provide an irreversible transformation of personal data so that individuals are no longer identifiable, either directly or indirectly (the pseudonymisation is possible, but less likely to be used. For pseudonymisation we refer to a reversible process in which personal data is replaced by artificial identifiers, but the original data can still be re-associated with individuals by using additional information -such as a key or index- stored separately. In this case, individuals remain indirectly identifiable (Article 4(5) GDPR)).
It is well known that if data is fully anonymised, meaning it can no longer be linked to any specific person, it is no longer considered personal data under the GDPR (Recital 26). In such cases, the obligations of the GDPR, including the requirement to conduct a DPIA, do not apply, as anonymised data is beyond the scope of data protection law.
However, achieving true anonymisation can be difficult, especially in complex datasets like those used in UDTs. The theoretical risk of re-identification, if anonymised data is combined with other datasets or if patterns emerge, can not be ruled out automatically.
For example, traffic data or environmental sensor data may appear anonymised at first, but when combined with other datasets (such as public transportation logs or mobile device tracking), it could become possible to identify individuals. Therefore, the effectiveness of anonymisation depends heavily on the methods used and the context in which the data is processed.
In the context of a UDT, a completely anonymous data collection can have less value (because it might be not usable for fine-grained analysis), while pseudonymisation might remain subject to GDPR requirements, and a DPIA may still be necessary if the data processing is likely to result in a high risk to individuals" rights and freedoms.
It is worth reminding that, when processing personal data in the context of an Urban Digital Twin (UDT), the issue of consent presents challenges, particularly when the data is collected in public spaces or for public purposes. Under the General Data Protection Regulation (GDPR), consent is one

of the key legal bases for data processing (Article 6(1)(a)). Consent must be freely given, specific, informed, and unambiguous, and data subjects should have control over how their data is used. However, obtaining explicit consent from individuals in a large-scale, public urban environment, such as a smart city setting, can be impractical or infeasible.
In cases where data is collected for public interest purposes—such as city planning, traffic management, or environmental monitoring—public authorities and private entities acting on behalf of public bodies may rely on alternative legal bases, such as performance of a task carried out in the public interest (Article 6(1)(e) GDPR). This can limit the reliance on individual consent when the data processing is necessary for the efficient functioning of public services or urban infrastructure. However, even in these scenarios, individuals" rights cannot be ignored, and transparency, fairness, and data minimisation principles must still be followed.

Another critical challenge lies in the reuse of data. The GDPR emphasizes the principle of purpose limitation (Article 5(1)(b)), which requires that data collected for one purpose must not be reused for a completely different, incompatible purpose without further consent or legal justification. In the case of UDTs, the initial collection of data might serve urban planning purposes, but reusing that data for other applications can raise serious legal and ethical concerns.
While there is growing interest in the potential of data reuse —especially in AI-driven analytics— there are significant limitations. Reusing data effectively requires careful consideration of whether the dataset was originally designed to support the new, emerging questions. The fallacy of assuming that data can always be repurposed for unforeseen applications is a common misunderstanding in the data science and big data landscape.

It is often suggested that data can be repurposed efficiently for problems not originally considered at the time of collection, particularly because advanced data analysis may reveal "emergent patterns" that provide new insights. However, this perspective overlooks a crucial point: while data analysis can indeed suggest emergent solutions, the initial design and scope of the dataset are typically driven by a pre-existing research or operational question. If the dataset was not structured with the necessary variables or granularity to address a future, unforeseen problem, its utility may be limited.
The notion that "more data" will always lead to better or broader insights ignores the reality that datasets must be appropriately designed for their intended analytical scope. Without this forethought, reusing data for new purposes can lead to bias, incomplete analyses, or even incorrect conclusions.
The design of the dataset must align with the intended purpose, and the reuse of data for new objectives must comply with legal principles like purpose limitation and data minimisation.

Similar to the GDPR, the AI Act adopts a tiered, risk-based approach, distinguishing between minimal, limited, high, and unacceptable risks posed by AI systems. The similarly High-risk AI systems are subject to stricter regulatory controls, including mandatory Conformity Assessments designed to ensure compliance with EU standards before deployment.

The Conformity Assessments ensure that AI systems deployed within the EU market meet stringent requirements to protect fundamental rights, safety, and public interests. These systems must undergo a Conformity Assessment before being placed on the market or used in the EU, ensuring that they meet all relevant legal requirements, including technical standards, data governance, transparency, and safety measures.

The Conformity Assessment applies primarily to AI systems classified as high-risk, such as those used in sectors like healthcare, education, law enforcement, and employment, and their potential to significantly impact fundamental rights, health, safety, or freedoms. The AI Act allows for different types of conformity assessment depending on the nature of the AI system:

• Self-assessment: Some high-risk AI systems may allow providers to conduct their own internal conformity assessments without involving external bodies, provided they meet certain criteria and the risks are well understood.

• Third-party assessment: For more complex or high-risk AI systems, external validation by a Notified Body is required. This process includes rigorous testing and auditing to ensure that the system adheres to legal and ethical standards.

To understand if it is required for an Urban Digital Twin (UDT), it depends on the specific use and classification of the AI systems integrated into the UDT, rather than the UDT itself as a concept.

If the AI components of the UDT are used in high-risk sectors outlined in Annex III of the AI Act (such as critical infrastructure, law enforcement, healthcare, or education), the AI systems involved may be classified as high-risk, and a Conformity Assessment would be required. For example, a UDT used for traffic management in critical urban infrastructure or for public safety surveillance could involve high-risk AI systems. Moreover, if the AI systems used in a UDT that directly impact individuals" fundamental rights —such as facial recognition for law enforcement or monitoring social behaviour in public spaces— would likely be categorized as high-risk. In these cases, a Conformity Assessment is necessary to evaluate compliance with the legal and ethical requirements related to privacy, non-discrimination, and other fundamental rights.
If the UDT includes AI that processes personal data in a way that poses significant risks (e.g., for smart city surveillance or automated decision-making affecting citizens), the UDT could be subject to the high-risk classification,

triggering the need for a Conformity Assessment. However, if the UDT only deals with non-personal data or anonymised environmental data (such as air quality or energy consumption), it may not fall under the high-risk category, and a Conformity Assessment might not be necessary.

The Fundamental Rights Impact Assessment (FRIA) introduces broader obligations for ensuring that high-risk AI systems do not infringe upon fundamental rights, but how these obligations translate into concrete assessment tools, like the FRIA, remains under development.

One of the primary difficulties in drafting a FRIA (to evaluate the potential threats to a broader spectrum of rights enshrined in the Charter of Fundamental Rights of the EU) is the novelty of the legal framework surrounding AI and fundamental rights. As the AI Act progresses, the precise methodology for conducting a FRIA remains unclear due to the lack of established standards and the complexity of the subject matter. Unlike traditional impact assessments, which focus on measurable risks (e.g., privacy risks in a Data Protection Impact Assessment), the evaluation of fundamental rights in the context of AI raises unique challenges, as these rights are often qualitative and contextual, not easily reduced to simple metrics.

A common misconception, in fact, is that a FRIA could be developed similarly to other risk assessments, where each right is valued on a scale or weighted based on perceived importance. This approach, however, misinterprets the legal nature of fundamental rights. Unlike risk assessments that quantify potential harms or benefits, the juridical reasoning regarding fundamental rights requires an all-or-nothing approach[388]: rights are either respected or they are infringed upon. For instance, an AI system that disproportionately impacts one group's right to non-discrimination cannot simply balance this harm by asserting that it upholds the right to privacy for others.

Fundamental rights such as dignity, privacy, non-discrimination, freedom of expression, and due process are protected on an equal footing in legal reasoning, meaning it would be incorrect, and potentially harmful, to reduce such assessments to a scoring system that implies certain rights can be traded off or minimized in favor of others.

Because of these complexities, it remains uncertain how a FRIA should be precisely structured under the AI Act. The European Artificial Intelligence Board (EAIB) and national supervisory authorities will likely play a critical role in developing best practices and guidelines for conducting FRIAs. These guidelines will need to reflect the non-quantifiable nature of fundamental rights while providing a structured way to assess how AI systems may affect these rights in practice.

[388]see O. Pollicino, "La Prospettiva Costituzionale Sulla Libertà Di Espressione Nell'era Di Internet". Media Laws, no. 1 (2017).

In the interim, it is essential for developers and deployers of high-risk AI systems to adopt a precautionary approach, ensuring that they conduct thorough and transparent assessments of potential rights violations. This may include consulting with legal experts, civil society organisations, and ethics boards to understand the broader social and ethical impacts of AI technologies on fundamental rights. Ultimately, the goal of the FRIA is not to reduce rights to a checklist or a scale, but to engage in a principled legal analysis that ensures that AI systems operate in ways that respect the inherent dignity and freedoms of all individuals.

4.3.2. Critical Consideration

The interplay between these assessments ensures that risk is evaluated not only in terms of technical failures or breaches of compliance but also with regard to their societal, ethical, and legal consequences.

The impact assessments mandated by EU legislation on AI, Big Data, and digital technologies are indeed sectorial and vertical, tailored to address specific risks depending on the type of technology and the context of its application. These assessments vary in scope, and the level of involvement of various actors—such as developers, deployers, data controllers, and data subjects—differs based on the nature of the assessment.

1. Data Protection Impact Assessment (DPIA) under the General Data Protection Regulation (GDPR):

   • Data controllers: As the primary actors, data controllers are responsible for conducting DPIAs when processing operations are likely to result in a high risk to the rights and freedoms of data subjects (Article 35 GDPR). This assessment must be done before the processing begins, with a clear identification of the risks and the safeguards, security measures, and mechanisms in place to mitigate them.

   • Data processors: Although processors act on behalf of controllers, they must assist in carrying out DPIAs, providing the necessary information about the data processing activities.

   • Data subjects: While data subjects are not directly involved in conducting DPIAs, their rights and freedoms are at the center of these assessments. The GDPR requires that risks to data subjects—such as loss of privacy, identity theft, or discrimination—be identified and mitigated.

   • Supervisory Authorities: If the DPIA indicates a high risk that cannot be mitigated, the controller must consult the supervisory authority (typically the Data Protection Authority, or DPA) before proceeding with the data processing.

2. Conformity Assessment under the Artificial Intelligence Act (AI Act):

    - AI Providers (Developers): The primary responsibility for conducting a Conformity Assessment rests with AI providers—those who develop or place AI systems on the market. Providers must ensure that their systems comply with the AI Act's requirements before deployment. This includes verifying that the AI system meets standards related to accuracy, robustness, cybersecurity, and transparency, as well as conducting an assessment of potential impacts on fundamental rights. Providers must also establish risk management systems to continuously monitor the AI system's performance after deployment and ensure ongoing compliance. This includes a duty to maintain technical documentation and a log of operational data, facilitating accountability and regulatory oversight.

    - AI Users (Deployers): While AI providers bear the responsibility for ensuring compliance during the design and development phase, AI users (deployers) also have significant responsibilities. Users must operate the AI system in accordance with the intended use and ensure that it is deployed under conditions that do not introduce new or unforeseen risks. For instance, if a high-risk AI system designed for a specific medical diagnostic purpose is repurposed without the necessary adaptation, the user could be held liable for non-compliance. AI users must also perform post-market surveillance, monitoring how the AI system functions in real-world environments and reporting any safety incidents or breaches to the appropriate authorities.

    - Notified Bodies: For certain categories of high-risk AI systems, particularly those that pose complex or significant risks, the AI Act requires the involvement of Notified Bodies—independent third-party entities designated by EU Member States. These bodies are responsible for performing external audits and evaluations to verify that the AI system meets EU standards. Notified Bodies play a crucial role when the AI provider opts for third-party conformity assessment rather than self-assessment, especially when the AI system's impact may be harder to evaluate internally due to its technical complexity or potential for high societal impact. Their role ensures that an impartial evaluation of the system's safety and compliance is conducted.

    - Importers and Distributors: The AI Act also assigns specific obligations to importers and distributors who place high-risk AI systems on the EU market. Importers must ensure that the systems they bring into the EU comply with the Act's requirements and

that conformity assessments have been properly conducted. They are also responsible for maintaining the necessary documentation and cooperating with regulatory authorities if issues arise. Distributors, while less involved in the technical aspects of conformity, must ensure that the systems they market are accompanied by the appropriate compliance markings (such as the CE marking) and meet the required standards. Both importers and distributors share in the responsibility for reporting safety incidents and ensuring that non-compliant systems are not placed on the market.

- Regulatory Authorities and Oversight Bodies: Regulatory authorities, such as national market surveillance authorities and the proposed European Artificial Intelligence Board (EAIB), oversee the proper implementation of the Conformity Assessment process. These bodies ensure that high-risk AI systems comply with the AI Act's requirements and have the power to conduct audits, demand documentation, and issue penalties for non-compliance. These authorities are also responsible for post-market surveillance, ensuring that AI systems continue to function within the scope of compliance even after deployment. They may issue corrective measures, such as requiring AI systems to be withdrawn from the market if significant risks are identified.

