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Jumping Off AI Anxiety and Enthusiasm Bandwagons: The Legacy of Positivism and Its Pluralist Antidotes in Planning Thought and Information Science

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Abstract
In the last three decades, post-positivist approaches to planning theory sprung in parallel to digital applications intended as decision support systems in planning practice. Today, artificial intelligence (AI) raises expectations about the solutions to planning problems these systems may deliver. These expectations stir either anxiety or enthusiasm depending on whether one acknowledges the limitations of expert knowledge, or assumes that they rest on inadequate computing abilities. This article traces the lineage of contemporary enthusiasm about AI in planning practice back to the legacy of positivism in planning thought. Moreover, the article addresses the anxiety by showcasing pluralist challenges to positivist legacies across planning theory and information science. In this light, the paper lays the conceptual ground for planners' engagement with scholarship akin to post-positivist perspectives in information science, to foster pluralist due diligence in the use of AI applications.

Keywords: Positivism; Pluralism; Ontology; Complexity; Human-Computer Interaction

1. Introduction

The history of ideas and practices in any scientific domain gives way to traditions. Traditions lay the ground for new contributions developing previous ones or critically searching for alternatives. They also work as moulds for mindsets, constraining intellectual innovation (Healey, 1997), steering motives and attitudes behind perceptions and understandings of new discoveries and inventions, especially those circulating across domains. The scrutiny of traditions cultivates awareness of the chain of inspiration informing a domain vocabularies, narratives and approaches, and the legacies shared across domains. Looking at planning traditions a couple of decades into the second millenium CE, their heterogeneity (Allmendinger, 2002) coexists with the persistence of the foundational positivist legacy in planning practice (Davoudi, 2012). This article's literature review recalls the positivist tradition of the engineering mindset in planning theory to revive its critique and compare it to the last thirty years advancements in information science. This comparison sheds light on the commonalities between intellectual traditions in these two domains. Identifying these commonalities challenges both anxious and enthusiast reactions to the adoption of information science tools in planning practice, as these reactions mutually intensify in the wake of artificial intelligence applications.

In his classic review of intellectual traditions defining the relation of knowledge to action, John Friedmann (1987) provides a comprehensive overview of two centuries of planning theory. Here, he traces the origin of planning back to the emergence of the belief that society can be improved by the guidance of scientifically based knowledge, beginning with early positivist thought. Indeed, he wrote at the beginning of what can retrospectively be considered the spring of post-positivist (Allmendinger, 2002), interpretative or hermeneutic (Davoudi, 2012) approaches to planning. These approaches challenged positivist assumptions such as the supremacy of technocratic decision making, the objectivity of expert knowledge, and the validity of certainty. While separated for explanatory purposes, these assumptions are dependent on one another, taking certainty as a fundamental attribute of knowledge, of its objective translation into decisions, and of the linear causality between decisions and their outcomes. The corresponding post-positivist counter-assumptions rely on the endorsement, to different degrees, of three aspects of a pluralist understanding of reality. These aspects are: the necessity, or the plain fact, of distributed multi-criteria decision-making; the legitimacy of different sources and types of knowledge; and the inevitability of uncertainty. This article identifies these aspects as three dimensions of pluralism, as they altogether do away with the idea of the singularity of truth.

The above-mentioned spring season also saw the parallel development of digital modelling applications intended as decision support systems in planning practice (Geertman and Stillwell, 2004). Since their onset, support systems developed within academia and the private sector keep facing the so-called implementation gap (Jiang et al., 2020). In fact, many public authorities, for example in the EU, lack the expertise required for the use of these systems, with few pioneer cases, such as the Amsterdam Institute for Advanced Metropolitan Solutions, proactively building partnerships across government, academia and the private sector to bridge these gaps. Yet, the development of digital decision support systems can also claim substantial achievements, first of all that of diversification including capabilities in data analytics, monitoring, scenario building and knowledge sharing. Next to data-driven applications centred on computational capabilities (Gil, 2020), other modelling applications adapted to suit different planning approaches. Significant efforts went into supporting participatory decision making and the integration of different sources of knowledge (Borri et al., 2006; Pelzer et al. 2015; Campagna, 2016). Others committed to adapting modelling techniques to shifts in system theory inspired by complexity science towards open-ended simulations (Batty, Torrens, 2001; Portugali, 2021). Moreover, looking beyond spatial planning applications, semantic cognitive approaches to information science also contributed to new breakthroughs in digital modelling (Guarino, 1998; Borgo et al. 2022). While these distinctions often go overlooked in outsiders' perceptions of digital modelling, the latest experiments in artificial intelligence (AI) have revived expectations that information science may ultimately be trusted to deliver technocratic solutions for planning problems. These expectations stir either anxiety or enthusiasm depending on whether one endorses the post-positivist critique of the singularity of truth and the limitations of expert knowledge, or whether they assume that these limitations rest on inadequate computing abilities.

