

When AIs become oracles: generative artificial intelligence, anticipatory urban governance, and the future of cities

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Abstract

Generative Artificial Intelligence (AI) is boosting anticipatory forms of governance, through which state actors seek to predict the future and strategically intervene in the present. In this context, city brains represent an emerging type of generative AI currently employed in urban governance and public policy in a growing number of cities. City brains are large-scale AIs residing in vast digital urban platforms, which manage multiple urban domains including transport, safety, health, and environmental monitoring. They use Large Language Models (LLMs) to generate visions of urban futures: visions that are in turn used by policymakers to generate new urban policies. In this paper, we advance a twofold contribution. Theoretically, we develop a critical theory of anticipatory governance in the age of generative AI. More specifically, we focus on technocratic approaches to anticipatory governance, to explain how the act of governing extends into the future by means of predictive AI technology. Our approach is critical in order to expose the dangers that the use of AI (generative AI, in particular) in urban governance poses, and to identify their causes. These dangers include the formation of a policy process that, under the influence of unintelligible LLMs, risks losing transparency and thus accountability, and the marginalization of human stakeholders (citizens, in particular) as the role of AI in the management of cities keeps growing and governance begins to turn *posthuman*. Empirically, we critically examine an existing city brain project under development in China and ground our critical theory in a real-life example.

Keywords: anticipatory governance; generative artificial intelligence; AI urbanism; urban governance; city brains

Since antiquity, governments from all around the world have tried to foresee the future, in an attempt to anticipate likely upcoming challenges. For example, in ancient Greece, the famous Oracle at Delphi was consulted by kings and politicians on matters of warfare and epidemics (Bowden, 2005). Over the centuries, this attitude has developed into anticipatory acts and manners of governing, whereby state actors have sought to predict the future and strategically intervene in the here and now to steer the present toward a given political ideal (Anderson, 2010). Historically, these forms of government have gone hand in hand with development in science and technology, as statistics and probability theory have been employed particularly by state actors to determine the likelihood of risky events as early as the 17th century and, since the digital revolution, computers have provided a significant calculative force

to deal with uncertainty (Reith, 2004). Nowadays, generative Artificial Intelligence (AI) is boosting anticipatory actions in the governance of states, regions and cities, due to its unprecedented computational power capable of processing large amounts of future possibilities (Luce-Ayala & Marvin, 2020; Son et al., 2023).

In urban governance, anticipatory manners of governing cities are not a novel phenomenon. They began to emerge in the late 1990s, propelled by the rise of smart urbanism and the growing use of so-called *big data* in the management of urban systems (Karvonen et al., 2018; Kitchin et al., 2015). More recently, anticipatory forms of urban governance have gained momentum with the popularization of AI and the passage from smart to AI urbanism where “the focus of technology is mostly on the future: activities and situations that have not yet taken place, but that are likely to occur” (Cugurullo et al., 2024: p. 1175). These are urban activities and situations that city managers seek to predict by means of AI technology, so to govern the city in an anticipatory manner. In urban studies and critical data studies, such a future-oriented type of governance mediated by AI is commonly referred to as *anticipatory governance* (Kitchin, 2014; Kitchin et al., 2015; Xu et al., 2024).

Within the vast and heterogeneous field of anticipatory governance, city brains represent an emerging type of generative AI currently employed in urban governance and public policy in a growing number of cities. City brains are large-scale AIs residing in digital urban platforms and capable of managing multiple urban domains including transport, safety, health, environmental monitoring, and planning (Caprotti & Liu, 2022; Cugurullo, 2021; Curran & Smart, 2021). This type of generative AI is being deployed particularly in China, Malaysia, and Saudi Arabia. It is equipped with closed-circuit television (CCTV) cameras coupled with facial recognition technology, serving as the digital eyes through which city brains observe urban spaces and develop a situational awareness. Most importantly, city brain systems are equipped with predictive analytics to predict future urban conditions and govern cities in an anticipatory manner (Cugurullo, 2021). Technically, their generative attribute lies in the influence of Large Language Models (LLMs) which are a core component of city brains’ inner mechanics and impact their ability to generate visions of urban futures: visions that are in turn used by policymakers to generate new urban policies.

To date, while there is a substantial body of literature on the governance of AI, focusing on how AI technologies should be governed and regulated, there are relatively less studies on how AI is deployed in the governance of states, regions, and cities (Radu, 2021; Taeihagh, 2021). This is the case particularly in urban contexts where emerging generative AIs, such as city brains, are being used to manage urban systems and services with consequences that we currently ignore. It is within this context that, in this paper, we seek to advance a twofold contribution. Theoretically, we develop a critical theory of anticipatory governance in the age of generative AI. More specifically, we focus on technocratic approaches to anticipatory governance whereby the act of governing extends into the future by means of predictive technology. Our theoretical approach is purposely critical, as we aim not to develop a set of rules or principles, but rather to critically expose the dangers that the deployment of AI (generative AI, in particular) in the management of collective services and problems poses, and identify their root causes. Empirically, our objective is to examine an example of AI-enabled anticipatory governance through the analysis of a city brain project under development in China. Here, our primary motivation is to extract lessons on the actual use of generative AIs as they impact urban governance and policy. We produce empirics that support our critical theory and ground it in real-life examples, so to avoid abstract theorizations.

Overall, we develop our contribution to knowledge across three sections. First, we review the theory of anticipatory governance and discuss its evolution in the age of AI. We unpack the core principles of technocratic forms of anticipatory governance and explain how nowadays they are being put into practice through emerging generative AIs such as city brains. Our perspective is interdisciplinary, and we synthesize theoretical insights from political theory, urban studies and philosophy of technology, to illuminate the hitherto understudied ramifications of the development of generative AI as they extend into the governance of cities. Second, we analyze an existing city brain in China, paying attention to its structure in terms of sensors and databases, and providing concrete examples of its predictions and related impact on urban governance and policy. Third, we critically discuss the theoretical implications of our empirical findings and reflect on the limitations and risks of generative AIs deployed to govern cities.

Methodologically, this paper is based on single case study research conducted in a district of Beijing called Haidian where a city brain project was initiated by the local government in 2019. The Haidian city

brain can be considered a *representative case* (Bryman, 2016). On the one hand, its technology and the way it is employed in the management of urban systems reflect an emerging trend worldwide as urban governance becomes increasingly mediated by AI across spaces and scales (Cugurullo et al., 2023a). On the other hand, however, city brain projects are *de facto* projects of mass surveillance that resonate mostly with authoritative forms of governance. In China, for instance, our case study is representative of analogous techniques and technologies of governance across the country. This is because Beijing is an official piloting city in the application of AI, whose example is supposed to be followed by other Chinese cities in the process of transitioning toward AI-mediated governance solutions (Xu et al., 2024). In addition, it is important to note that the specific case of Haidian has been used by policymakers beyond China to learn about city brains and develop similar projects in different geographical contexts, through processes of *policy mobility* that, so far, have had an impact on Malaysia and Saudi Arabia.