3. Fundamental Rights Impact Assessment (FRIA):

    - Developers and providers of AI systems: When designing or deploying AI systems that may impact fundamental rights (e.g., surveillance technologies, AI used in law enforcement), developers and providers must perform a Fundamental Rights Impact Assessment (FRIA) to evaluate risks to rights enshrined in the Charter of Fundamental Rights of the European Union. These actors must assess potential infringements on rights such as privacy, freedom of expression, or non-discrimination.

The present list serves as a description of the complexity and multidisciplinary nature of stakeholders involved in the assessments around UDTs. The coordination of these actors is complex, but even more is, according to some literature, the orchestration of the data protection.
Lilian Edwards pointed it out clearly in her paper titled "Privacy, Security and Data Protection in Smart Cities: A Critical EU Law Perspective", which analysed the intricate legal challenges posed by the burgeoning development of smart cities, with a keen focus on privacy, security, and data protection under the framework of EU law.
The work, situated within the field of Critical Studies on EU Law, offered a clear perspective on the complexities and potential pitfalls of integrating

several advanced technologies into urban environments without a holistic perspective on data protection.
A key issue identified by Edwards is the lack of opportunities for individuals to provide meaningful consent to the processing of their personal data within ambient or smart city environments. This concern is compounded by other critical issues, including the extensive collection of private data from inevitable public interactions, the privatisation of ownership of both infrastructure and data, the repurposing of "big data" derived from the Internet of Things (IoT) in smart cities, and the storage of such data in the Cloud. These factors collectively pose significant threats to personal privacy, as smart cities inherently combine three of the greatest current threats to personal privacy: IoT or "ubiquitous computing," Big Data, and Cloud computing. Edwards argues that existing regulations have thus far failed to effectively address these intertwined challenges.

Edwards noted that while IoT, Big Data, and Cloud computing have been extensively examined in privacy literature, particularly in the US and EU, the combination of these technologies within the context of smart cities remains under-explored. This lack of exploration is even more pronounced in the case of digital twin cities, where the convergence of these technologies presents unique and complex challenges that have yet to be fully addressed.

One of the primary challenges is obtaining *meaningful consent* for data collection. In a smart city environment, data is often collected passively from public spaces and through various IoT devices, making it difficult for individuals to be fully informed about what data is being collected and how it is being used. This lack of transparency undermines the principle of informed consent, a cornerstone of data protection regulations.

Another significant issue is the challenge of maintaining privacy when personal data is collected from *public spaces*. In smart cities, data collection is pervasive, occurring through surveillance cameras, sensors, and other IoT devices embedded in public infrastructure. This constant monitoring can lead to a sense of surveillance and erode individuals' privacy, as they may be unaware of the extent and nature of data being collected about them.

The problem of data ownership and control is also highlighted in the paper. In many smart city initiatives, data is managed by private entities through *public-private partnerships (PPPs)*. This raises concerns about who owns the data, who has access to it, and how it is used. The involvement of private companies in managing public data can lead to conflicts of interest and challenges in ensuring accountability and transparency.

For these reasons, traditional privacy concepts and legal frameworks may be inadequate to protect citizens in smart cities. The dynamic and interconnected nature of smart city technologies requires a more flexible and adaptive

approach which address the complexities of data flows and the potential for data repurposing and re-identification in such environments.

In 2015, Edwards proposed two potential solutions to these pressing issues, aiming to enhance transparency and empower individuals to make informed decisions about their personal data.

- The first is the implementation of a mandatory holistic privacy impact assessment (PIA) exercise for smart cities. This approach would require a comprehensive evaluation of the privacy implications of smart city initiatives, ensuring that potential risks are identified and mitigated before implementation.
- The second solution involves developing code solutions that flag the need for, and consequences of, giving consent to data collection in ambient environments.

In particular, for the first potential solution, the paper proposes the implementation of a holistic Data Protection Impact Assessment (DPIA) specifically tailored for smart cities. This DPIA would form part of a broader strategy to enhance privacy protection and ensure compliance with data protection laws. The holistic DPIA can also be adapted for Digital Twin City projects, which involve creating virtual models of cities that replicate their physical counterparts.

Comprehensive Evaluation The holistic DPIA would involve a comprehensive evaluation of all data flows within the smart city. This includes examining how data is collected, processed, stored, and shared across various systems and stakeholders. By mapping out the entire data lifecycle, the DPIA would identify potential privacy risks and vulnerabilities that may arise at different stages. This thorough assessment would enable stakeholders to implement targeted measures to mitigate identified risks and enhance data protection.

Stakeholder Involvement A key component of the holistic DPIA is the involvement of all relevant stakeholders. This includes public authorities, private companies, and civil society organisations. Engaging a diverse range of stakeholders ensures that the privacy concerns of all parties are adequately addressed and that different perspectives are considered in the assessment process. Collaborative stakeholder involvement fosters transparency and accountability, promoting trust in smart city initiatives.

Continuous Monitoring Unlike traditional impact assessments, the holistic DPIA would not be a one-time exercise. Instead, it would be a continuous process that adapts to changes in technology and the legal

landscape. This ongoing monitoring allows for the assessment and adjustment of privacy protections as new risks emerge and technologies evolve. Continuous monitoring ensures that smart cities remain responsive to privacy challenges and maintain robust data protection measures over time.

Integration with Privacy by Design (PbD) The DPIA would be integrated with the principles of Privacy by Design (PbD)[389], ensuring that privacy considerations are embedded in the architecture and systems of smart cities from the outset. By incorporating privacy into the design and development of smart city technologies, potential privacy risks can be identified and addressed early in the planning process. This proactive approach reduces the need for costly and complex retrofitting of privacy measures after technologies have been deployed.

The holistic DPIA aims to go beyond the traditional scope of impact assessments by providing a more detailed and ongoing evaluation of privacy risks in the highly interconnected and data-intensive environment of smart cities. The goal is to create a robust framework that ensures the protection of personal data and privacy rights in the evolving landscape of smart urban environments.

Almost a decade later, this perspective can resurface in the UDTs debate. The research gap addressed by Edwards' paper was the largely overlooked intersection of three significant technological phenomena —IoT, Big Data, and Cloud computing— within the context of smart cities. The literature examination of the present work sufficiently indicated that UDTs can potentially bring this intersection to a new level of integration.

4.3.3. AI and Risk

An in-depth analysis of the risk management system in the AI Act was carried out by Prof. Mantelero[390].

The primary objective of the article is to fill the theoretical and methodological gaps in the implementation of FRIA, as indirectly outlined in the AI Act.

The Conformity Assessment is broader, and addresses a range of risks, including safety and compliance with performance standards. It balances risks against benefits.

[389] see G. Bincoletto, *La privacy by design: un'analisi comparata nell'era digitale*, Università di Trento. Dipartimento di scienze giuridiche, 2017. https://doi.org/10.15168/11572_177733.

[390] See A. Mantelero, "The Fundamental Rights Impact Assessment (FRIA) in the AI Act: Roots, Legal Obligations and Key Elements for a Model Template", *Computer Law & Security Review* 54 (September 2024): 106020. https://doi.org/10.1016/j.clsr.2024.106020.

Instead, the FRIA is going to be specifically designed to focus on the impact of AI on fundamental rights. The author stresses that both assessments should be harmonized to avoid conflicts and ensure a comprehensive evaluation of AI's impact.

The paper critically examines the need for a robust methodological framework for FRIA. It highlights the necessity of integrating FRIA with other impact assessments, such as Conformity Assessments, to ensure that all potential risks to fundamental rights are thoroughly evaluated. It then proposes a 3-layered model template for risk assessment, that even extends beyond its immediate regulatory requirements. This includes assessing not just the technological design but also the societal context in which the AI will operate.

Articles 7, 9 (and Section V), and 27 are not organised into a distinct, sequential risk management process. However, they must be seen together to understand their specificity and see with loopholes (or overlaps) exist.

The analysis starts with Article 7, which focuses on general prohibitions of certain AI practices deemed unacceptable.

Technological Assessment under Article 7 of the AI Act serves as the initial layer in the risk management process. This assessment is closely tied to identifying AI systems that pose unacceptable risks and ensuring they do not reach the market. It involves a pre-market evaluation of AI technologies based on their intended use, technical characteristics, and the potential societal impact.

- Purpose: The aim of this assessment is to categorize AI systems based on their risk levels, with particular emphasis on identifying those that may pose significant risks to health, safety, or fundamental rights. Technologies that fall under the category of "unacceptable risk," such as systems that manipulate human behaviour or engage in social scoring, are prohibited outright.
- Methodology: This layer focuses on evaluating the inherent properties of the technology itself, including its design, functionality, and intended applications. It is fundamentally a technological risk assessment that seeks to flag potentially harmful systems early in the development process. The technological assessment serves as a filter, preventing high-risk AI systems from advancing to subsequent stages without necessary modifications or safeguards.
- Limitations: The primary limitation of this layer is that it is largely technical and does not fully engage with the societal or contextual implications of AI use. It tends to assess AI systems in isolation from the real-world environments in which they will operate, thus missing

the nuanced interactions between technology, context, and affected individuals.

If the system is considered with "High risk", Article 9's purpose (later explained in Section V of AI Act) is to ensure compliance with safety and performance requirements (which may indirectly include fundamental rights considerations but are not explicitly its primary focus).

The Conformity Assessment involves a more comprehensive evaluation of high-risk AI systems before they are deployed in the market, with a broader focus on compliance with legal, safety, and performance standards.

- Purpose: The Conformity Assessment aims to ensure that high-risk AI systems meet the defined standards set by the AI Act, focusing on technical specifications, quality control, and safety measures. It is a procedural check that AI providers must undertake to demonstrate that their systems comply with regulatory requirements, including those related to fundamental rights.
- Methodology: This assessment adopts a standards-based approach, applying predefined criteria that encompass risk identification, risk analysis (evaluation and estimation), and risk management (prevention and mitigation). The process may involve self-assessments, third-party evaluations, or certification by notified bodies, depending on the level of risk associated with the AI system.
- Integration of Fundamental Rights: While the Conformity Assessment does consider fundamental rights as part of its broader evaluation, this aspect is embedded within the general framework of safety and performance checks. As such, the focus on fundamental rights is often diluted by other compliance concerns, and the assessment may lack the specificity required to address nuanced human rights issues fully.
- Challenges: The Conformity Assessment's reliance on standards poses a methodological challenge. Standardisation bodies may lack the expertise to evaluate fundamental rights impacts adequately, leading to assessments that are overly procedural and insufficiently sensitive to the specific rights at risk. Furthermore, the rigid nature of standards may not accommodate the variability and context-specific nature of fundamental rights implications, thus requiring careful consideration and adaptation.

Lastly, Article 27 addresses the impact on fundamental rights, but it should not be conceptualized as a discrete step that follows other assessments. Rather, it should be integrated throughout the AI system's lifecycle.

- Purpose: The primary aim of FRIA is to assess potential infringements on fundamental rights, such as privacy, non-discrimination, and free-

dom of expression, that may arise from the deployment of high-risk AI systems. This assessment is critical in contexts where AI systems are used in sensitive or vulnerable environments, such as healthcare, law enforcement, and public services.

- Methodology: FRIA adopts a rights-based approach, distinguishing itself from the broader Conformity Assessment by concentrating solely on the implications for fundamental rights. It involves a detailed evaluation of how AI systems interact with the rights of individuals and communities, requiring a thorough analysis of the societal context, user characteristics, and potential adverse effects. Key methodological features include:
  - Ex-Ante Analysis: FRIA is conducted prior to the deployment of the AI system, allowing for the identification and mitigation of risks before they materialize.
  - Iterative Process: The assessment is not static; it evolves with the lifecycle of the AI system, adapting to new information, changes in use, or emerging risks.
  - Expert-Based Evaluation: FRIA requires specialized knowledge, often drawing on interdisciplinary expertise in law, ethics, and technology to ensure comprehensive risk identification and mitigation.

One of the major challenges identified is the need for a clear procedural integration between AI providers (who develop the technology) and deployers (who use the technology in specific contexts). The AI Act mandates FRIA primarily for deployers, but successful assessments depend heavily on information provided by AI developers. The current regulatory framework inadequately addresses the flow of information between these stakeholders, complicating the assessment process.

Additionally, there is (yet) a lack of standardized guidelines or templates that can provide deployers with concrete steps to conduct FRIA. The AI Office is tasked with developing a questionnaire template, but the risk remains that FRIA could devolve into a checkbox exercise rather than a substantive evaluation of risks.

While the FRIA is a key component of the AI Act, its principles can be extended to other regulatory contexts. The article proposes that FRIA could serve as a blueprint for other national and international initiatives aiming to align AI technologies with human rights standards. The AI Act's focus on high-risk applications should not limit FRIA's applicability, as the assessment framework can be adapted for other uses where fundamental rights are at stake.

The analysis suggests that the AI Act's assessments are fragmented and in-

adequately harmonized, partially because it is fundamentally different from what scholars and practitioners already experienced with the DPIA.