Comparing literary insights from specific sectors of planning and information science scholarships, this article challenges flattening and polarized perceptions of digital applications in planning. The methodological section explains the criteria applied in the selection of sources. Afterwards, the literature review splits in two sections, the former focused on planning and the latter on information science and digital modelling. The first section looks at positivism and post-positivism in planning thought. The second section covers two focuses among contemporary developments in the umbrella category labelled by John Friedmann (1987) as system engineering. It looks at pluralism in philosophical and semantic-cognitive approaches to information science and at uncertainty in digital modelling of urban and environmental complexity. The findings encourage like-minded scholars to join forces to foster pluralist approaches across domains. Based on the shared interests highlighted by the literature review, such collaboration constitutes the most appropriate response to both enthusiasms and anxieties regarding the persistence and revival of positivist planning through AI applications.

2. A literature review across domains

The literature review does not provide a systematic account of the ongoing debates on its topics of interest in the domains of planning and information science. It rather spots evidence of the relevance of these topics across domains, highlighting the thread or line of argument by which some authors address these topics, and tracking the matching of meanings behind terminological variety. Accordingly, the selection of sources prioritized authors whose citation rates and involvement in scholarly circles, joint events and publications suggest a fair degree of relevance in ongoing debates in each research area. Here, the prominence given to geographically and intellectually situated circles depends on the author's participation in these circles. Moreover, the selection cumulatively integrated two criteria for both domains. The first criterion was the use of one or few related starter key words. The second criterion added sources using one or few related follow-up key words, hand-picked from the texts selected by the first criterion to root the review in the terminology in use in the referenced literature. In a few cases, additional ad hoc references provided explanatory examples, evidence of shared interests across domains and/or insights on terminological matches and mismatches. The starter and follow up search key words for each domain are presented in Table 1.

Domain	**Starter key word**	**Follow-up key word**
Planning theory	tradition, typology	positivism
Information science (philosophy, cognitive-semantic)	pluralism	ontology
Modelling urban and environmental complexity	uncertainty, prediction	open/closed systems, wholes

Table 1: starter and follow up key words used in the search for references

3. Planning, positivism and its critics

Introducing the intellectual traditions which shaped the domain of planning, John Friedmann (1987) points to the eve of the industrial revolution as the cradle of the very project of scientific planning. He stresses Saint-Simon's (1760-1825) influence on the foundation of sociology, through his disciple Auguste Comte, and other disciplines relevant to the domain of planning. According to Friedmann, Saint-Simon's social physiology assigned to scientists and engineers the task of serving humanity with "their ability to predict the future outcomes of present actions" (ibidem, p. 52). He introduced the idea that scientific planning can guide social progress by the assumption that history is governed by objective laws, and that human freedom submits to these "immutable laws of human progress" (ibidem, p. 73). Accordingly, planning can guide social progress by observation and measurement, focusing on functional fit and efficiency as stable absolute principles. Meanwhile, politics with its volatility could be made unnecessary by the consolidation of a consensual society, according to a supposedly neutral and value free system, "supposed to be obvious and therefore reasonable to all who were properly informed" (ibidem, p. 68). Knowledge was intended as "the power of technical reason to determine what is correct" (ibidem, p.58), something which would be beyond the reach of the masses, but rather the monopoly of "initiates" (ibidem, p. 71) acting in the service of rulers. Here, the term "initiates" recalls John Stuart Mill's accusation that Comte's positivism pursued a form of spiritual domination comparable to the old religion which Comte himself originally opposed. This accusation exposes the positivist attitude towards a secular endorsement of the singularity of truth. According to Friedmann, these premises gave way to different intellectual traditions, upholding different interpretations of the role of science in the exercise of power in society, the organizing principle of his typology of planning theories. He visualizes these traditions chronologically as a set of parallel lines, from the most conservative to the most radical interpretation. Here, he groups thinkers across most of the set under the label of engineering sciences, defined by the trust in technical reason to determine what is correct into a single objective reality. This is the model of the ecole polytechnique, with its focus, as he puts with a von Hayek' s quote (ibidem, p. 59), on the deliberate and conscious construction of the world. This idea of the world included both the physical and the social reality, both considered as artifacts. Yuval Portugali (2021), describing this idea of the world as mechanistic, clarifies