In terms of research methods, we conducted 14 semistructured interviews in 2022 and 2023 with key stakeholders, such as project directors, AI scientists and civil servants, responsible for the development of the Haidian city brain. The purpose of these interviews was to gather information on our case study, which is not publicly available. Their value thus lies in the collection of novel empirical data on aspects of city brains, which had hitherto been unknown. For example, our questions probed into the use of generative AI in the production of predictions about Haidian's future, their degree of accuracy, and policy impact. In line with the research ethics policy of our institution, we have sought to protect the anonymity of our research participants by removing interview quotes or job titles that might make them traceable from the empirical data discussed in the paper.

Toward a critical theory of AI-enabled anticipatory governance

Approaches to anticipatory governance

In this section, we begin to theorize anticipatory governance in the age of generative AI by identifying and discussing the core ideas and beliefs that characterize this type of governance. Our conceptual exploration starts with the recognition of two main different understandings of anticipatory governance in the literature. These are *anticipatory governance of technology* and *technology for anticipatory governance*. In the first strand of literature, the notion of anticipatory governance concerns "principles on how to collectively imagine, deliberate, design and influence the development of emerging technologies" (Wiek et al., 2013: p. 55). From an epistemological point of view, this approach to anticipatory governance derives largely from political science and Science and Technology Studies (STS), in an attempt to anticipate the likely outcomes of the development of new technologies, so to "steer innovation processes toward public goods and away from plausible ills" (Nelson et al., 2022: p. 49). Here, governance is intended as "a wider set of activities than mere 'government' that is actions by public sector authorities" (Guston, 2010: p. 434). The emphasis is on "governing activities that are more broadly distributed across numerous actors", in a participatory manner, with the aim of "amplifying the still, small voices less often heard in the innovation process" (Guston, 2014: pp. 226, 229).

From a theoretical perspective, it should be noted that what distinguishes this strand of anticipatory governance is the will to "collectively" influence the development of new technologies (Wiek et al., 2013: p. 55). Such will originates from a double Marxian premise that is quite common in STS literature. First is the assumption that, while technological innovation might at times appear to be getting out of control, it is in reality a process steered by human actors in a deliberate manner (Winner, 1977). These dynamics have been recently observed in relation to generative AI as an emerging technology that is strategically developed and then deployed by powerful individuals to fulfill politico-economic agendas (Cugurullo, 2024). Second is a long-standing concern over the uneven distribution of the benefits and harms that are inevitably generated by the diffusion of new technologies (Johnson & Acemoglu, 2023). In *anticipatory governance of technology*, these assumptions and concerns come together motivated by the realization that if human actors can indeed influence the process of technological development, then such an influence should be exerted in a collective way. Morally, the ethos underpinning this strand of anticipatory governance promotes a situation in which those who are influenced by technology can, in turn, influence technology's design, purpose and deployment. This ethos, practiced through governing activities widely distributed among the population, is, for scholars such as Guston (2014), key to align technological development with the realization of "public goods" (Nelson et al., 2022: p. 49).

In practice, advocates of *anticipatory governance of technology* endorse foresight for the purpose of "anticipating changes in technological and scientific progress" (Maffei et al., 2020: p. 126; Miles, 2010).

In this strand of anticipatory governance, foresight is understood as the ability to think critically about long-term technological developments and imagining what technology might cause in the future. In these terms, “the goal of foresight”, as Maffei et al. (2020: p. 125) remark, is “anticipation rather than an actual prediction” since “to envision multiple futures supports a wiser course of action in the present.” This is a process that is supposed to take place in a bottom-up manner, by mobilizing as many stakeholders as possible, with different backgrounds, so to bring together different sources of knowledge and understandings of technology (Wilkinson, 2016). In this theoretical context, it is important to remember that “multiple, plausible futures” are seen as “objects for deliberation” (Guston, 2010: p. 434). This means that there is not one single future that is being accepted and pursued, but rather many different technological futures that are being collectively discussed through public engagement events.

In the second strand of literature, which we refer to as *technology for anticipatory governance*, anticipatory governance is understood in technocratic terms, as a form of government mediated by technology and controlled by technical experts, with little to no citizen engagement. Seen from this perspective, anticipatory governance seeks to “anticipate what is likely to happen under different conditions and for different populations and to act in a pre-emptive manner” (Kitchin, 2023: p. 28). Here, predictive technologies become a tool in the hands of technocrats to “nip problems in the bud before they occur” (Kitchin et al., 2015: p. 9). There is an explicit focus on the future and, unlike in the practice of foresight advocated by scholars such as Maffei et al. (2020) and Miles (2010), on actual predictions. Technology is believed to be capable of predicting events that are yet to take place, and, in this sense, it extends the timeframe of governance into the future (Cugurullo et al., 2024). Such future is supposed to be taken at face value, and there is none of the critical thinking that Maffei et al. (2020) deem necessary to reflect on the potentially dangerous repercussions of technological innovation.

Another crucial difference between *anticipatory governance of technology* and *technology for anticipatory governance* is that while the former aims to envision potential futures as “objects for deliberation” (Guston, 2010: p. 434), the latter targets one single future that is not meant to be questioned, particularly by the public. In essence, *technology for anticipatory governance* is against dissent. It attempts to crystallize a form of universal consensus based on technological solutions that are presented as objective and thus unquestionable truths. This is an understanding of governance that has been substantially critiqued in contemporary debates in urban studies, where scholars often lament techno-managerial and undemocratic practices of urban governance (Swyngedouw, 2017). Swyngedouw (2009: p. 602), for example, criticizes the emergence of depoliticized spaces whose governance is performed in a top-down and technocratic manner, in a way that prevents meaningful political engagement with citizens. Through this conceptual lens, governance continues to be intended as a set of governing activities performed by state and nonstate actors. However, the nonstate dimension of this strand of governance is understood as being formed mainly by technical experts, such as technology companies like IBM, Google and Alibaba, which assume significant managerial roles in smart city initiatives, to the detriment of an expanded public dialogue and engagement (Karvonen et al., 2018).