Each article addresses different aspects of risk management, which cannot be easily harmonised.
The impact of AI on fundamental rights often depends on the specific context of use, which is not fully captured in technology-centered or standardised assessments. Harmonisation requires a more flexible, context-sensitive approach that goes beyond procedural checklists and incorporates real-world factors, such as user demographics, societal impact, and deployment conditions.
The flow of information between the layers is crucial for a comprehensive risk management strategy. Technological Assessments should inform Conformity Assessments, and both should provide a foundation for FRIA. This requires clear communication channels and shared data standards to ensure that each layer benefits from the insights and findings of the others. Effective harmonisation demands expertise not only in technology but also in legal and ethical considerations. Standard-setting bodies, regulatory agencies, and AI providers must build capacity to assess fundamental rights impacts alongside technical performance, ensuring that assessments are robust, nuanced, and legally sound.

The three-layered risk assessment structure of the AI Act reflects a comprehensive approach to managing the diverse risks associated with AI technologies. However, the effective protection of fundamental rights requires a harmonised methodology that integrates technological, conformity, and rights-based assessments. This harmonisation should address gaps, enhance context sensitivity, and ensure that all layers of assessment work together to uphold the AI Act's overarching commitment to safeguarding fundamental rights in the digital age.

While the AI Act emphasises the need for tailored assessments that reflect the specific risks associated with each AI system, there is also a need for consistency in how fundamental rights are evaluated across different assessments. As Prof. Mantelero clearly writes[391]:

The first major difference with the traditional approach adopted in HRIA/FRIA is the focus on the AI product alone. This overlooks the fact that these products operate in a context, and that this contextual dimension, especially with regard to impact on individuals, is crucial for risk prevention. Article 9(3), limiting the risks to those which "may be reasonably mitigated or eliminated through the development or design of the high-risk AI system,

[391] see A. Mantelero, "The Fundamental Rights Impact Assessment (FRIA) in the AI Act - Regulation (EU) 2024/1689: Roots, Legal Obligations and Key Elements for a Model Template". *Computer Law & Security Review* 54 (September 2024): 106020. https://doi.org/10.1016/j.clsr.2024.106020.

or the provision of adequate technical in- formation", does not recognise that AI systems are often socio-technical systems. The design to consider is therefore not only the design of the AI system, but also62 the design resulting from the interaction and mutual modification that these systems generate in society. Thus it is not only the "development or design of the high-risk AI system" that is relevant but also the conditions of the context of use, which in some cases can also be appropriately modified to prevent risks, without changing the AI design.

This balance can be achieved through the development of methodological guidelines that allow for contextual adjustments while maintaining core principles of rights protection. More will said in Chapter 5.

4.3.4. Closing Remarks

The current AI Act focus on application-specific risks, while necessary, fails to fully address the systemic risks that AI poses, particularly as the technology becomes more integrated into critical aspects of the social infrastructure. One of the most pressing issues is that, as recent research has shown, hallucinations in large language models (LLMs) are not simply correctable dysfunctions, but are mathematically unavoidable elements[392]. LLMs operate by predicting word sequences based on probabilities derived from training data and are not inherently constrained by the need for factual accuracy. The lack of a "reality constraint" makes hallucinations, i.e., incorrect or invented outcomes, a structural feature of generative artificial intelligence systems. The implications are profound, especially when these systems are employed in fields where factual accuracy is critical, such as legal services, health care or public administration.

Luciano Floridi's concept of "hypersuasion"[393] is particularly relevant in this context, as it highlights the risks of AI systems - particularly those based on generative models - not only in terms of output, but also in their potential to manipulate and shape human behaviour. In his paper, Floridi argues that AI systems, particularly those embedded in ubiquitous platforms, have the ability to influence individuals on a massive scale through what he calls "hypersuasion", i.e. the ability to push or even coerce users into certain behaviours or beliefs, often without their awareness. This is not a purely theoretical risk, but a tangible one, especially as AI systems become increasingly integrated into the digital ecosystems that underpin public life.

[392] See Z. Xu, S. Jain, and M. Kankanhalli. "Hallucination Is Inevitable: An Innate Limitation of Large Language Models". arXiv, 2024. https://doi.org/10.48550/arXiv.2401.11817.

[393] see L. Floridi, "Hypersuasion – On AI's Persuasive Power and How to Deal with It". *Philosophy & Technology* 37, no. 2, 2024: 64, s13347-024-00756–6. https://doi.org/10.1007/s13347-024-00756-6.

A critical mechanism to mitigate these risks is the alignment process[394], in which AI systems are trained not only to optimise their performance based on technical metrics, but also to align with human values and social norms. In the case of LLM, alignment refers to the effort to reduce the likelihood of harmful or misleading results by refining models with positive and negative examples. The process can be extended to almost all AI as understood in common discourse. Post-training alignment is necessary because, although AI is able to operate with remarkable fluidity, its results are independent of ethical or moral, strictly human, evaluations. The fine-tuning process, often referred to as "reinforcement learning", involves the collection of specific examples of desirable and undesirable behaviour and the subsequent adjustment of the model. This process, however, is imperfect and cannot guarantee the complete elimination of risks such as hallucinations or biases inherent in the training data.

Although various regulatory frameworks, including those governing data protection (e.g. GDPR) and intellectual property (e.g. copyright law), provide guidance on what data can be used to train AI models, these frameworks are insufficient to ensure that AI systems are in line with broader societal values. As seen above, current regulations focus primarily on the inputs of AI systems - what data is allowed and under what conditions - without adequately addressing the outputs and behaviours of these systems. As a result, there remains a significant gap in the regulatory landscape in terms of controlling the alignment of AI systems with human values and community needs, such as when an entire city is involved.

To ensure the effectiveness of alignment efforts, several strategies must be implemented. One such strategy is the incorporation of continuous feedback loops from users. User feedback can be a valuable source of information to identify problematic behaviour or output generated by artificial intelligence systems. By analysing user interactions, developers can identify patterns that indicate a misalignment with user expectations or societal norms and adjust the system accordingly. However, relying solely on user feedback leads to a number of problems, particularly when users may not fully understand the complexity of the AI systems they interact with or recognise when an output is incorrect or harmful. Therefore, although user feedback is essential, it cannot be the only mechanism to ensure alignment.

To overcome this limitation, review and supervision by a group of experts can be envisaged. plays a crucial role in the alignment process. Experienced auditors, with specialist knowledge in the relevant field, are better equipped to assess the results of AI systems and identify potential risks that may not be immediately apparent to non-expert users. For example, in the le-

[394]see G. Iason, "Artificial Intelligence, Values, and Alignment". *Minds and Machines* 30, no. 3 (September 2020): 411–37. https://doi.org/10.1007/s11023-020-09539-2.

gal sector, experienced auditors with a legal background can assess whether legal advice generated by AI complies with applicable laws and ethical standards. Similarly, in the health sector, medical experts can assess whether AI-generated diagnoses or treatment recommendations are clinically valid.

However, even with these safeguards in place, it is essential to recognise that AI systems must still have the possibility of making mistakes. No AI system, no matter how well aligned it is, can be entirely error-free. Therefore, robust "Plan Bs" must be implemented to mitigate the impact of these inevitable errors.

However, beyond these technical and procedural approaches, it is urgent to consider the role of civil society in the alignment process. Alignment of AI systems should not be a "black-box" process conducted solely by developers, regulators or industry experts. On the contrary, alignment must be transparent and open to verification by civil society. This means creating mechanisms through which the public can observe, understand and criticise ongoing alignment processes. One promising avenue to enable such transparency is the use of digital tools that allow for real-time monitoring and evaluation of AI systems, as also suggested by Edwards about holistic DPIA. For instance, artificial agents from civil society could cyclically interrogate AI systems in order to examine the datasets used for training or testing the response in certain circumstances deemed critical. This transparency is essential to build public trust in AI systems and to ensure that these systems are truly aligned with the values and needs of the societies they serve.

Coming to the Digital Twin Cities, or urban digital twins, the principle of transparency must also extend to the administration itself. Just as the digital twin can provide the administration with a clear and comprehensive view of the city, the administration must in turn make itself transparent and accountable to citizens. This concept is in line with what has been described as "radical transparency"[395], according to which the more advanced and integrated a digital governance system becomes, the more it must open itself up to public scrutiny and input. By applying this principle to AI alignment, society can ensure that AI systems, particularly those with generative capabilities, are not only aligned with human values in theory, but are also accountable in practice.

[395]see the Swiss law "Federal Law on the Use of Electronic Means for the Fulfillment of Government Tasks" (EMBAG - Bundesgesetz über den Einsatz elektronischer Mittel zur Erfüllung von Behördenaufgaben, vom 17. März 2023 (Stand am 1. Januar 2024).

4.4. Simulation and Law (for DTCs)

Summary: 4.4.1. Digital Twin and Simulation - 4.4.2. Simulative Scenarios - 4.4.3. Simulation and the Compass of the Possible

4.4.1. Digital twin and Simulation

As discussed in section 3.4, Digital Twin Cities (DTCs) place significant emphasis on the simulation of scenarios. However, as previously mentioned, the term "digital twin" remains somewhat imprecise and warrants further conceptual refinement. The models proposed for digital twin cities do not adequately address how this concept is philosophically and conceptually embedded within the notion of the city itself.

While it may be premature to assert that the new capabilities of Urban Digital Twins (UDTs) define the future trajectory of cities, it is nonetheless possible to raise critical questions regarding the relationship between "simulation" and "law." Throughout this analysis, UDTs have often been viewed, perhaps reductively, as mere administrative tools. In this context, one might argue that the significance of such tools remains confined to the internal workings of municipal governance. The use of a particular software or service by the Administration would be of interest only when discussing issues related to ownership, licensing, cost, return on investment, or the practical benefits delivered—much like any other tool deployed in public administration or subject to public procurement. From this perspective, it could be inferred that the legal classification of these tools would be of limited interest to external parties.

However, this inquiry has sought to highlight the broader potential of UDTs, which extends far beyond their conventional administrative role. As explored in the preceding chapters, UDTs possess the capacity to become fundamental "building blocks" of the urban fabric, deeply embedding themselves into the structure and operation of cities according to their own design and functionality. This integration can profoundly affect the interests at stake, potentially influencing the very identity of the city itself—as exemplified by the case of "Virtual Singapore."

The risks posed to citizens, particularly in light of developments such as social scoring, are also noteworthy. Legislative frameworks have already imposed significant restrictions on such practices in response to the transformative potential of these tools, a potential that is recognized even though their development remains in its nascent stages. This transformative power suggests that UDTs, particularly in their more advanced iterations (which might correspond to TOGI maturity level 3), should not be reduced to mere

administrative tools. Instead, they demand recognition as a new conceptual category.

The deployment of UDTs, therefore, should not be perceived simply as the use of a tool, but rather as the incorporation of a genuine "constituent element" of the city—what we might aptly describe as a "twin" in the fullest sense. Regardless of the technical maturity of the digital twin, it transcends its functional role, evolving beyond the confines of the municipal office to become "something more". This "something more" is deeply connected to the nature of knowledge and our relationship with it, as articulated by Professor Tagliagambe[396].

Law, however, has not yet adequately engaged with this phenomenon to the extent that it ought to.
A possible path for exploration is, however, offered by Prof. Floridi through the recalling of John R. Searle's distinction between "regulative rules" and "constitutive rules"[397].

John R. Searle's paper *"Constitutive Rules"* offers an in-depth philosophical framework that is crucial for understanding how various types of rules shape behaviours and institutions, both in the physical and digital realms. While the original context of the paper focuses on social institutions like governments, legal systems, or games such as chess, its insights can be seamlessly applied to modern innovations like Digital Twin Cities or systems of Urban Digital Twins. In such a context, the types of rules Searle defines—constitutive rules, regulative rules, and deontic powers—can help explain how digital systems structure, manage, and give meaning to urban environments.

In particular[398], formalising the "constitutive rules" of a city could overcome the "regulatory rules" (descriptive, such as sanctions and rewards, of the type *if..., then...*") and then really make the digital twin an ongoing experimentation / simulation, to try out future scenarios and then reduce the costs of development, experimentation, and "side-effects" costs.

In a Digital Twin City, constitutive rules would be the rules that define and create the digital infrastructure and behaviours unique to the twin. These rules do not just regulate how existing urban processes are mirrored in the digital environment but, instead, create entirely new layers of reality that augment and transform the city's operation. For example, in a Digital Twin City, sensors and algorithms continuously generate data on traffic patterns.

[396]see S. Tagliagambe. *Metaverso e gemelli digitali. La nuova alleanza tra reti naturali e artificiali.* Mondadori Università, 2022

[397]see J. R. Searle, "Constitutive Rules". Università degli studi di Sassari, 2018. https://doi.org/10.14275/2465-2334/20187.SEA.

[398]The passage is expressly rooted in a brief dialogue between the author and Prof. Floridi on the sidelines of a doctoral lecture.

The constitutive rule in this context could be the one that states, "Real-time sensor data counts as actionable traffic management information in the digital twin environment." This rule not only mirrors physical traffic flow but also creates a new digital dynamic that can autonomously adjust signals, reroute vehicles, or optimize energy consumption. Without such constitutive rules, the data collected by sensors would simply be raw information without any operational significance. By defining how digital representations of the physical city function within the twin, constitutive rules create the very possibility of managing and altering the city's performance in real-time through the digital layer.