> artifacts are 'facts of art' – products of human intention, imagination and action – whether they are artistic entities, socio-cultural organizations or machines. Modern science started with 'the world as a clockwork' – the machine as a metaphor for the natural universe at large. […] The generality of this mechanistic world view that dominated science for more than 300 years was falsified at the beginning of the twentieth century following Einstein's relativity, quantum theory, and, more recently, complexity theory. What was falsified was not the existence of a mechanistic domain, but its generality, namely, the view that its basic properties apply to nature, society and culture. (ivi, p. 15)

The plausibility of technical reason uncontroversially determining what is correct relied on the assumption of the singularity of truth according to this mechanistic idea of the world. This assumption trickles down into derivative assumptions attributed by Friedmann to smaller sub-sets, narrowing the focus from technical reason, to technocratic decision-making, and further to the objectivity of knowledge and to its certainty. In Friedmann's reading, the trust in truth-endowed technocratic decision making characterizes both conservative and reformist thinkers, sparing only the most radical ones. Moreover, conservative thinkers justify this trust by assuming the objectivity and political neutrality of expert knowledge and technical reason, serving the state and those who are in power. Furthermore, system engineering, placed on the conservative end of the set, including cybernetics, game theory, information theory, computer science, and robotics, adds the trust in prediction of the consequences of action in relation to desired objectives. In this regard, Friedmann also blames futurology as a sign of crisis in the social sciences, “a bogus science [where] our seeming inability to understand the world by studying its past, [pushes to] the flight into the future” (Friedmann, 1987, p. 73).

Friedmann’s typology adopted an historical and disciplinary perspective, without engaging with the categories proposed in the 1980’s debate on the typology of urban planning theories (Yiftachel, 1989). Two years after the publication of Friedmann's seminal book, Oren Yiftachel reviewed the previous debate on typologies to propose a new one. This review departs from Andreas Faludi’s “ 'procedural' and 'substantive' planning theories, termed theories of planning and theories in planning, respectively“ (ibidem, p. 24), followed by an alternative dichotomy between explanatory and prescriptive theories based on Taylor’s critique of Faludi. Against this background, Yiftachel proposes his classification, which is incommensurable to Friedmann’s, even though they share meaningful commonalities. These commonalities include the chronological and linear structure, though Yiftachel’s starts with the XX century while Friedmann’s from 1789. They also share a common focus on the dichotomy between conservative neutrality and partisan change. Yet, they place this dichotomy in different parts of their respective chronologies. For Friedmann the distinction separates different parallel traditions all along the history of planning. Yiftachel, instead, frames the distinction between “openly politicised approaches and persisting technical-neutral orientations” (ibidem, p. 23) as an historical shift from the latter to the former occurring in the mid-1960s. He considers this shift as part of the paradigm breakdown which splits his chronology in a before and an after. The main reason for the incommensurability of the two typologies most probably lies in the different definitions of planning they refer to. Indeed, Yiftachel refers to urban land use planning, while Friedmann to scientific based planning, excluding “other forms of planning, such as urban design, piecemeal social reforms and administrative city planning [which...] did not yet embody a scientific practice.” (Friedmann, 1987, p. 53). Regardless of these differences, Yiftachel's observation that planners portrayal “as neutral and apolitical experts” (Yiftachel, 1989, p. 36) dominated the first half of the XX century confirms the hegemony of the engineering mindset at the onset of modern spatial planning practice.

Allmendinger (2002) provides an example of the later reception of both works, reacting to Yiftachel’s typology in an article about post-positivism in planning thought, where he also includes a reference to Friedmann’s classification. Arguing in favor of a post-positivist typology of planning thought, he criticizes the evolutionary character of both Friedmann's and Yiftachel's chronologies for formalizing a linear progressive view of planning theory. Instead, he calls for a post-positivist typology “identifying and tracing influences and how theories are transformed, mediated and used in a linear and non-linear way and different contexts including time and space” (Allmendinger, 2002, p. 89). He also stresses how most developments in planning theory at the time of his writing stem from a post-positivist perspective, including collaborative, neo-pragmatist and postmodern approaches to, and feminist perspectives on, planning. In this regard, he stresses: “What is important to note is not that there has been linear progress or evolution but that at different times and in different places over the past 2500 years or so the basic positions have been held simultaneously as they still are now.” (Allmendinger, 2002, p. 86). Options are open, as they were in the past, for scholars and practitioners to chose. Nonetheless, positivism remains highly influential in planning practice, even though the occasional endorsement of new devices, identified by Simin Davoudi as network analysis, relational functional regions, fuzzy maps, scenario building and experiential knowledge, signals a search for alternatives by planning practitioners (Davoudi, 2012).