These two strands of literature are, at first glance, conceptually oppositional. *Anticipatory governance of technology* aspires to “engage the public in a meaningful conversation about how new technology will be developed”, so that innovation can become useful in “meeting human needs through city planning” (De Barbieri, 2018: pp. 79, 107). In *technology for anticipatory governance*, instead, critics stress a lack of public engagement in urban development and question whose needs are really being taken into account in the governance of the city. However, we argue that these conceptual perspectives can complement each other in the development of a holistic understanding of anticipatory governance in the age of generative AI. In this paper, we initially position our discussion of anticipatory governance within the second strand, in order to critically understand the limits of technocratic forms of AI-mediated anticipatory governance. In the conclusion, we add conceptual insights from the first strand, in an attempt to mitigate the lacunae of technocratic anticipatory governance that our case study makes empirically evident.

Technocratic anticipatory governance

The desire to anticipate the future has always been in the mind of the rulers. Historical examples abound across time and space, and we can find attempts to foresee future events as early as in Neolithic China in the form of bone divination which, as Flad (2008) remarks, was a precious source of political power. In ancient history, a renowned example is that of Delphi whose oracle was consulted by kings

and generals as a conscious exercise in statecraft (Bowden, 2005). The predictions of the oracle were used to steer the development of city-states on matters of economics, politics and warfare, as a form of knowledge believed to express conditions of a time to come. It is in modern history that, with the invention of statistics and probability theory through the work of scholars such as Cardano (1501–1576) and Pascal (1632–1662), we find rational attempts to calculate the future (Reith, 2004). In the words of Anderson (2010: p. 784), these are techniques employed by modern governments in particular to make uncertain futures present “through the domain of number.” Through the ages, techniques and technologies of anticipatory governance have changed, but the idea that the future can somehow be foreseen and its knowledge used to govern society has remained a constant common denominator.

From a philosophical perspective, there are three core ideas at the foundation of technocratic anticipatory governance, whose discussion can help us understand the peculiar nature of this type of governance. First, there is a strong disposition toward rationality. This is the tendency, rooted particularly in Enlightenment philosophy, of believing that everything can be calculated and should be rendered visible in mathematical terms. In this strand of anticipatory governance, such mathematical impetus is extended into the future in an attempt to calculate phenomena that are yet to happen. As Anderson (2010: p. 783) observes, this tendency goes “contra to Beck’s thesis” of the risk society. According to Beck (1992), we live in a society dominated by a number of environmental, social and technological risks, which are incalculable and thus unavoidable. In this sense, technocratic anticipatory governance rejects the theory of the incalculability of the future and sets on unravelling it through science and mathematics.

Second, there is the assumption that the future is deterministic. The philosophy of determinism assumes that future events are determined by previous events (Pereboom, 2014). According to this line of thought, the universe follows a linear temporality whereby past, present and future are connected through a chain of events. In technocratic anticipatory governance, this idea unites with the one previously discussed, under the belief that science is a tool by means of which it is possible to look at time linearly and get a glimpse of future events that, triggered by events that have already occurred, are inevitably bound to happen. Third, there is the *future shock* imperative. This idea goes back to the work of Toffler (1984) who posits that too much unexpected change in too short of a time is dangerous and can shock individuals as well as entire societies. This view pictures the future as a dark temporal situation full of unknown obstacles that science needs to shed light on for the benefit of humanity. Seen from this perspective, conceptually, the future becomes in this strand of anticipatory governance a problematic source of danger, perpetually overhanging human society like a sword of Damocles.

In the practice of technocratic anticipatory governance, the aforementioned philosophical assumptions are politicized and actioned. A predetermined and calculated future becomes then “cause and justification for some form of action in the here and now” (Anderson, 2010: p. 778). This is important to remember for a twofold reason. Technocratic anticipatory governance is intrinsically connected to questions of power. It is a future-oriented act of governing whereby certain political actors exercise their power over a given polity. Furthermore, the science underpinning anticipatory governance (i.e., the calculation of possible futures) tends to be politicized. It is not a neutral science, inasmuch as it aims to steer development toward a subjective political ideal, through a process whereby the means (scientific methods) absorb part of the end (a political agenda). Ultimately, the outcomes are of course far from being neutral since predictions are employed to enable certain futures to the detriment of others.

From a critical perspective, what is important to note is that the ethos of anticipation per se is not problematic. As Bali et al. (2019: p. 1) observe, particularly in the field of public policy, “foreseeing the future and preparing for it” can be conducive to policy effectiveness, through the design of solutions for impending collective problems. Similarly, Kimbell & Vesnić-Alujević (2020) note how anticipation can be a progressive force to anticipate the needs and aspirations of citizens, so to design policies that are in sync with their visions of the future. In these terms, digital technologies can potentially be a medium in the hands of governments, to connect with citizens and involve them in the process of policy making, “thus to benefit from their personal knowledge, expertise and opinions” (Capano & Pavan, 2019: p. 97). However, as we will see in the next sections, digital technologies such as AI often go against the progressive potential of anticipatory governance, by turning citizens not into stakeholders, but rather into subjects at the mercy of disciplinary powers.

The impact of AI on anticipatory governance in cities

With the advent of AI, governance is shifting from reactive to proactive approaches intended to shape the future (Brayne, 2017). For Brayne (2017), a proactive governance is one that pre-empts a problem before its occurrence, and she refers to her fieldwork in the United States to show empirically how several American police departments are employing predictive algorithms to foresee where crimes are likely to take place within a given city. AI is boosting technocratic forms of anticipatory governance, because of its unprecedented computational power through which large amounts of future possibilities can be calculated to get a glimpse of futures yet to come (Luque-Ayala & Marvin, 2020). In these terms, we argue that the essence of technocratic anticipatory governance has not changed much since the introduction of AI, particularly from a philosophical perspective, as the predisposition toward supposedly calculable futures full of unknown challenges remains evident. What differs in practice is the scientific method whereby the future is calculated and rendered visible in mathematical terms. Nowadays, AI is both a tool that scientifically calculates the likelihood of future events and an agent that generates predictions with a concrete impact on governance. For a theory of anticipatory governance in the age of AI, this is important to remember because in the past, predictions were developed by humans, such as oracles in ancient history and statisticians in modern history. In the 21st century, however, the advent of AI is adding novel nonbiological intelligences to the networks of actors who govern our cities and societies (Cugurullo, 2020; Hilb, 2020).