Moreover, constitutive rules in a digital twin system extend beyond immediate, practical applications. For example, the model of a bridge within the digital twin is more than just a visual representation; it is "constituted" by rules that define how digital stress analysis or environmental factors (like wind or traffic) impact its real-world counterpart. The rule "This digital representation of the bridge, when simulated under specific conditions, counts as predictive maintenance data for the real bridge" enables the digital twin to create an entirely new method of urban management that wouldn't exist without this digital-physical interconnection.

Regulative rules, on the other hand, come into play when existing urban behaviours or systems are mirrored and optimized within the digital twin. These rules govern pre-existing activities, providing guidelines and constraints to ensure proper operation within both the digital and physical spaces. For instance, in the case of urban traffic, a regulative rule could be "The traffic lights must switch to red when the pedestrian crossing signal is activated." This rule does not create new traffic behaviours; it regulates the flow of traffic that already exists, whether the city is digitally represented or not. In a Digital Twin City, such regulative rules would still apply, but they might be dynamically managed or adjusted by the digital twin to improve efficiency, reduce congestion, or enhance safety. The key here is that regulative rules govern actions that have a pre-existing reality—such as vehicles moving through a city—but they allow these behaviours to be more effectively managed within a digitally augmented system.

In an Urban Digital Twin, these regulative rules could also govern how data flows and interacts between various digital subsystems. For example, a rule might state, "Traffic data from sensors must be transmitted to the central server every five seconds." This rule is regulative because it does not create new traffic patterns but ensures the proper functioning of the system by regulating the frequency and accuracy of data transmission.

Finally, deontic powers in a Digital Twin City would refer to the rights, duties, obligations, and permissions that are created by the constitutive rules of the system. Deontic powers give actors within the system, whether they

are city managers, government entities, or even automated systems, specific rights and responsibilities. For instance, the system might grant a city planner the right to alter the layout of a virtual traffic grid based on real-time data, or an autonomous system might have the duty to reroute emergency vehicles during a crisis. These rights and obligations, made possible by the constitutive rules of the digital twin, represent a new layer of governance and control that exists within the urban infrastructure.

In this way, deontic powers are central to how a Digital Twin City operates and evolves. The planner's obligation to ensure energy efficiency, for example, might be tied to the digital twin's continuous simulation of energy use across the city. A constitutive rule such as "Data from smart meters counts as an indicator of energy consumption efficiency" generates a deontic power —the obligation for the city to adjust heating or cooling systems in real-time to conserve energy. These powers are critical because they provide "desire-independent reasons for action," meaning that decisions within the digital twin environment are driven by rule-based obligations rather than subjective desires.

Another significant insight from Searle's paper is how constitutive rules are recursive and scalable. In a system as complex as an Urban Digital Twin, constitutive rules can build on each other in layers, creating vast, interconnected systems of reality. For example, at the foundational level, "A digital sensor reading counts as valid data" might be the initial rule. This data could then be built upon: "Valid data about air quality counts as a trigger for adjusting urban green spaces." Then, at a higher level, "Adjustments in green spaces based on air quality data count as regulatory compliance with environmental law." This cascading effect illustrates how constitutive rules enable the Digital Twin City to scale upward and manage increasingly complex urban tasks.

Searle also argues that constitutive rules require language for representation. In a Digital Twin City, this "language" could be interpreted as the various forms of digital code, communication protocols, or data models that represent and simulate the physical city. Just as constitutive rules in human society require language for their representation (e.g., contracts, legal codes), the rules governing a Digital Twin City require an advanced form of digital language—algorithms and models that can interpret sensor data and take autonomous actions. Without this digital representation, the twin would be inert, unable to function or create the deontic powers necessary for urban governance. The very act of defining "X counts as Y in context C" within a digital system requires a sophisticated framework of data representation, coding, and modelling.

In the context of a Digital Twin City, Searle's concepts of constitutive rules, regulative rules, and deontic powers can be directly applied to explain how

these systems function and create new urban realities. Constitutive rules define how digital simulations and models not only represent the physical city but actively constitute new methods of managing and improving urban life. Regulative rules ensure that existing behaviours—whether traffic flow or data transmission—are properly managed within this digital framework. Finally, deontic powers define the rights and responsibilities of actors within the system, allowing for sophisticated governance and real-time decision-making that fundamentally alter how cities are managed in the digital age. This philosophical framework provides a robust theoretical lens through which we can better understand the architecture and power dynamics of Urban Digital Twins.

The difficulty of correctly identifying the "constitutive rules" does not allow us to abandon the discussion, especially in view of the massive use of UDTs.

Taking a cue from philosophical literature, UDTs can be compared to Karl Popper's "World 4"[399], which acts as an interface between human perception and reality.

- World 1: The World of Physical Reality.
  This world includes all physical and material entities, such as objects, natural processes, living organisms and anything that exists independently of human beings. It is the objective reality that surrounds us and that we perceive through our senses.
- World 2: The World of Mental States
  This is the world of psychological processes, subjective experiences, emotions, thoughts and consciousness. It includes everything that takes place within an individual's mind, such as perceptions, desires, fears and dreams. It is the world of subjectivity and personal experience.
- World 3: The World of the Products of the Human Mind.
  World 3 concerns objective knowledge and the products of the cognitive activities of human beings, such as scientific theories, works of art, philosophical ideas, social institutions and cultural structures. It is a world that, although originating from the human mind, has a certain independence because ideas and knowledge can be shared, analysed and developed by others.

Tagliagambe writes: the "digital twin" enables such an analysis of data and monitoring of systems in the physical world that it is possible to reason in

[399]Not much will be said about the relationship between Digital Twin and Metaverse in this work, as it is beyond the scope of this one. It is clear, however, that in his book 'Metaverse and Digital Twins' Prof. Tagliagambe uses the two terms as synonyms, and certainly the analysis he offers of 'World 4' fits perfectly with what is meant in this work by 'Digital Twin' or 'Urban Twins'.

a predictive mode. There are two points to be touched on: - "digital twin" and its relationship with the physical world (in our case, the city) - what we mean by predictive mode, and hence by prediction applied to the city[400].

The implications of this qualification are important. This analogy greatly emphasises their dual role as:

- "collective intelligence" (or "swarm intelligence")[401]
- as a dynamic simulation that influences the very city it represents[402]

However, the intersection between this powerful "World 4" and the law presents challenges, as legal frameworks traditionally do not accommodate hypothetical or experimental entities, unless (but still exploratory) they are legislative sandboxes.

As Chapter 4 began, the evolving nature of UDTs requires a re-evaluation of legal perspectives in order to exploit their full potential while ensuring compliance and ethical governance.

4.4.2. Simulative Scenarios

UDTs' ability to simulate scenarios provides unprecedented opportunities for urban planning and decision-making. By modelling potential outcomes, they allow stakeholders to foresee the impacts of various interventions before implementation. Yet, this capability raises complex legal questions.

The law typically requires tangible evidence and concrete data, while UDTs operate in a realm of possibilities and projections. This discrepancy necessitates innovative legal approaches to accommodate these digital constructs within existing regulatory frameworks.

Simulation is functional to - reduce costs without reducing experimentation - extend experimentation - evaluate the performance of different scenarios under multiple conditions - assess possible side effects of smart city projects

The topic is connected with the problem of "agency" and the problem of using extensively synthetic data.

The agency of individuals involved in city management can be significantly impacted by the digitisation of administrative processes and predictive tools. These technologies, while designed to enhance efficiency, can inadvertently undermine the decision-making autonomy of city officials. For example, predictive policing models have been implemented to anticipate crime hotspots, but they can lead to resistance among officers who feel their professional

[400] This topic will be addressed in Chapter 5 - see Predictivity-Reactivity in 3.4.
[401] the implications will discussed in Chapter 5, and in particular in 5.2.1.
[402] as discussed in 3.2.4.

judgment is being overridden by algorithmic suggestions. This phenomenon was observed with police officers who rejected "gamified patrolling" systems, which they perceived as diminishing their agency and expertise[403].

The digitisation process often involves the use of automated systems that prioritize data-driven decisions over human intuition. While this can streamline operations, it may also lead to a reliance on technology that reduces the perceived value of human input. This shift can cause frustration and disengagement among staff, as their roles become more about following algorithmic recommendations rather than exercising professional judgment[404].

Synthetic data plays a crucial role in training AI models used in city management simulations. It is artificially generated to mimic real-world data, providing a cost-effective and privacy-preserving alternative to collecting large datasets. However, relying exclusively on synthetic data can present challenges:

1. Performance Concerns: Systems that depend solely on synthetic data might not perform as effectively as those trained with real-world data. Synthetic data may lack the complexity and nuances of actual scenarios, leading to models that do not generalize well to real-world applications[405].

2. Data Pollution: The use of synthetic data in AI training can lead to "data pollution", where models trained on self-generated data lose touch with reality. This issue arises when synthetic data is not carefully balanced with real-world data, potentially degrading model performance over time[406].

4.4.3 Simulation and the Compass of the Possible

French scholar Mireille Delmas-Marty offer with the "compass of the possible" a guiding tool through uncertainties, promoting flexibility, innovation, and adaptation while harmonising universal human rights with cul-

[403] see G. Suffia, A. Lavorgna, S. Icardi, *Polizia "smart" tra paure e realtà: un'analisi esplorativa sulla rappresentazione mediatica dello smart policing in Italia*, Studi sulla questione criminale, XVII, n. 3, Carocci Editore SpA, 2022, (ISSN 1828-4973) pp. 95-116.

[404] on this point, see for example M. Ferraris. *Documanità: filosofia del mondo nuovo.* I Robinson. Bari: GLF editori Laterza, 2021.

[405] see X. Xing, F. Shi, J. Huang, Y. Wu, Y. Nan, S. Zhang, Y. Fang, et al. "When AI Eats Itself: On the Caveats of Data Pollution in the Era of Generative AI", arXiv, 25 July 2024. http://arxiv.org/abs/2405.09597. or Nature, "Garbage out" # Volume 631 Issue 8022, 2024 (https://www.nature.com/nature/volumes/631/issues/8022).

[406] see X. Xing, F. Shi, J. Huang, Y. Wu, Y. Nan, S. Zhang, Y. Fang, et al. "When AI Eats Itself: On the Caveats of Data Pollution in the Era of Generative AI", arXiv, 25 July 2024. http://arxiv.org/abs/2405.09597. or Nature, "Garbage out" # Volume 631 Issue 8022, 2024 (https://www.nature.com/nature/volumes/631/issues/8022).

tural diversity. In the work titled *"Una Bussola dei Possibili"*[407], curated by Emanuela Fronza and Carlo Sotis, it is presented the exploration of global governance and juridical humanism in the face of globalisation's challenges which characterised the work of Mireille Delmas-Marty.

Delmas-Marty emphasizes the necessity for legal frameworks that uphold human rights, environmental protection, and social justice. The work is structured around three core objectives: resisting dehumanisation, holding global actors accountable, and anticipating future risks. In the section on anticipating future risks, Delmas-Marty provides a forward-looking analysis of how legal systems must evolve to address emerging global challenges effectively. She identifies three layers of tools essential for anticipation: empirical, axiological, and formal.

Empirical Tools involve using data and scientific research to understand threats like climate change and technological disruptions. These tools leverage big data and technological monitoring to integrate scientific advances into policymaking. This approach is crucial for analysing risks such as environmental degradation and social inequities.

Axiological Tools are value-driven, focusing on shared ethical values that should guide global governance. Delmas-Marty stresses the importance of establishing common ethical commitments to address issues like biodiversity loss and rising authoritarianism. This involves a delicate balance between universal human rights and diverse cultural practices.

Formal Tools consist of legal mechanisms such as treaties and regulatory frameworks that need to be adaptable to changing global dynamics. Examples include international institutions like the International Criminal Court, which require flexibility yet enforceability to manage evolving global challenges.

Delmas-Marty also highlights the interconnectedness of global actors and warns against the fragmentation of international cooperation due to nationalism and populism. She advocates for a multi-level governance approach to manage these complexities effectively. Furthermore, she addresses technological and environmental risks by advocating for legal frameworks that balance innovation with ethical considerations.

The "compass of the possible" does not point in a fixed direction but encourages an adaptable approach to governance that can stabilize without immobilising societies.

In a bewildered world, the compass of humanism does not aim to predict

[407] see M. Delmas-Marty, *Una bussola dei possibili.* Edited by Emanuele Fronza and Carlo Sotis, 1088press Alma Mater Studiorum – Università di Bologna, 2021. https://doi.org/10.12878/1088pressbyte2021_1.

or prescribe a still virtual world order, but to resist violence by unmasking ongoing dynamics to reconcile opposing winds such as:

- security/freedom (principle of equal dignity)
- competition/cooperation (principle of solidarity);
- exclusion/integration (principle of hospitality);
- innovation/preservation (creativity principle)

- Figure 5 - Wind rose of globalisation. The main winds: security, competition, freedom and cooperation and the "winds between the winds", resulting from the intersection of the main winds, such as exclusion, innovation, integration and preservation[408].