Given that the urban is the principal space where AI technologies are being deployed, a focus on the city is useful to identify and examine the main dynamics of anticipatory governance in the age of AI (Cugurullo et al., 2024). As Luque-Ayala & Marvin (2020: p. 133) observe, "the city and its infrastructures are increasingly becoming privileged sites for the application of, and experimentation with, forms of prediction." In their analysis of predictive algorithms and AI in the governance of cities, they also note how "engaging with prediction is fundamentally *preemptive* rather than *preventive*" (Luque-Ayala & Marvin, 2020: p. 130). This means taking action to prevent an anticipated event from happening, which, in turn, means targeting specific spaces and individuals. For instance, the work by Richardson et al. (2019: p. 21) on the practice of predictive policing in cities shows that this is an algorithmic form of anticipatory governance that "analyzes available data to predict either where a crime may occur in a given time window (place-based) or who will be involved in a crime as either victim or perpetrator (person-based)."

From a philosophical perspective, the practice of technocratic anticipatory governance in cities contradicts Byung-Chul Han's recent reflections on soft power. For him, in the age of AI, algorithms and big data, governments do not exercise their power directly on individuals, acting instead indirectly on their psyche in a way that subtly influences their behavior (Han, 2017). This is the same conclusion reached by Zuboff (2019) in her conceptual analysis of surveillance capitalism as a form of data-driven governance that keeps people under surveillance, primarily by drawing on personal data harvested from the Internet and social media activities. Similarly, Han (2017) rejects in his philosophy the idea of a physical panopticon within which citizens are observed by government actors and then disciplined through what Foucault (2020) used to call disciplinary power. For him, such idea is outdated (Han, 2017). In reality, however, when technocratic anticipatory governance is put into practice in cities, what we often observe is an actual physical panopticon made of sensors distributed across the built environment, which keeps citizens under continuous surveillance. In this type of context, Foucauldian interventions on spaces and people take place to mold the future in a *hard* rather than *soft* manner. Moreover, in urban contexts where technocratic anticipatory governance replaces or reduces public engagement, citizens are not involved as stakeholders. Instead, they are exploited as data points producing information that governments employ to control them (Cugurullo et al., 2023a; Gabrys, 2014).

City brains as a generative AI deployed in technocratic anticipatory governance

City brains represent an emerging form of AI-driven anticipatory governance. A city brain can be conceptualized as an AI operating at the intersection between anticipatory governance and the management of cities (Figure 1). It is a large-scale AI (which is different from a small-scale AI, such as a driverless car) because its agency extends to large portions of territory, infrastructure and the public sector, thus including, for instance, entire cities, telecommunication networks and public security (Cugurullo, 2021). City brains reside in a digital platform (acting as a brain) and are connected to hundreds of cameras (acting as eyes) positioned all around the city (Cugurullo, 2020). Through their synthetic eyes, city brains

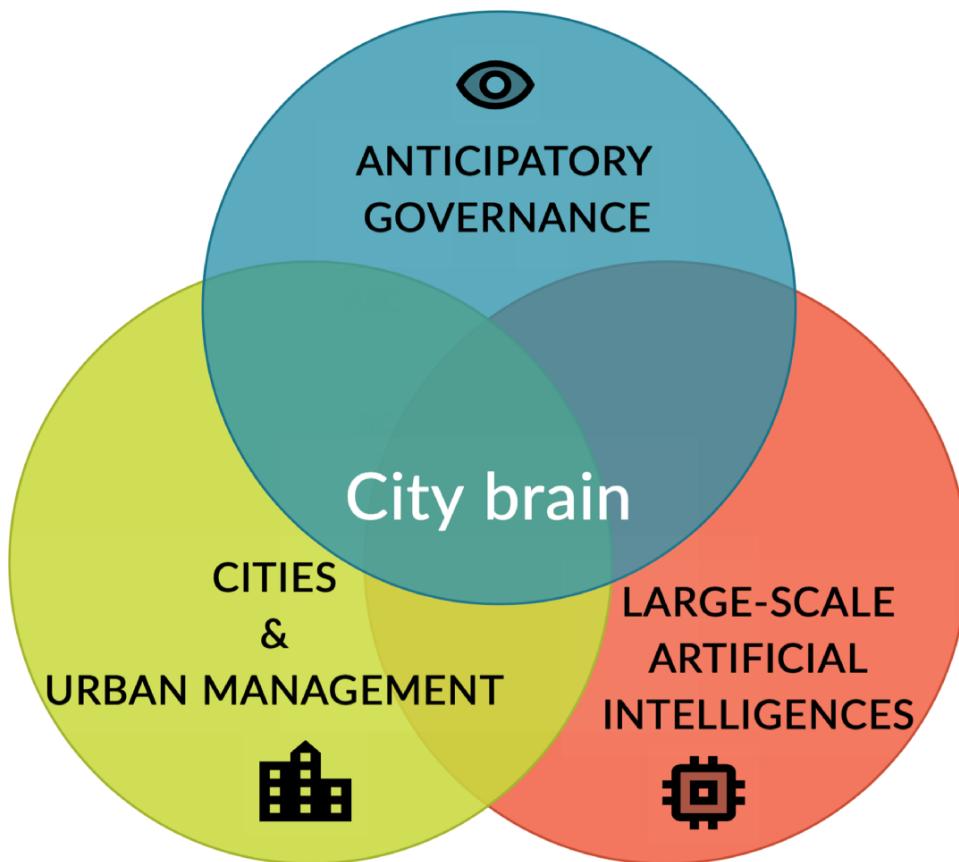


Figure 1. A Venn diagram conceptualizing the city brain.

Source: Authors' original.

observe the city, absorbing information and developing an urban “situational awareness”: the knowledge of what is happening in the city (Luque-Ayala & Marvin, 2020: p. 138). The peculiarity of city brains is that they use this urban knowledge to predict future urban events, so that policymakers can act in advance and mitigate or eliminate a potential problem before its occurrence. In these terms, they are one of the most advanced technologies of anticipatory governance applied to the urban environment.

This emerging strand of AI-driven anticipatory governance is already observable in several cities, particularly in China. As of this writing, more than 500 Chinese cities have announced the development of city brain systems as part of rapid processes of digitalization which are reshaping urban governance across China (Xu et al., 2024). A prominent example is Alibaba's ET City Brain which is currently employed in 23 Chinese and Malaysian cities to foresee, for instance, the occurrence of traffic jams and car accidents, thereby giving local policymakers and traffic officers the opportunity to deal in the present with the root causes of future transport problems (Caprotti & Liu, 2022). City brain developers hail this type of AI as a potent technology destined to significantly improve urban governance and public policy. They promise accurate predictions through sophisticated processes of machine learning whereby city brains can, in theory, absorb past and present information about a given city and then generate new information regarding its future. In this sense, the promise of the city brain resonates with the promise of generative AI: an “umbrella term” that “describes machine learning solutions trained on massive amounts of data” and capable of generating a wide array of new content ranging from text and images to audio and 3D models (Sætra, 2023: p. 1).

In addition, the technology of city brains resonates with the technology of generative AI, because of their growing reliance on LLMs. These are mostly transformers, akin to ChatGPT, trained on large

datasets and “highly capable at a range of natural language tasks, such as question answering, text summarisation, machine translation and code generation” (Magee et al., 2023: p. 1). Coding is a crucial capability of LLMs. One that demands attention and critical reflections. In essence, the implication of this capability is that programs are now being generated by AI, rather than coded exclusively by human computer scientists, in a way that can easily escape human comprehension (Welsh, 2022). In relation to city brains, this means that the programs whereby they predict the future of the city and inform its governance and policy would not be simply human-made but also LLM-made. Such a scenario raises concerns over who or what is behind the governance of cities in the age of generative AIs, posing a series of pressing challenges which will be the focus of the next section.

City brains’ epistemological challenges as problems of governance and policy

The core of the challenges posed by the deployment of city brains in urban governance is epistemological in nature. More specifically, the crux of the matter is how city brains produce new knowledge about potential futures by means of generative AI, including LLMs, and how such algorithmically generated knowledge then feeds into urban governance and policymaking. From the existing literature, we know that city brains use the data in their possession to produce novel knowledge about what is likely to happen in the city. More specifically, they utilize a very heterogeneous mix of data gathered via cameras scattered around the city and large datasets i.e., big data installed and redirected by the developers, including digital maps, social media feeds and government databases (Cugurullo, 2021; Curran & Smart, 2021). City brains feed on big data to produce so-called “epistemic objects,” such as charts, maps and simulations, which attempt to visualize in the present the knowledge of what might happen in the future (Anderson, 2010: p. 783). Yet, in the fields of urban studies and public policy, we ignore the dynamics of the process of knowledge production whereby information about the urban past and present is turned into information about the urban future, which culminates in policy impact. In this regard, there are three interconnected issues and challenges that it is important to discuss in order to develop a critical theory of AI-enabled anticipatory governance in the age of city brains and generative AI.

First, it is unclear where exactly city brains are assimilating data from and how the information at their disposal is analyzed and turned into predictions. Here, the presence of generative AI is epistemologically problematic. This is a type of AI capable of producing new contents (including codes) in a way that escapes the comprehension of its users and creators (Welsh, 2022). It is a *black box* that absorbs existing information and then generates new information through an obscure epistemological process (Chun & Elkins, 2023). In these terms, the deployment of city brains’ predictions in urban governance and policy is a matter of public concern, because neither policymakers nor citizens would be able to fully comprehend and thus assess the *episteme* at the foundation of anticipatory governance.

Second, attention to new AI-based predictive systems has emerged in urban studies, sparking theoretical debates which depict the city as a “calculative machine” employing statistical data to estimate “an array of possible projected futures” (Amoore, 2013: p. 9; Luque-Ayala & Marvin, 2020: p. 130). However, algorithmic predictive techniques can be powerful tools in the hands of governments, not only to anticipate and actualize some futures but also to “rule out other potential futures” that are deemed undesirable by some influential stakeholders (Amoore, 2011: p. 38; Leszczynski, 2016). Third, it is important to remember that AI is far from being flawless. AI-based predictive systems, in particular, tend to become unreliable when they operate in time intervals that are far away from the present (Luque-Ayala & Marvin, 2020; Shapiro, 2023). In relation to city brains, we do not know how far in the future their predictions go, what impending collective problems are being prioritized, and what degree of accuracy is deemed sufficient when a prediction is crafted. By providing an on-the-ground account of how an existing city brain generates new visions of urban futures that impact urban governance, we now attempt to shed light on the aforementioned questions and issues and turn the discussion to the empirical case of the Haidian city brain in China.

The case of the Haidian city brain

The context and structure of a city brain

Technocratic anticipatory governance in the age of AI is not a theoretical notion. It is an action and manner of governing that can be observed in several cities; especially in China where innovation in

AI is rapidly being combined with new forms and technologies of governance. China has made AI an integral part of its national development strategy (Khanal et al., 2024; Xu et al., 2024). Particularly in relation to governance, the Chinese government began to officially promote an AI-enabled “intelligent governance” in 2017 as a policy priority, which was later actioned in 2019 via 17 piloting cities (State Council & The State Council of the Chinese Government, 2017: p. 9). These are cities that act as urban experiments in which new AI technologies are trialed across different domains of urban governance ranging from transportation to security and from environmental preservation to urban development. In China, the urban is a key site for AI experimentation, as it is in cities that multiple stakeholders from the public and the private sector join forces and mobilize resources to accelerate the genesis and deployment of AI technologies (Marvin et al., 2022). Among the official piloting cities identified by the Chinese government, we find, for example, Beijing, Tianjin, Shenzhen, Hangzhou and Suzhou, and observe a geographical accumulation of urban AI experiments in eastern China which is an area characterized by high levels of economic growth, human capital and technological innovation (Xu et al., 2024).

In this context, the case of Beijing is emblematic. In the capital of China, urban AI experimentation began in 2019 in Haidian: a mixed-use district situated in northwest Beijing, with a population of over 3 million people and a significant concentration of knowledge-based industries (high-tech companies, in particular). From a geographical perspective, the dynamics of Beijing’s experimentation with urban AI reflect those that scholars working in the field of experimental urbanism have repeatedly highlighted: urban experimentation takes place under controlled conditions in a portion of a city, with the ambition of scaling-up the experiment at a later stage (Cugurullo, 2016). The city brain system trialed in Haidian is the product of a variegated consortium composed of several public and private stakeholders. It includes (1) a government-led task force responsible for coordinating the urban experiment; (2) a think tank offering consulting services by drawing upon AI experts from universities and research institutes such as the Beijing Academy of Artificial Intelligence (BAAI), the Chinese Academy of Sciences, and Beijing Jiaotong University; (3) a general contractor (Zhongguancun Smart City Co. Ltd) in charge of building and operating the city brain and its related infrastructure; and (4) a number of tech companies (notably Baidu) which are developing and providing the hardware and software underpinning Haidian’s city brain.