In practical terms, using the "compass of the possible" involves fostering legal systems that are dynamic and responsive to rapid changes while main-

[408]see M. Delmas-Marty, *Una bussola dei possibili.* Edited by Emanuele Fronza and Carlo Sotis, 1088press Alma Mater Studiorum – Università di Bologna, 2021. https://doi.org/10.12878/1088pressbyte2021_1., pag. 69.

taining ethical responsibility towards future generations. Delmas-Marty's work is a call for proactive governance that anticipates challenges in a humane and adaptive manner, considering long-term impacts on global communities, including non-human life and future generations.

Chapter 5

5.1. The Two Ways

Summary: 5.1.1. The Two Ways (Not Everything is Governable) - 5.1.2. Principles for the Design of a Digital Twin City (1) - 5.1.3. Principles for the Design of a Digital Twin City (2)

5.1.1. The Two Ways (Not Everything is Governable)

In this chapter, I evaluate the possibility of combining the outcomes and results of the literature review with the proactive approach to law. From the literature and legal analysis on Digital Twin Cities, or Urban Digital Twins, three problems emerged:

1. The Maturity levels found in literature for describing the Digital Twin Cities are not automatically aligned to other frameworks, like the AI Act Risk based system. Major adaptations are then needed.
2. Literature on AI systems is dominated by sectoral analyses. There's a recognised lack of systemic analyses or systemic risks evaluations.
3. The fight against inequalities finds difficulties in a European legal framework that, for the most, deals with formal equality and not substantive equality.

All three problems can be addressed by a coherent, European strategy on Digital Twin Cities. However, such a strategy necessitates a high degree of coordination, political alignment, and potential regulatory interventions, making its implementation particularly complex.
First, the coordination of numerous actors is required. As seen, the development of Digital Twin Cities involves a wide array of stakeholders, including municipal governments, national and EU policymakers, private-sector technology providers, research institutions, and civil society organisations.
Second, both governance and political alignment across Europe are essential. The effectiveness of a Digital Twin Cities strategy depends not only on technical and financial feasibility but also on the willingness of European policymakers to prioritise and sustain long-term investment in inclusive digital urban infrastructure.
Third, legal and regulatory interventions may be necessary. Existing legis-

lation, despite being numerous and highly detailed, may not fully be able to tackle inequalities in the urban context effectively. The introduction of new regulations or modifications to enforcement mechanisms might be required to ensure compliance with the GDPR principles, enhance data-sharing protocols, and create standardised governance frameworks for inclusive cities managed by effective digital technology.
Despite these complexities, an adaptive framework may already offer solutions to mitigate the three problems by providing structured guidance on governance, collaboration, and legal adaptation. By leveraging flexible implementation pathways and fostering a shared knowledge base, an adaptive approach could enable cities to navigate these obstacles.
The adaptive framework that will be outlined in this chapter aims to be a basis on which, with a rather limited intervention, exponential effects can spread alongside the pipeline of designing a Digital Twin City in Europe.

While the supranational and national strategy provides a prescriptive framework, the regional and local tactics[409] involved will adapt and negotiate this framework to fit local contexts, leveraging existing infrastructures, and mobilising resources to achieve the desired objectives.

This approach highlights the importance of flexibility and adaptability in managing complex information infrastructures in public initiatives.

The digital transformation of cities, facilitated by technologies like Urban Digital Twins, offers vast potential for improving urban governance. Yet, the profound question remains: are these technologies inherently inclusive, or do they risk perpetuating existing urban inequalities? Addressing the problem of inequality in cities, as seen, is not just an ethical imperative; it is the keystone to overcoming the current limitations of urban digitisation.

The ambitious project of constructing a digital city must take into account both the technical and human dimensions of urban spaces to avoid reinforcing disparities and exclusions. Digitisation as it stands today primarily leans towards optimising the mechanical aspects of cities—factors that are quantifiable and manageable through data flows, such as traffic systems, energy efficiency, and waste management. However, this narrow focus often overlooks the organic aspects of the city, which encompass human behaviours, democratic participation, and socio-cultural experiences. These organic facets are crucial to achieving genuine inclusivity and social equity.
In European countries, the challenge of urban inequality is compounded by

[409] see A. Resca, M. Grisot, and M. Velicogna. "Building Smarter Healthcare for Smart Cities: Investigating the Infrastructural Dimension of Smart Services Provision Through an e-Prescription Case Study". In Setting Foundations for the Creation of Public Value in Smart Cities, edited by Manuel Pedro Rodriguez Bolivar, 35:117–35. Public Administration and Information Technology. Cham: Springer International Publishing, 2019. https://doi.org/10.1007/978-3-319-98953-2_5.

the ambiguous conceptualisation of equality itself, oscillating between formal and substantive approaches. Formal equality aims for equal treatment under the law, which, while necessary, is insufficient to address the complex socio-economic and cultural inequalities that manifest in urban spaces. On the other hand, substantive equality requires positive interventions to rectify imbalances, ensuring that all residents, regardless of socio-economic background, can enjoy equal opportunities and outcomes. The uncertain qualification of these inequalities—whether cities should focus merely on legal parity (formal equality) or also on proactive measures for equity (substantive equality)—limits the efficacy of current digital interventions.

In this context, digital twins and smart technologies often exacerbate inequalities[410] rather than mitigate them, as they tend to serve those who are already well-positioned within the formal systems of governance and access. Thus, the philosophical and sociological debate surrounding equality must extend into urban policy, particularly in the digital age. Philosophical and sociological considerations introduce a fundamental question that must guide the architecture of the digital city: Is the digital serving the mechanical or the organic aspect of the city?

This distinction is not simply conceptual; it holds practical consequences for urban governance and the design of smart cities. Philosophically, Luciano Floridi's concept of the infosphere and Maurizio Ferraris's concept of dochumanity suggests that the digital layer is not separate from the human experience but is deeply embedded within it. Urban Digital Twins and similar technologies influence the very nature of our interactions with physical spaces. This interconnectedness necessitates a rethinking of whether digital systems are there to regulate, optimize, and control (serving the mechanical aspect), or whether they should enrich, democratize, and humanize urban life (serving the organic aspect).

From a sociological standpoint, concepts like governability and the new urban question present cities as complex socio-political entities rather than mere aggregates of infrastructure. Governability emphasizes the challenge of governing dynamic and often unpredictable urban populations, suggesting that digital technologies need to empower human agency rather than constrain it through rigid control systems. The new urban question explores the evolving nature of inequality and social justice in a rapidly digitising world, highlighting the need to address not just economic and spatial disparities but also the risks posed by an increasingly algorithmic governance model. The core challenge lies in how we encode the city digitally—that is, how we model, represent, and act upon urban environments through digital systems.

[410] See V. Eubanks, *Automating Inequality: How High-Tech Tools Profile, Police, and Punish the Poor*. First Picador edition. New York: Picador St. Martin's Press, 2019.

The encoding must balance what Mireille Delmas-Marty calls the "winds of mondialization": in particular balancing attractiveness and inclusivity.

The mechanical aspect of the city, which includes elements like traffic flow, energy consumption, waste management, and climate monitoring, naturally lends itself to formal digital systems. These aspects can be quantified, optimized, and managed through data-driven processes that enhance efficiency and make the city more attractive to businesses, tourists, and investors. The current trajectory of urban digitisation focuses heavily on these mechanical dimensions, enhancing a city's allure by making it smarter, more efficient, and better organised.
However, the organic aspect of the city involves the human factor—people's behaviours, their right to self-determination, and their capacity for democratic control over the technologies that shape their lives.
Inclusivity cannot be achieved through formal systems alone. It requires a preservation of informality, a respect for unpredictability, and a recognition of the value inherent in social diversity. Technologies designed to manage cities must therefore account for this organic complexity, creating spaces where individuals and communities feel empowered rather than merely managed.

For a city to thrive in the digital age, it must be both attractive and inclusive. The mechanical components of urban life must be optimized to increase a city's attractiveness—its capacity to offer efficient services, manage resources sustainably, and foster economic growth. Digitisation, as it currently stands, is well-suited to this task; it employs formal equality mechanisms that apply consistent rules and standards across urban systems to improve efficiency and reliability. Inclusivity, however, must be approached differently. It requires recognising and preserving the organic elements of the city, ensuring that digital transformation does not erase the informal social networks and community dynamics that give cities their unique character. This involves embracing informality within governance, allowing for bottom-up innovations, community-driven projects, and participatory decision-making processes. The organic elements of the city—public spaces, cultural practices, and the social fabric—must be nurtured in ways that resist purely technocratic control and instead promote meaningful civic engagement. The future of urban digitisation depends on our ability to navigate the delicate balance between the mechanical and organic dimensions of cities. While optimising mechanical processes through digitisation is essential for making cities more efficient and attractive, achieving true urban equality demands a broader vision—one that encompasses both formal systems of control and informal practices of inclusion. Cities must not become digital machines devoid of human warmth and diversity. Instead, they should be living entities where digital technologies serve not only to manage but also to empower communities, cultivate inclusivity, and celebrate the

human experience in all its complexity. It is only by embracing both the quantifiable and the unquantifiable, the mechanical and the organic, that we can hope to build cities that are both smart and just, both efficient and humane.

5.1.2. Principles for the Design of a Digital Twin City (1)

The maturity models of digital twin maturity helps to contextualise the discussion of inclusivity versus attractiveness within five distinct maturity levels.
At Maturity Level 1 (of the TOGI model, taken as example for the less nuanced division), cities are primarily focused on digitising existing processes, creating basic models that replicate the physical city without any real-time interaction. This level serves mainly the mechanical aspects by digitising infrastructure but lacks any organic, human-centered element. Maturity Level 2 introduces connectivity between systems, enabling data flow between different urban components. However, it remains largely mechanical, as data integration is primarily used to optimise flows like traffic or energy consumption, still not addressing the nuanced needs of human agency. Maturity Level 3 marks a significant shift, as digital twins begin to incorporate predictive capabilities, allowing cities to foresee possible scenarios and adjust policies proactively. At this level, there is a nascent engagement with organic aspects, as prediction can help address social inequities, but the main focus is still efficiency. Maturity Level 4 involves comprehensive interaction and integration, where real-time adjustments can be made, and citizens start interacting more directly with digital systems. This level is where the organic dimension gains importance, as there is a stronger focus on citizen participation and the democratic control of urban technologies. Finally, Maturity Level 5 envisions digital twins as fundamental building blocks of urban life, where the mechanical and organic aspects are fully intertwined. At this level, technology serves to not only optimise flows but also to empower citizens, enhance democratic engagement, and support the socio-cultural fabric of the city. This comprehensive maturity framework highlights the evolution required for cities to become truly inclusive digital entities that embrace both efficiency and humanity.

If a Digital Twin City is marked as Maturity Level 3 (or more), it becomes essential to conduct a comprehensive assessment that determines whether the primary goal of digital initiatives is to enhance the city's attractiveness or to foster inclusivity, and whether the interventions target a mechanical or organic component of the city. This distinction is crucial because, as identified earlier, there is a strict connection between the mechanical/formal aspects, which aim at attractiveness, and the organic/informal aspects, which aim at inclusivity.

For cities at Maturity Level 3 or higher, it is no longer sufficient to pursue a one-size-fits-all approach; instead, interventions must be tailored based on the specific needs and characteristics of both the mechanical and organic dimensions. If the assessment reveals that the focus is on attractiveness, the approach should prioritise optimising systems like transportation, energy efficiency, and infrastructure management, all of which contribute to the mechanical efficiency and allure of the city. These aspects, often data-driven and quantifiable, can enhance the city's appeal to investors, tourists, and residents by creating a well-functioning, smart urban environment.

If a Digital Twin City is managing systems and optimising the mechanical parts of the city, the intervention (i.e., the encoding of the city) must follow the guiding concepts of 'formality' and 'attractiveness'. The balance here is to ensure that the digital encoding strictly respects and primarily impacts only the mechanical components of the city without expanding into, or compromising, the organic components. This means that the intervention must be controlled so as not to inadvertently affect the social and human aspects of urban life. Conversely, if the encoding is primarily directed towards the organic parts of the city, the focus should be on protecting these organic components, fostering informality, and promoting inclusivity. This requires designing interventions that actively safeguard community dynamics, cultural practices, and democratic engagement, ensuring that the technology enriches rather than diminishes the human experience.

Ultimately, a DTC at Maturity Level 3 or higher requires nuanced and multidimensional approaches. These approaches must ensure that technological advancements do not merely optimise urban systems but also promote social equity, democratic participation, and human well-being. By understanding and respecting the balance between the mechanical and organic dimensions of the city, urban planners and policymakers can design interventions that enhance efficiency without compromising inclusivity. This balanced approach ensures that digital progress serves all citizens equitably, upholding social justice and fostering a sense of belonging and engagement in the digital urban landscape.

5.1.3 Principles for the Design of a Digital Twin City (2)

What we have described until now can be considered a *Proportionality Assessment* (or other formula that might be favoured in the debate), which acts as a foundational building block for a more comprehensive Fundamental Rights Impact Assessment (FRIA) under the AI Act.
The *Proportionality Assessment* serves to evaluate whether digital interventions within a city maintain an appropriate balance between enhancing attractiveness (mechanical aspects) and promoting inclusivity (organic aspects).