The Haidian city brain has a complex structure which comprises both material and immaterial components, in a way that escapes clear geographical boundaries. First, there are over 14,000 CCTV cameras scattered all around the Haidian district. These are, in metaphorical terms, the “eyes” through which the city brain observes what is happening in the city. However, cameras are not its sole source of information. The city brain also relies on an extensive perception network composed of more than 20,000 sensors integrated into the urban fabric of Haidian. For instance, environmental sensors are placed along Haidian’s rivers to monitor water quality, water level and riverside human activities (Figure 2), as well as in residential areas to monitor air quality and noise levels across neighborhoods (Figure 3). There are also sensor stations positioned along the streets of Haidian to monitor traffic and detect illegal parking (Figure 4). Haidian’s city brain can thus see and hear what is happening within its vast sensorial range.

In addition, there is a big data center that is directly connected to the city brain. Referring to the “brain” metaphor that is intrinsic to city brain technologies, we can think of this component as a “hippocampus” which is the place where our information and memories are stored. In the case of the Haidian city brain, the knowledge at its disposal comes from government databases, the Internet and social media. Eventually, all the information that the city brain gathers through CCTV cameras and sensors and that it can get access to by means of its big data center, is processed in a digital cloud and in a physical computing center. This is where the “thinking” takes place and the city brain analyzes the variegated pieces of information at its disposal, finding patterns and reaching a situational awareness regarding what is happening in the Haidian district.

The predictions of a city brain

City brains do not simply observe the present, monitoring what is happening in cities. According to their developers, they are also capable of seeing the future, generating information about future urban scenarios for policymakers and city managers to govern cities in a proactive manner. We illustrate how these dynamics of AI-enabled anticipatory governance take place in Haidian, by focusing on three



Figure 2. An example of the city brain's environmental sensors in Haidian.

Source: Authors' original.

dimensions of its management: environmental risk management, traffic management and public security. In the first instance, the Haidian's city brain draws on its suite of environmental sensors and, above all, taps into the database of the Haidian's weather information center, to foresee how weather conditions will impact urban infrastructure and systems, such as transportation. For example, in the case of extreme weather conditions leading to urban flooding, the city brain identifies the areas that are likely to be inundated and calculates alternative traffic routes to pre-empt car accidents. This is a chance for city managers to anticipate a potential environmental disaster, by proactively building new infrastructure to reinforce riverbanks and improving the city's drainage systems such as storm sewers.

Second, in the domain of traffic management, Haidian's city brain relies on CCTV cameras and traffic sensors scattered along public roads, coupled with predictive analytics, to analyze the evolution of traffic and predict the formation of traffic jams as well as the likelihood of road accidents. There is a spatial dimension to the city brain's predictions, consisting of the location of future accidents, for example, but there is also an axiological one since this AI is designed to make a value judgment. More specifically, the city brain determines the gravity of the impending accidents that it foresees, deciding whether it is necessary to send police officers, physicians and paramedics to the places where accidents are supposed to occur. Third, in relation to public security, the Haidian's city brain taps into the database of the local police department and its network of CCTV cameras coupled with facial recognition software, to establish where crimes will take place in the city and who will be involved in criminal activities. Once again, beyond a simple mapping exercise, there is a delicate value judgment at play, as it is up to the city brain to determine the gravity of the anticipated crimes and dispatch a given number of police officers accordingly.

Critical reflections on the practice of anticipatory governance enabled by a city brain

Technocratic anticipatory governance is not a mere technological process: it is first and foremost an epistemological process. As we stressed in the previous part of the paper, this is a future-oriented act of



Figure 3. Sensors monitoring noise and air pollution as part of Haidian's city brain system.
Source: Authors' original.

governing which is based on the production of knowledge concerning possible futures. When it comes to city brains and their anticipatory attitude to governance then, it is important to critically reflect on how this type of AI generates knowledge that eventually informs the management of cities and the resolution of collective problems. In these terms, there are three key epistemological steps to consider. The first step is the process whereby a city brain collects information regarding the present and past of a given city. In the case of the Haidian city brain, large volumes of data are collected through an extensive

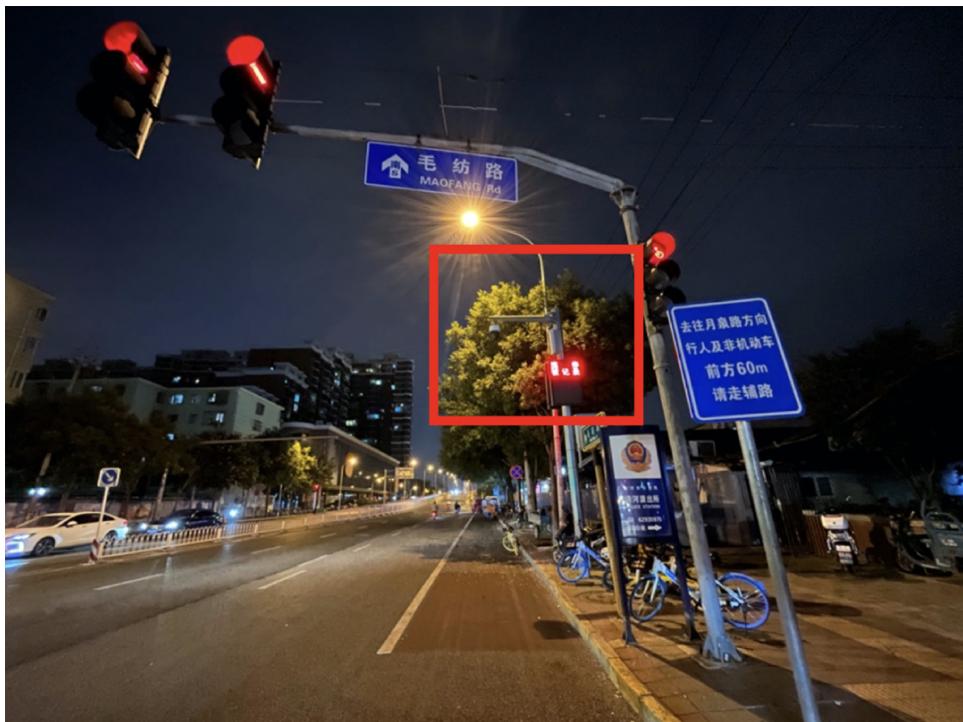


Figure 4. A sensor station integrated into Haidian's road infrastructure.

Source: Authors' original.

sensorial apparatus that is embedded in the built environment. This is a condition that does not resonate with recent critical analyses on soft power and Internet-based forms of surveillance (Han, 2017; Zuboff, 2019). Instead, it evokes images of a Foucauldian panopticon that constantly observes what is happening in concrete urban spaces, rather than monitoring digital activities in cyberspace (Foucault, 2020). This is a real and tangible infrastructure that is growing exponentially. Our research reveals that in 2020, the Haidian city brain was connected to 10,000 sensors, while in 2022 the number of sensors doubled, thereby permeating the urban environment. Geographically, we can see that while cyberspace remains an important spatial component of AI applications in the city (McCarroll & Cugurullo, 2022), it is certainly not the only one and the role of physical spaces and infrastructures is far from becoming obsolete in the age of generative AI. Epistemologically, the gigantic physical panopticon built around Haidian's city brain is the main source of knowledge for AI, but its awareness extends beyond sensorial information. The examples discussed earlier show that this city brain also relies on knowledge accumulated over the years in government databases (such as criminal records), as well as on off-site data centers including the local weather information center.

The second step is the process whereby a city brain turns the information at its disposal into knowledge of possible urban futures, de facto developing predictions of events yet to take place. This is where generative AI and LLMs come into play and obfuscate the process of knowledge production at the foundation of anticipatory governance. Part of the programs that the Haidian city brain employs to develop its predictions have not been coded by human computer scientists. Instead, our empirical research shows that this city brain relies on an LLM called WuDao (ironically meaning enlightenment) to code some of its core applications. WuDao has been developed by BAAI, a key member of the consortium behind the development of the Haidian city brain (see *The context and structure of a city brain section*). From an epistemological perspective, this means that the city brain's predictions are partly the outcome of an obscure algorithmic process that lacks transparency: neither the computer scientists working for BAAI nor the policymakers who rely on the city brain to govern Haidian, fully comprehend how this AI is generating new knowledge of the future. WuDao does not shed light: it brings darkness. Paradoxically

then, despite the tremendous scientific progress that has characterized the age of generative AI, today those who listen to the predictions of the Haidian city brain are not in a better position than those who were listening to the sibylline predictions of ancient oracles thousands of years ago. In both cases, the nature of the prediction is unknown and yet its contents are accepted at face value.

The third and final step is the process whereby the predictions of a city brain are actioned and generate policy impact. In the case of Haidian, there are three main areas of governance that are being shaped by the city brain's predictions, namely environmental risk management, traffic management and public security. On the basis of what the city brain foresees, local policymakers implement ad hoc policies and take action in a variety of ways. For example, in the case of an impending natural disaster, policies are rapidly implemented to build new infrastructure meant to reinforce riverbanks and increase the efficiency of the city's drainage systems. Outcomes also include direct interventions when, for instance, police officers are dispatched to prevent illegal activities in an area where, according to the city brain, crimes are likely to take place in the near future. However, the predictions of the Haidian city brain are far from being infallible. Our research reveals that the accuracy rate of what the city brain predicts varies from 60% to 90%. According to one interviewee, a computer scientist involved in the development of the Haidian city brain, the accuracy of the predictions will improve as the sensorial apparatus of the city brain will keep expanding, but as of this writing the margin of error remains significant. It is also important to note that our research participants reported that the city brain can foresee within a time range from 6 hours to 10 days, and the further its predictions extend into the future, the less reliable they become. This is the same issue that critical studies in anticipatory urban governance have often reported (Luque-Ayala & Marvin, 2020). It is with the aim of exposing the gravity of such issues that we conclude the paper, by combining the theoretical insights from the *Toward a critical theory of AI-enabled anticipatory governance* section with the empirics hitherto discussed, in an attempt to develop a critical theory of anticipatory governance in the age of generative AI and city brains.

Conclusions: a critical theory of anticipatory governance in the age of generative AI and city brains

Techniques and technologies to anticipate the future and use its knowledge to govern cities and states have changed over the centuries, but the essence of technocratic anticipatory governance has remained almost the same. However, the advent of AI and the diffusion of generative AIs, in particular, are now altering some of the fundamental dynamics whereby futures are calculated and acted upon, thereby generating challenges that threaten the status quo underpinning the governance of human society. We illustrate these recent alterations and the challenges that they pose in Figure 5.

The principle of rationality, the belief in determinism and the intention to avoid future shocks continue to inspire the practice of technocratic anticipatory governance, as a force that state actors in particular channel toward an idealized and subjective vision of the future. The first difference that we observe is that nowadays AI is the medium whereby futures are calculated and rendered visible. AI is also an agent that does not simply calculate potential futures but also takes action toward their realization, thereby actively influencing governance. This is a noteworthy dynamic that denotes a transition to a *posthuman governance* "which goes beyond the human in the sense that human agency constitutes only a portion of it" and "actions and powers of governing come from intricate human-AI relations" (Cugurullo et al., 2023b: p. 379). Second, specifically in relation to city brains, we observe the formation of a gargantuan panoptic system as the main epistemological source feeding information to AI. CCTV cameras and sensors embedded in the built environment constitute a panopticon through which AI develops a situational awareness regarding what is happening in the city. As our empirical research shows, this is by and large a physical system. From a geographical perspective then, concrete urban spaces and infrastructures remain prominent in the age of generative AI, and their role in anticipatory governance is far from being overshadowed by cyberspace. Third, LLMs come into play and shape the epistemological process whereby AI employs the information at its disposal to develop predictions targeting hypothetical futures. Here, knowledge enters a black box and subsequently exits it in the shape of predictions. Given the obscure mechanics of LLMs, policymakers cannot comprehend the nature of such predictions, but they use them nonetheless, taking them at face value as an instrument of disciplinary power. This attitude corrupts the original principle of rationality based on Enlightenment philosophy since LLMs do not shed light on the policy process, but rather obfuscate it by generating knowledge whose origin escapes human understanding.