As seen, a well-structured FRIA should[411]: 4. Define the system's purpose and tasks; 5. Assess the technology used and data processing methods; 6. Identify rights impacted and specific contractual terms; 7. Determine the responsibilities of key stakeholders; 8. Establish internal governance mechanisms within the implementing organisations.

The proposed assessment can be seen as an integration of the early phases of the EU's FRIA, or a critical passage of it, capable of spreading exponential effects on the following stages of the process. It helps ensure that interventions do not disproportionately affect marginalised communities or compromise human dignity and democratic participation in favour of efficiency.

This intervention is needed to address the cited three problems at the opening of this chapter, considering the complexity of interactions within the digital urban environment; the rights and interests at stake; the difficulty (or impossibility) of avoiding involvement for citizens in some form of digital control, due to the absence of "opt out" solutions of these systems.

Some considerations emerge. The described *Proportionality Assessment* directly impact the outcome of the evaluation process over the digitisation. This assessment, once initially intersected with the literature and the actual cases of digitisation, suggests a framework to determine how Urban Digital Twins serve either the mechanical or the organic facets of the city, ensuring that the implementation respects and balances these aspects.

The "Triple Equation" -that constitute a new knowledge hypothesis on how the city is encoded- is formulated as follows:

a) The UDT manages a component of the city that can be described as a mechanism.

- The intervention introduces Formality (the aim is to boost Attractiveness)
- The intervention, to be effective, must be Centralized
- The intervention, to be effective, must be Top-down

  → The primary concerns in this type of "city encoding" must be in Controlling the mechanism (both controlling if the tool is capable to control the mechanical component of the city)

b) The UDT manages a component of the city that can be described as an organism.

[411] See S. Abbady, *The EU Artificial Intelligence (AI) Act: A Commentary.* Edited by Ceyhun Necati Pehlivan, Nikolaus Forgó, and Peggy Valcke. Alphen aan den Rijn: Wolters Kluwer, 2025, p. 129.

- The intervention introduces Informality (the aim is to boost Inclusivity)
- The intervention, to be effective, must be Decentralized
- The intervention, to be effective, must be Bottom-up

  → The primary concerns in this type of "city encoding" must be in Preserving the organism (controlling that any digital tool or instrument is affecting the *organic life* of the city)

These two aspects —mechanical and organic— define how cities can be encoded through digital systems. When a UDT intervention focuses on mechanisms, it must adhere to the principles of formality and attractiveness, which include centralisation and top-down approaches to improve efficiency and enhance the city's allure. The aim here is to optimise mechanical processes such as infrastructure management, transportation flows, and environmental control, ultimately making the city more structured and appealing for growth and investment. The balance of this approach is to ensure that the digital encoding strictly affects the mechanical parts of the city, without encroaching upon or compromising the organic aspects, which are crucial for human agency.

Conversely, when the UDT is serving the organism, the intervention must prioritise preserving the organic aspects of urban life, which are characterised by informality, inclusivity, and bottom-up governance. The focus here is on ensuring that digital transformation supports community cohesion, democratic participation, and social diversity. It is about safeguarding the informal networks, cultural practices, and public engagement that make a city vibrant and inclusive. This approach decentralizes decision-making, empowering citizens to take an active role in shaping their urban environment, thereby maintaining the essential human-centric elements of the city.

This Triple Equation serves as a guiding principle for encoding the city through digital transformation, balancing the mechanical needs for efficiency and attractiveness with the organic requirements for inclusivity and human flourishing. This balanced approach ensures that digital technologies enrich rather than undermine the urban experience, upholding the fundamental rights of all citizens in a digitally transformed city.

5.2. The Actors and the Two Ways

Summary: 5.2.1. The Actors and the Two Ways - 5.2.2. Four Scenarios - 5.2.3. Limitations and Further Research - 5.2.4. Closing Remarks: Integrating Formal and Informal Digitisation in the Twin City Governance

5.2.1. The Actors and the Two Ways

To reconstruct city governance effectively, the proposed analysis on the "two ways" in which the city's encoding is done have to intersect with the city's complexity. The prominent characteristic that shapes this complexity is the very foundational level of each city: the variety of actors that form the core of urban dynamics.
As suggested by Alois Paulin in his work, understanding the "Atoms"[412] of governance allows for a more nuanced approach to structuring how cities are managed in the digital age. These "Atoms" represent the smallest, indivisible units that collectively create the intricate ecosystem of governance, especially when considering digital tools like Urban Digital Twins (UDTs). Building on findings in literature around "swarm intelligence"[413], this new adaptive framework proposes categorising these governance elements into Primary, Secondary, and Tertiary Actors, which together offer a blueprint for reshaping city governance based on their roles and interactions.

1. Primary Actors or Essential Actors: The Atomic Elements of a City

Primary Actors are those foundational elements that exist inherently within the physical and social structure of a city. They include the citizens, public officials, and the social institutions that traditionally form the governance framework—such as schools, courts, healthcare providers, and public utilities. These actors are deeply embedded in the tangible reality of the city and are essential for ensuring that the governance reflects the real needs and rights of people living within the city. They operate based on the principle of "presence" in the urban space, actively participating in and shaping the lived experience of a city. In Paulin's vision, these Primary Actors are the human agents empowered to provide and sustain public services and social functions. Moreover, Primary Actors can express the principle of Proactivity in Public Services by anticipating community needs and deploying services that proactively address those needs before problems arise. This includes

[412] See informability in A. Paulin, "Informating Smart Cities Governance? Let Us First Understand the Atoms!", *Journal of the Knowledge Economy* 7, no. 2, 2016: 329–43. https://doi.org/10.1007/s13132-016-0368-6.

[413] See S. Capaccioli, "Blockchain, Bitcoin and Stigmergy: An Explanation and a New Perspective for Regulation". *BioLaw Journal - Rivista Di BioDiritto*, 2 July 2020, 467-476 Paginazione. https://doi.org/10.15168/2284-4503-672.

efforts such as preventive healthcare, preemptive traffic management, and community outreach programs that leverage real-time data.

2. Secondary Actors or Native Actors: Present Exclusively Inside the DTC

Secondary Actors are native to the Digital Twin City (DTC) environment and do not have a direct physical counterpart. These actors are algorithms, software systems, and digital tools that are designed specifically for governance processes. They include automated monitoring systems, AI-based prediction tools, digital platforms that help manage urban infrastructures such as traffic systems, energy distribution, and waste management, as well as AI Agents. AI Agents operate both on behalf of Public Authorities and Civil Society. AI Agents from Public Authorities are typically focused on efficiency, optimisation, and real-time governance, expressing Proactivity in Public Services by using predictive models to foresee issues like potential infrastructure failures or traffic bottlenecks and intervening before they become serious problems. Meanwhile, AI Agents from Civil Society play a critical role in maintaining transparency, accountability, and citizen empowerment. These agents perform a vast range of activities such as controlling public spending, overseeing the actions of the Public Authority, testing different solutions, and proposing improvements to City Administration. Importantly, AI Agents from Civil Society work following the principle of "generating data" from citizens rather than "extracting data" from them, ensuring a participatory and ethical approach to data collection and governance. This proactive data generation is a powerful tool that allows communities to voice their needs and concerns, directly influencing the digital governance process. While Secondary Actors are not present in the tangible aspects of the city, they provide critical functionality to optimize and manage the urban landscape. They represent the digital-first layer of governance, operating in real-time to ensure efficiency, inclusivity, and control over various urban systems.

3. Tertiary Actors or Connectors: Creating Links Between Primary and Secondary Actors

Tertiary Actors are connectors between Primary Actors (actors which exist in the real world) and Secondary Actors (actors which exist in the digital replica of the city). They enable the interaction and integration between people and technology, ensuring that the governance mechanisms reflect both human needs and the capabilities offered by digital tools. Examples of Tertiary Actors include IoT devices, urban data sensors, and communication platforms that facilitate interactions between the physical and digital domains. The Tertiary Actors play a critical role in aligning the Digital Twin City (DTC) with the expected outcomes, especially when considering the input from numerous AI Agents, each performing different tasks within

the digital city environment.

With so many AI Agents operating simultaneously, the challenge becomes aggregating their diverse outputs and ensuring they contribute to coherent, actionable decisions. Tertiary Actors are primarily responsible for this alignment—integrating and synthesising data and insights from Secondary Actors to ensure that the DTC effectively serves the goals set by urban governance and community needs. They work to ensure that the proactive measures envisioned by Public Authorities and the activities carried out by AI Agents are effectively integrated into a cohesive governance strategy that benefits all stakeholders. These connectors are essential for translating real-world inputs into data that can be processed by the DTC, as well as ensuring that decisions made in the digital space can be effectively implemented in the physical world. In Paulin's framework, these connectors embody the concept of governance "informatisation," where human experience and digital infrastructure interact and co-evolve.

This categorisation helps reimagine governance not as a static and monolithic entity but as an evolving ecosystem of interactions between human and digital elements. The different types of Actors—Primary, Secondary, and Tertiary—provide a layered approach that is both holistic and adaptable. Understanding governance through the lens of these "Atoms" allows for a more structured intervention in urban management, especially when leveraging technologies like UDTs.

By framing city governance around these Actors, and upon the previously mentioned "two ways", it is possible to propose a design blueprint for any governance model, that embraces both the tangible and digital aspects of urban life.
This reconstruction starts at the foundational level and integrates digital tools in a way that respects and enhances the role of each actor in the governance process, allowing cities to evolve into smarter, more inclusive, and more sustainable environments. Importantly, this model emphasises the principle of Proactivity in Public Services[414], where Public Authorities, AI Agents, and Civil Society collaboratively work to anticipate needs, control actions, and express collective interests—ultimately contributing to the well-being of the entire urban community. The adaptive model described build upon this idea and aims to offer a guidance for the design of more and more effective digital tools for the cities.

[414]See "Proactive Services" in H. Scholta, I. Lindgren. "Proactivity in Digital Public Services: A Conceptual Analysis", *Government Information Quarterly* 40, no. 3, 2023: 101832. https://doi.org/10.1016/j.giq.2023.101832.

5.2.2. Four Scenarios

To early test the validity of the adaptive framework proposed in the analysis, as specified in the Methodological section (Chapter 2), four different scenarios will be imagined, each based on specific problems affecting cities. These scenarios are designed to challenge the framework by placing it in diverse urban contexts, allowing for an evaluation of its effectiveness in balancing the mechanical and organic aspects of city governance.

a) Prevent = in this scenario, the DTC framework will be designed (and put under stress) to prevent pandemics and health disruptions, analysing implications and challenges;

As the COVID-19 pandemic revealed systemic vulnerabilities in public health systems, especially in urban areas, the concept of a Digital Twin City (DTC) framework has emerged as a promising model to prevent and mitigate future health crises. In European cities, where both technological innovation and rigorous regulatory frameworks coexist, implementing a DTC framework to prevent pandemics offers unique insights into the balance between formal, structured interventions and more agile, informal methods of public health support. This essay examines the dynamics between formal and informal digital interventions in a DTC context, advocating for a dual approach: while formal tools can support public health efficacy, informal tools —especially those that engage citizens directly— are invaluable for addressing social inequalities and fostering community resilience.

Formal digital tools in a DTC framework serve as the backbone of urban health resilience. By orchestrating data collection, analysis, and response systems, these tools enable cities to monitor health indicators, detect patterns, and intervene proactively when risks emerge. In a preventive mission against pandemics, such as the one explored in this scenario, a DTC operating at advanced maturity levels in the TOGI and CITYSTEPS models (Levels 4 and 5 for TOGI, Stages 6 to 8 for CITYSTEPS) allows for smart, responsive management. These tools leverage AI and machine learning to analyse real-time health metrics, environmental data, and mobility trends, allowing city officials to predict potential outbreaks and orchestrate interventions swiftly and effectively. Additionally, formal digital tools can integrate private sector data, from telecommunication companies to healthcare providers, to provide a comprehensive view of health trends, mobilising these actors in a coordinated response. For example, private healthcare providers can be engaged to scale testing and vaccination efforts based on citywide data, while telecommunications data may assist in tracking and managing outbreaks.

The efficacy of these formal interventions depends not only on technological sophistication but also on robust legal and ethical frameworks, especially in a European context where data privacy and citizen rights are paramount. Compliance with regulations such as the GDPR requires that formal digital tools incorporate stringent data protection measures, ensuring that individual privacy is preserved even as public health data is harnessed for the greater good. As such, citizens are stakeholders in this framework, with rights to transparency and oversight in how their data is used. To support this, public policies should encourage citizens to engage in the governance of digital tools, including ensuring cybersecurity. Citizen engagement in cybersecurity could take the form of collaborative monitoring, where individuals are equipped with training and tools to detect and report anomalies in digital health systems. Such participation not only promotes transparency but also strengthens public trust in digital governance, a crucial factor in the DTC's overall effectiveness.

While formal tools enable the city to function efficiently, the potential of more informal digital and non-digital interventions to address social inequalities and support marginalized communities is equally important. Informal interventions, such as agile AI agents, can empower citizens directly by providing flexible, community-driven solutions that complement formal efforts. For example, agile AI agents created by citizens or local organisations could be employed to collect unstructured data on health trends and personal experiences within communities. This unstructured data, encompassing subjective accounts and local insights, can provide invaluable perspectives that structured, top-down data collection efforts might overlook. The flexibility of such informal tools allows them to operate effectively within community-specific contexts, adapting to cultural nuances and specific local needs.

Further, these agile AI agents can serve an immediate, supportive function for citizens, extending the scope of public health beyond the formal system. For example, a community-managed AI assistant could provide residents with real-time information on nearby testing facilities, offer advice on managing symptoms, or help schedule appointments with healthcare providers. By engaging communities directly, informal digital tools empower citizens to participate in their health management, fostering a culture of self-help and resilience. Moreover, the use of citizen-created AI agents as data collectors or initial points of assistance can promote inclusivity, ensuring that underserved areas or vulnerable populations have access to health resources without barriers.

Critically, the informal nature of these tools must be balanced with robust data protection standards to safeguard the rights of individuals contributing unstructured data. Citizen-driven tools must incorporate privacy-by-design principles, ensuring that information collected remains confidential and se-

cure. Encryption, anonymisation, and limited data retention are essential practices that these tools must uphold, even if they are developed outside formal municipal structures. This data-protective approach aligns with the European emphasis on digital sovereignty and individual privacy, helping prevent the potential misuse of personal data in informal interventions.

The value of informal, citizen-oriented tools also extends beyond digital platforms. Non-digital resources, such as community health programs or neighbourhood support groups, can serve as informal health interventions that address structural inequalities. These non-digital tools often provide personalised support that bridges gaps in access to healthcare, education, or essential resources—gaps that digital tools alone may not sufficiently address. For instance, in low-income areas, community-led initiatives might include delivering masks, setting up sanitisation stations, or distributing information on hygiene practices in multiple languages. Such non-digital initiatives complement the DTC's formal interventions by ensuring that the physical and social needs of underserved populations are met directly within their communities.

In this DTC scenario, formal digital tools and informal, community-driven solutions collectively create a resilient urban ecosystem capable of preventing health crises and responding equitably to the diverse needs of its citizens. While formal tools provide structure and coordination, the agility of informal interventions allows them to respond sensitively to social inequalities and promote inclusivity. Together, these approaches foster a preventive public health model that integrates data, respects privacy, and empowers citizens in their well-being and safety.

b) Manage = in this scenario, the DTC framework will be designed to manage extreme-weather events, related to climate change (promoting monitoring, alerting and response to them), analysing implications and challenges;

In an era where European cities face increasingly frequent and intense weather events due to climate change, the ability to manage these crises has become critical. While the sophistication of Digital Twin City (DTC) frameworks offers powerful, formal tools to predict, monitor, and respond to extreme weather conditions, the potential of these systems also extends beyond direct public intervention. These advanced systems, structured through formal digital mechanisms, ensure swift and effective city-wide responses, orchestrating both public and private entities in a coordinated effort to protect lives, infrastructure, and resources. Yet, the role of citizens in engaging with these technologies is equally vital—not only to build trust but also to enhance transparency and public accountability. In parallel, informal, citizen-driven initiatives, both digital and non-digital,

can supplement these formal systems, addressing localized needs and inequalities often overlooked by centralized tools.

The highly formal nature of a DTC framework enables precise, reliable interventions. By design, these frameworks integrate standardized data collection from sensors, satellite imagery, and predictive models, which provide detailed forecasting on factors such as temperature surges, rainfall, and flood risks. When a particular threshold is reached—such as a high probability of extreme heat or flooding—formal protocols trigger emergency responses, from activating public alerts to deploying resources to vulnerable zones. The DTC framework can also orchestrate private sector engagement, such as directing utilities companies to divert resources or adjust energy allocations to reduce blackout risks. This level of structured, automated response is invaluable, ensuring that the city operates as a unified system in crisis management, with each part mobilized to mitigate harm efficiently.

However, the deployment of such sophisticated systems also necessitates citizen oversight to ensure both reliability and fairness in public response. Citizens could play an instrumental role in verifying the forecasts and data outputs provided by city authorities, particularly when these data underpin life-saving decisions. Tools to monitor the allocation of resources during these weather crises, for instance, would empower citizens to hold authorities accountable for equitably distributing aid, reinforcing the system's integrity. Without this layer of public oversight, trust in DTC frameworks could erode, potentially hindering compliance with emergency directives and diminishing public support for further digital investments in urban resilience.

Complementing these formal, structured approaches, informal interventions—particularly those grounded in community-led, digitally enabled efforts—provide unique advantages in addressing inequality in crisis management. Informal digital tools, such as agile AI-driven agents developed within local communities, allow citizens to collect and organize "collective knowledge" about their specific areas. These digital agents, which can be coded to operate independently or collaboratively with DTC frameworks, are capable of monitoring local infrastructure, identifying immediate risks, and flagging needs that formal citywide models might overlook. For instance, while a formal system may predict flood-prone areas based on historic data, community-generated data can provide real-time insights into how particular streets or homes fare during heavy rains, or note recurring drain blockages that could exacerbate flooding.

Community-driven AI agents and digital applications also empower citizens to contribute actively to pre-event preparations. They can mobilize residents to engage in small-scale preventive actions, like clearing drainage systems in anticipation of storms or reinforcing fragile structures before anticipated heatwaves. During extreme weather events, these informal networks can also

support immediate rescue activities by enabling neighbors to check in on each other or report real-time incidents. Such hyper-localized, community-driven responses not only provide more tailored support during crises but also amplify resilience within vulnerable areas, creating a dual safety net that complements the broader DTC mechanisms.

Addressing post-event needs, informal tools and local knowledge networks are equally critical, providing insights that centralized frameworks might overlook. Community-based digital applications can track ongoing hazards, report unmet needs, and relay the condition of local infrastructure back to authorities, enabling a continuous feedback loop that informs both immediate recovery efforts and longer-term urban planning. Additionally, these post-crisis tools empower communities to advocate for improved city services in anticipation of future crises. As local communities continue to contribute data and insights about their experiences, they can shape municipal responses in ways that better reflect the realities faced by those on the ground, reinforcing a feedback loop between the formal and informal systems.

A balanced approach that incorporates both formal and informal digital mechanisms offers a compelling vision for urban resilience in the face of climate risks. Formal DTC frameworks ensure an organized, equitable response, supported by a high level of technical accuracy and real-time decision-making. Simultaneously, informal, community-led efforts foster adaptability, trust, and inclusivity, addressing the nuances and needs of diverse urban populations. Together, these systems form a resilient model where digital tools serve not only to predict and control but also to empower and include, driving a dynamic response that protects and serves all city inhabitants.

c) Protect = in this scenario, the DTC framework will be designed to protect from crime, analysing implications and challenges;

In the evolving landscape of European urban governance, the integration of Digital Twin City (DTC) frameworks to fight crime has introduced formal digital tools capable of enhancing the efficacy of public intervention in maintaining safety. These tools leverage advanced data analytics, predictive algorithms, and real-time surveillance, providing law enforcement agencies with unprecedented resources to preemptively address crime. The deployment of a DTC framework at higher maturity levels (TOGI Level 4 and CITYSTEPS Stage 6) enables cities to orchestrate interventions effectively, optimising resource allocation, automating responses, and managing collaborations with private actors, including security firms, technology providers, and community groups. By defining clear constitutive and regulative rules, this system ensures data is processed with precision, supporting public safety initiatives

by generating alerts and assigning resources based on high-frequency data from both public and private sources.

However, while these formal digital mechanisms enhance the operational capacity of the city, they are insufficient if they remain detached from citizen control and oversight. To address inequalities and ensure that public safety benefits all segments of society, citizens themselves must be empowered to participate in controlling these systems. Through greater involvement, citizens can monitor crime rates, assess how resources are allocated, and contribute to ensuring that these systems work equitably. Legal frameworks within Europe, such as the General Data Protection Regulation (GDPR) and the European Convention on Human Rights (ECHR), have established initial protections for data privacy and transparency. Still, additional measures are necessary to allow citizens meaningful access to the workings of DTC frameworks. Providing citizens with accessible platforms for data visibility and accountability would allow them to track resource allocation and understand the justifications behind surveillance and policing activities, particularly in relation to their neighborhoods and demographic groups. This would foster a form of democratic oversight essential to preserving trust, autonomy, and inclusivity within digital governance systems.

Formal systems alone, however, cannot address the subtler and less-visible issues within urban environments. For example, issues such as tax evasion, corruption, or the discriminatory allocation of police resources often elude traditional crime prevention systems due to their opacity or indirect impact on immediate public safety. Informal digital interventions offer an alternative means for citizens to address such issues. Agile AI tools and decentralized applications could be deployed by citizens or local organisations to bring attention to these matters, creating community-driven checks on activities often neglected by larger surveillance infrastructures. For example, citizens could use informal digital tools to crowdsource and report suspicious financial activities or suspected cases of resource misallocation, like corruption or discriminatory practices in law enforcement, allowing for a grassroots response to misconduct that is as dynamic and responsive as the DTC's formal structure. Such tools, functioning outside the constraints of official systems, would empower citizens not only to report crimes traditionally targeted by the DTC but also to expose "invisible" crimes that undermine community trust and justice.

This informal, citizen-led approach to digital intervention also has potential beyond digital-only applications. By promoting a culture of proactive community engagement, cities can support grassroots initiatives that expose crime and hold public and private actors accountable. The application of both digital and non-digital tools within these informal spaces is critical to establishing a multidimensional approach to urban crime. For instance,

grassroots reporting mechanisms can facilitate public assemblies and initiatives against local issues like corruption or neighborhood violence, creating support networks that amplify local voices and strengthen public resilience against such challenges. These community-led interventions would act as vital complements to the formal DTC framework, bridging gaps in coverage and enhancing the overall transparency and accountability of urban governance structures.

In essence, digital twins as formalized systems are highly effective for coordinating public safety efforts, and their efficiency in organising resources and controlling criminal activity is clear. Yet, equally important is the recognition that such efficacy is maximized when citizens are invited to participate in governance, oversight, and informal justice. By enabling informal tools and platforms that foster whistleblowing and community-based accountability, citizens can address inequalities that are often left unaddressed by formal systems. The combined use of formal DTC technology and citizen-powered informal digital tools offers a balanced approach to urban safety, creating a governance model that is both technically sophisticated and socially responsive.

d) Reward = in this scenario, the DTC framework will be designed to "reward positive behaviour" of citizens without using the social scoring, and to maximise the correspondence between individual behaviour and individual/collective benefits, analysing implications and challenges.

Implementing a reward-based Digital Twin City (DTC) framework focused on encouraging positive citizen behaviour, especially without relying on social scoring, offers a compelling vision for urban development. In this context, formal digital tools play a vital role in orchestrating efficient and effective public interventions. By standardising data protocols, establishing secure platforms, and clarifying the criteria for participation, formalised digital systems contribute to the credibility and efficacy of public projects. They also offer a "good practice" model—acting as a public reward—by enabling better coordination among various actors, both public and private. However, it is essential to emphasise that such rewards should never blur the boundaries of citizen rights. Rather than being seen as privileges granted by government discretion, public resources should reinforce citizens' rightful access to transparency, accountability, and participation in public life. For this reason, incentives must be managed with care and responsibility to avoid becoming tools of control that undermine the autonomy of individuals and communities.

To balance these formal structures, citizens themselves should be actively empowered to create informal tools that serve as checks on the digital systems in place. A powerful example is giving communities the means to monitor

resource allocation within government and administration. Allowing citizens to participate directly in the oversight of public spending, for instance, strengthens not only transparency but also trust, ensuring that the digital tools meant to support the community are aligned with its actual needs. This civic engagement becomes a form of participatory governance, where informal digital interventions complement the more rigid formal structures. When citizens have the power to influence and control how digital tools operate, a form of digital democracy emerges, one that addresses inequalities and fosters inclusive urban development.

The use of informal digital tools, particularly those that are agile and adaptable, is especially promising in this regard. AI agents designed for proactive service delivery to citizens—potentially even created or configured by citizen groups—can become essential resources for improving access to city administration. Such tools can operate on a local level, collecting data on neighbourhood needs and ensuring city services are deployed where they are most beneficial. For instance, an informal AI-based reporting system might monitor public service efficiency or track whether certain areas receive less attention in terms of infrastructure investments. By decentralising these functionalities, informal tools can introduce more flexibility and adaptability, allowing rapid adjustments that directly address emerging urban needs and resource disparities.

In a European context, where data protection and privacy laws set high standards, informal tools can also help mitigate risks associated with formalized digital governance. While official digital systems are bound by regulatory standards, informal citizen-controlled tools can introduce agile and localized solutions that fill in gaps left by larger, slower-moving public platforms. However, these tools must still adhere to principles of inclusivity, meaning they should be designed in ways that are accessible to all, avoiding a new layer of inequality by privileging only those with advanced technological skills or resources.

This dual approach, with formal tools ensuring the efficacy of structured public interventions and informal tools promoting flexibility and inclusivity, embodies a comprehensive strategy for urban governance in digital cities. As this scenario would suggest, combined, these elements can form a balanced ecosystem in which technological innovation and democratic participation reinforce each other, making cities not only smarter, but also fairer and more responsive to the diverse needs of their inhabitants.