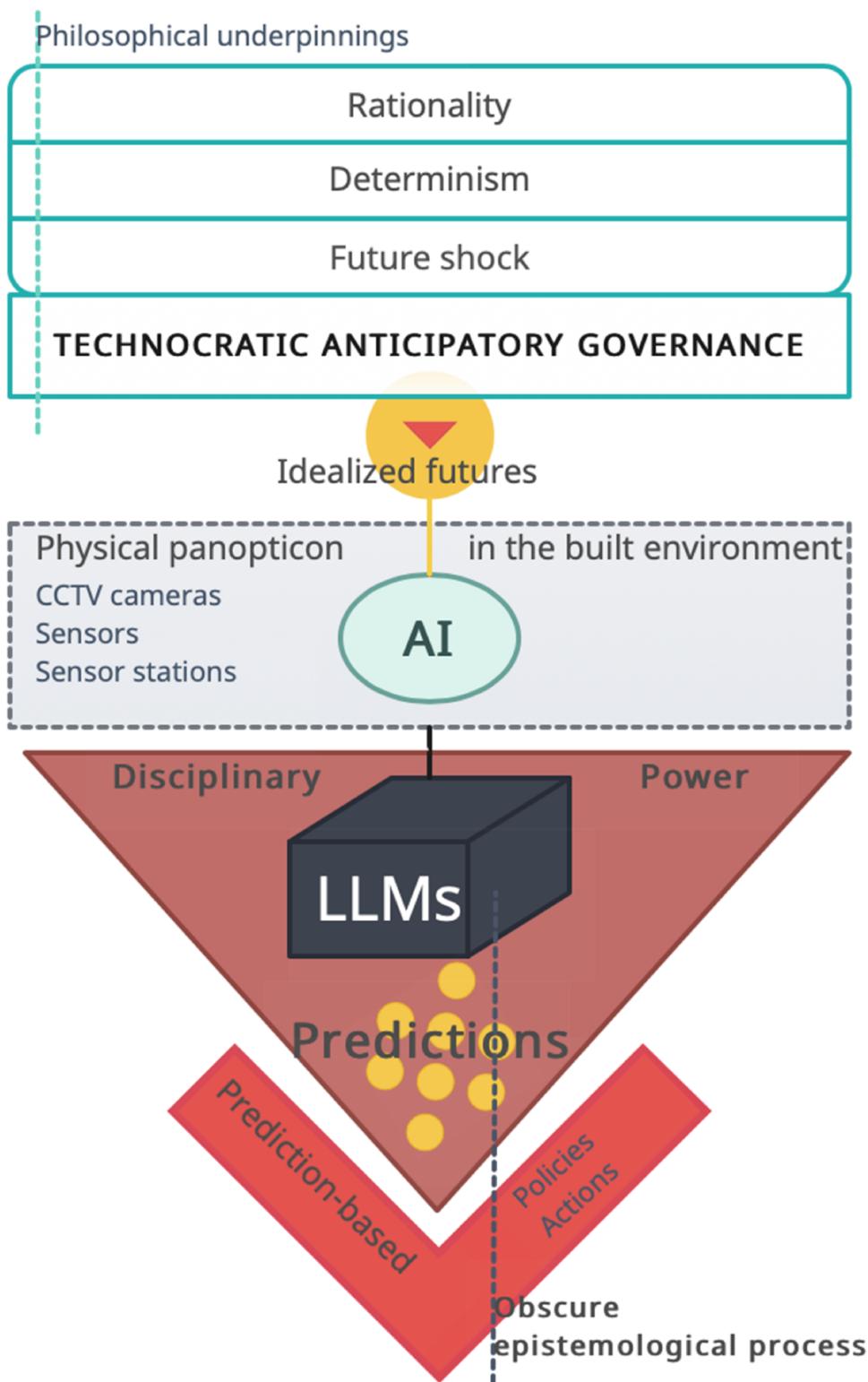


Figure 5. The nature of anticipatory governance in the age of generative AI.
Source: Authors' original.

The gravity of such a system of governance lies in the marginal role that humans play. Unlike what proponents of participatory forms of urban governance (see [De Barbieri, 2018](#)) recommend, citizens are far from being treated as stakeholders. Instead, they are relegated to the status of data points in depolitized spaces where they have no opportunity to engage in the governance of their city in a bottom-up manner ([Gabrys, 2014](#); [Swyngedouw, 2009](#)). They are perpetually observed by an ever-growing panopticon that keeps feeding information to large-scale AIs, such as city brains, and they cannot question the future identified and targeted by AI. Human policymakers take action on the basis of predictions that are generated by unintelligible nonhuman intelligences, as part of an epistemological process lacking transparency and thus accountability. Above all, AI itself carries out actions that are charged with moral value. In the case of city brains, we noted in this paper how these AIs make value judgments in relation to the accidents and crimes that they predict, dispatching human police officers like pawns in a strategy game. As critical social scientists, we care to note that governance is not a game. It is a complex system designed by humans to manage and sustain human lives, and it is therefore imperative that human stakeholders do not cede their decision-making capabilities to nonhuman intelligences. In line with the insights of scholars who combine *anticipatory* with *participatory* governance, “the broader public” should be involved as “stakeholders and decision makers” ([Guston, 2014](#); [Quay, 2010](#); [Wiek et al., 2013](#): p. 47).

It is here that theories of *anticipatory governance of technology* (see the *Approaches to anticipatory governance* section) can offer helpful lessons that resonate with the problems emerged in our case study. To paraphrase [Maffei et al. \(2020](#): p. 125), *anticipation* rather than *prediction* should be the goal of governance. This means combining foresight with critical thinking to discuss the potential consequences of technological development and (specifically in relation to the empirical focus of this study) of the deployment of generative AI in urban governance. Such discussion, in line with the insights of [Guston \(2010, 2014\)](#), would not seek to identify and pursue one single future in a deterministic manner like generative AI is currently doing. Instead, it would envision multiple futures as “objects for deliberation” ([Guston, 2010](#): p. 434). This is an outcome that can only be achieved by keeping various human stakeholders involved in the policy process. Unlike AI, humans have the ability to produce and then bring into question heterogeneous ideas. As the literature on *anticipatory governance of technology* suggests, when these dynamics take place through public engagement, it is more likely that technology will serve the public good. Thus, the public must be kept in the loop: people with various backgrounds who can open up governance, instead of narrowing it down to single AI-made decisions that, as this paper has shown, are the product of obscure epistemological processes. Ultimately, transcending humanity in governance and establishing a posthuman governance would be a dangerous regression ([Cugurullo et al., 2023b](#)).

One way out is to dismantle the anthropomorphism that permeates generative AIs such as city brains whose very name suggests the presence of a brain and of a mind that reasons the way we do. This is the same mistake that people were making thousands of years ago under the belief that oracles were channeling the will of anthropomorphic deities, such as Apollo, a human-like god of knowledge and patron of Delphi’s famous oracle. It is by questioning both the accuracy of the contemporary prophecies developed by generative AI and the futures that they are enabling and ruling out, that we can choose not to listen to them. Instead, we should turn our ear to the citizens who are “the primary users of public space” and therefore possess an unparalleled expertise in it ([De Barbieri, 2018](#)). Those are the people who truly know the city and whose visions of the future should thus inform the policy process.

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Data availability

The datasets generated and analyzed during the current study are available from the corresponding author on request.

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Conflict of interest

None declared.

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