5.2.3. Limitations and Further Research

The initial research question (How can Digital Twin Cities be used to respond to social problems and inequalities?) presented several challenges

and complexities.
The literature review revealed a fragmented landscape, characterised by a lack of holistic approaches, multiple vertical studies focusing on sectorial topics, and a pervasive difficulty in integrating three key dimensions: understanding the city, understanding Digital Twin Cities, and understanding inequalities.
Despite these challenges, the analysis conducted in this work has moved beyond the current state of the art, leading to the formulation of design principles for Digital Twin Cities in Europe. The proposed adaptive framework is a direct outcome of this effort, structuring the relationship between the "two ways" of urban governance (the suggested *Proportionality Assessment*) and an initial "matrix" mapping the different Actors involved in city governance.
The imagined "Four Scenarios" provided an initial opportunity to theoretically test the framework, exploring how it responds to distinct urban challenges.
However, to fully assess its validity and practical applicability, further research is required—particularly through empirical analysis. Future studies should apply the adaptive framework to real-world case studies, evaluating its effectiveness in guiding digital urban transformations while ensuring inclusivity, equity, and sustainable governance.

An additional layer of research could derive from a better understanding on how to encode the law in simulations, like the initial studies on "Regulative and Constitutive Rules", as suggested by Prof. Luciano Floridi, can benefit our understanding on how to better design simulative tools like the DTCs.

To effectively implement and complete FRIA, seem also essential to revisit the literature and expand the knowledge on the principles of solidarity and the Right to Science[415].
The principle of solidarity could extend the idea that cities should function as cohesive units where the benefits and responsibilities of digitisation are shared collectively, particularly focusing on protecting vulnerable groups.
The Right to Science —as enshrined in international human rights documents— emphasises the obligation to ensure equitable access to scientific advancements, technologies, and their associated benefits, without discrimination. In the context of urban digital transformations, this principle calls for open access to the benefits that smart technologies bring to cities.

To further strengthen this framework, it is critical to promote and integrate

[415]See Right to Science, https://www.ohchr.org/en/special-procedures/sr-cultural-rights/right-access-and-participate-science (last accessed 12.02.2025); D. Moeckli, S. Shah, S. Sivakumaran, and D. J. Harris, eds. *International Human Rights Law.* Third edition. Oxford: Oxford University Press, 2018.

collective actions or public interest actions at Maturity Level 3 or higher. These actions aim to protect groups against inequalities, especially when digital transformations impact communities on a large scale. By integrating public interest actions into the digital twin maturity process, policymakers and urban planners can proactively address potential disparities, ensuring that interventions do not solely serve the affluent or technologically privileged but provide substantial protections and opportunities for all residents. Collective actions within this context can include citizen assemblies, public consultations, and other participatory governance mechanisms that allow diverse voices to influence the direction of urban digitisation. This approach ensures that urban technologies are developed not only to optimise mechanical processes but also to promote inclusivity and social equity at a fundamental level.

Thus, building on the *Proportionality Assessment*, legal instruments like the FRIA becomes a holistic evaluation tool that integrates solidarity, the Right to Science, and collective public actions to safeguard fundamental rights and promote inclusivity. This expanded framework ensures that digital transformation serves all parts of the urban community, respecting human dignity and fostering a truly inclusive, equitable urban environment.

5.2.4. Closing Remarks: Integrating Formal and Informal Digitisation in the Twin City Governance

In synthesising the components of Digital Twin City (DTC) governance, it is essential to recognise how Primary, Secondary, and Tertiary Actors collectively establish a robust ecosystem for urban management. Primary Actors—citizens, public officials, and institutions—ground the framework within the tangible urban environment, ensuring that governance remains aligned with real-world needs. Secondary Actors, comprising AI systems, digital platforms, and automated agents, facilitate a real-time, proactive governance layer dedicated to optimising the urban experience. Tertiary Actors serve as the critical bridge, connecting these physical and digital realms through devices and sensors that synchronize governance actions with immediate urban conditions. Together, these actors form an adaptive model capable of responsive and efficient governance while respecting the social complexities of urban life.

The application of DTC governance across diverse scenarios—Prevent, Manage, Protect, and Reward—highlights the framework's flexibility and dual structure. Each scenario demonstrates that formal, top-down interventions are only one part of an effective governance system; informal, community-driven initiatives are equally essential for achieving inclusivity and equity. For instance, in public health or climate crises, formal tools coordinate data collection, response, and resource allocation, while informal initiatives offer

granular, community-specific insights and resources that bolster resilience. The Protect and Reward scenarios further underscore this dual approach by integrating formal digital security tools with citizen-led oversight mechanisms, ensuring transparency and accountability while avoiding the risks of overreach. This layered governance approach aligns the DTC's technological capabilities with the nuances of citizen agency and needs, fostering a more resilient urban environment.

Ultimately, a balanced governance model is indispensable for DTC frameworks to thrive. As digital twin systems mature, they must go beyond optimising "mechanical" aspects of the city—such as traffic management, infrastructure, and utilities—toward actively preserving the "organic" dimensions of urban life. This organic layer encompasses democratic engagement, cultural practices, and social equity, which cannot be reduced to data alone. The DTC's potential, therefore, lies in its ability to integrate formal structures with informal, adaptive responses that empower citizens. By embracing both the quantifiable and unquantifiable dimensions of urban life, DTC governance can create smart cities that are not only efficient but inclusive, promoting a digital future where technological progress and human dignity coexist harmoniously. This balanced, citizen-centered approach positions DTCs as models for cities that are both innovative and responsive, meeting the evolving needs of urban communities in the digital age.

Conclusions

Shaping a Digital Twin City for the Future

The development of Digital Twin Cities (DTCs) marks a significant evolution in urban governance, presenting opportunities and challenges that demand careful navigation. The rapid growth of technology in urban environments, coupled with an increased reliance on data, has necessitated a rethinking of how cities can be managed effectively and equitably. Throughout this thesis, we have explored how a new governance ecosystem, composed of foundational "atoms," can leverage digital advancements to transform the way cities are managed. By employing a layered approach of Primary, Secondary, and Tertiary Actors, the DTC framework not only replicates but also fundamentally reimagines urban governance. This reconstruction is grounded in proactive public services, maturity models, and the holistic assessment of rights, aiming to ensure that digital transformations truly benefit society as a whole. The concept of the Digital Twin City represents more than just a technological advancement; it is a reimagining of how urban systems can operate in a synchronized, efficient, and socially responsive manner.

Central to this governance model is the concept of maturity levels. By applying a maturity model to DTCs, cities can progressively evolve from basic data collection and infrastructure management to sophisticated, integrated urban environments that harness digital tools for real-time, responsive governance. The maturity levels are designed not only to assess the technological advancement of the city but also to determine the depth of integration between digital tools and urban governance processes. At Maturity Level 1, cities focus on digitising existing processes without major changes in how these processes are carried out. At Maturity Level 2, there is a higher degree of system connectivity and data sharing, which starts to create efficiencies across different urban domains. As cities move to Maturity Level 3, they begin incorporating predictive capabilities, enabling the anticipation of urban issues and preemptive decision-making. At Maturity Level 4, there is extensive interaction between physical and digital city layers, leading to real-time optimisation and responsiveness. Finally, Maturity Level 5 represents a seamless integration where digital twins are not just reactive but also actively contribute to shaping urban life in collaboration with residents and stakeholders.

The maturity levels emphasise not only technological growth but also the social and ethical dimensions of urban governance. As DTCs mature, the governance framework must be sensitive to both the technological efficiency and the ethical implications of these advances. This means addressing concerns such as privacy, data security, the equitable distribution of technological benefits, and ensuring that technological growth does not deepen existing inequalities. At higher maturity levels, proactive measures are taken to address the nuanced needs of both the mechanical and organic parts of the city. This ensures a balanced evolution that supports efficiency without compromising the human values that define urban life. In this framework, technology becomes an enabler of better governance, focusing on the empowerment of individuals and communities rather than purely on control and efficiency.

Another key element of this new ecosystem is the commitment to substantive equality and the Right to Science. These principles empower all citizens to benefit from the technological advancements brought about by DTCs. Substantive equality ensures that all citizens have not only equal rights but also the necessary support to benefit from the advancements being implemented within their cities. For example, while digital tools like urban analytics can significantly improve services, substantive equality requires that these services are accessible and beneficial to marginalized communities who might not otherwise have the resources to engage fully with new technologies. Proactive governance must thus ensure that technological interventions do not merely perpetuate or widen existing disparities but instead work towards their resolution.

The Right to Science further asserts that all residents should have equitable access to the benefits derived from scientific and technological advancements, enhancing their quality of life. This principle implies that digital infrastructure and data services, like the information provided by AI Agents or other Secondary Actors, must be developed and deployed in such a way that all citizens can understand and derive tangible benefits from them. For example, data about pollution levels or public transportation must be made accessible to all, including those who may not be digitally literate. This right is not limited to access but also includes the ability to influence scientific and technological development, meaning that communities have a say in how digital tools are used in their environment. This ensures that digital governance does not merely cater to the well-connected or technologically privileged but provides a platform for fair and equitable progress that is inclusive of the entire urban population.

The *Proportionality Assessment* is the cornerstone of this new governance framework. This assessment ensures that DTCs balance two fundamental goals: the control of the mechanical aspects of the city, and the protection

of its organic components. In this context, Collective Actions and Public Interest Actions are promoted as a counterbalance to the digital formalism driving the attractiveness and efficiency of the city. These actions, rooted in the public interest and often spearheaded by Civil Society, ensure that inclusivity is maintained and the human elements of the city are safeguarded. By incorporating collective actions, the governance framework encourages active community participation, which serves as a balancing force against the centralised control mechanisms of digital governance. These actions can include participatory budgeting, citizen assemblies, and other forms of community-led decision-making that give voice to underrepresented groups within urban governance.

On one hand, controlling the mechanical part —such as traffic systems, waste management, and energy consumption— requires a focus on optimisation, efficiency, and centralised data management. These mechanical aspects can be significantly improved through digital interventions that provide more precise and responsive services, thus making the city more attractive to investors and residents alike. Optimisation of these systems often involves real-time monitoring, predictive analytics, and automated adjustments to keep urban operations running smoothly. However, while these improvements are vital, there is a risk of over-prioritising these aspects at the expense of inclusivity.

On the other hand, protecting the organic part of the city —embracing human behaviours, community interactions, and democratic engagement— demands a commitment to informality, inclusivity, and bottom-up approaches. This dual focus prevents the potential pitfalls of over-centralised, data-driven control that could reduce individuals to mere data points, ensuring instead that digital interventions foster human agency, social diversity, and democratic participation. The organic components are what make cities vibrant, diverse, and liveable, and maintaining this vitality involves ensuring that technologies serve to enrich human experience rather than diminish it. Initiatives such as community-based data projects (even with AI and autonomous agents), neighborhood forums, and other inclusive governance structures can help maintain this balance, ensuring that digital advancements support rather than undermine social dynamics.

Ultimately, this thesis proposes a governance model that is both technologically advanced and socially grounded —one that respects human dignity, embraces inclusivity, and advances urban life in ways that are consistent with European values and legal frameworks. By focusing on proactive governance through maturity levels, aligning interventions with the principles of substantive equality and the Right to Science, and employing a robust *Proportionality Assessment*, DTCs can become tools that genuinely serve society rather than instruments of control. In this new ecosystem, the col-

laboration between Public Authorities, AI Agents, and Civil Society plays a pivotal role in ensuring that DTCs are transparent, accountable, and responsive to the real needs of urban residents.

The vision of a Digital Twin City is not just one of efficiency and data-driven optimisation; it is a vision that actively seeks to humanise urban environments through intelligent design and ethical governance. It is a framework for the future—a future where cities are not only smart but also just, inclusive, and resilient, genuinely reflective of the people who inhabit them. This balanced approach, centered on the holistic assessment of rights, ensures that digital transformation in urban governance is not merely compliant with European regulations but also enriches the fabric of society, making cities places that empower, support, and nurture all their inhabitants. If formalism and informality are effectively balanced, the model also opens up the possibility for Collective Intelligence or Swarm Intelligence to emerge. This collective intelligence ensures that the governance model is not only dynamic and adaptive but also deeply responsive to the evolving needs of urban residents, further enhancing the capacity of Digital Twin Cities to serve society comprehensively. Collective intelligence is where individuals and systems come together to generate solutions that are greater than the sum of their parts, and this is most achievable when inclusivity and technological formalism coexist in harmony.

In conclusion, shaping a Digital Twin City involves more than simply deploying advanced technologies. It requires a fundamentally new way of thinking about governance—one that is proactive, inclusive, and ethically grounded. By leveraging a framework built upon maturity models, substantive equality, the Right to Science, and a comprehensive Proportionality Assessment, cities can use digital tools not just to optimize but also to inspire and elevate urban life. The balance between the mechanical and organic components, guided by collective intelligence, makes for a governance structure that is adaptive, just, and truly reflective of the needs of its citizens. This holistic and responsive approach ensures that cities of the future are prepared to meet the diverse challenges of urban life, offering environments that are efficient, equitable, and enriched by the contributions of all their residents.

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