Indeed, the turn of the millennium brought a wide recognition of a post-positivist drive in spatial planning, even though different observers associated this drive to different examples and even to different categories of examples (Fainstein, 2000; Allmendinger, 2002; Davoudi, 2012). This literature provides a comprehensive and at times conflicting interpretation of the different aspects marking the distinction between positivist and post-positivist planning approaches. This article focuses on aspects of positivism highlighted by Friedmann such as the trust in technocratic decision making, the objectivity of expert knowledge, and the validity of certainty, as expressions of the positivist commitment to the singularity of truth. Despite their different takes on the subject, the three above mentioned sources agree on the pluralist post-positivist shift towards what altogether they address as contingency, variance, diversity, fragmentation, multiplicity, polyvocality and pluralism (Fainstein, 2000; Allmendinger, 2002; Davoudi, 2012). Moreover, the emphasis on variance in interpretation and explanation

puts in the spotlight the question of meaning (Allmendinger, 2002; Davoudi, 2012). “A post-positivist approach requires ‘shifting from causal reasoning as a basis for plan-making to discovering and confirming meaning’ (Moore-Milroy, 1991: 182)” (Allmendinger, 2002, p. 87). “Rather than recourse to objective evidence or reality, the emphasis in post-positivist planning is on
language and ‘making meaning’ through language” (Allmendinger, 2002, p. 88). According to Davoudi, “meaning refers to what is consciously and individually intended as well as what is commonly and often unintentionally significant […]. Place is defined subjectively with people living not ‘in a framework of geometric relationships but a world of meaning’ (Hubbard et al., 2004, p. 5)” (2012, p. 430-432). This interpretation requires planning to acknowledge “the influence of the cognitive, social and institutional environment in which decisions, or more precisely practical judgments, are made” (Davoudi, 2012, p. 437). According to Davoudi, planning practice is far from endorsing post-positivism. She points to evidence-based planning and system thinking, echoing Friedmann's interpretation of system engineering, as pressures towards positivist technical rational approaches. She considers these pressures as heralds of a new and on the rise scientism characterized by “over-emphasis on rationality and objectivity, and the over-confidence in the power of reason to control time and space” (Davoudi, 2012, p. 439).
The next section of the literature review looks at the domain labelled by Friedmann as system engineering, to highlight how the undeniable positivist drive of system thinking does not prevent its permeability to pluralist approaches. The section focuses on more recent contributions in computer science, information science, knowledge engineering and system theory applied to spatial analysis, pursuing pluralist approaches in the decades following the publication of Friedmann's book.

4. Post-positivism as pluralism in information science and digital modelling

Looking at information science, the first part of this section highlights post-positivist and pluralist concerns in philosophical and semantic-cognitive approaches. Then the closing focus on uncertainty and on open systems completes the picture with the shift from modelling to open-ended simulation in system thinking, leaving behind the predictive tenet of positivist science (Batty, Torrens, 2001). Helen Couclelis features as the first reference of this section in direct dialogue with John Friedmann’s 1987 description of computer science and system engineering as helplessly positivistic. On the one hand, the significance of her scholarship on the philosophical underpinnings of geographic information science is comparable to that of Friedmann in planning theory. Moreover, the time span of her research covers exactly the decades following the publication of Friedmann’s book, starting a few years earlier. Arguing, at the onset of her career, in favour of abandoning positivist epistemology in human geography and the social sciences, Couclelis (1983) provides a telling description of post-positivist science which is worth an extended quote:

> *not truth and objectivity, but clarity of argument and internal coherence in discourse; not quantification, but the creative use of mathematical language, be it of a quantitative or of a more general qualitative sort; not accuracy of measurement and the discovery of general laws, but the thorough definition of the logical classes in which we order the phenomena we study, and an appreciation of the function of the formal tautologies inherent in abstract mathematical structure in securing logical consistency in theory […]; not the possibility to reproduce a tidily structured external world, but the ability to make intelligible to man an in itself unfathomable realm of external 'happenings'; not the privileged access to the 'real world', but the capacity to push to its creative limits the world-defining potential of theoretical language. For one of the central messages to emerge out of contemporary theoretical scientific advances surely concerns the extent to which the world we know is the product of the linguistic component in our knowledge* (Couclelis, 1983, p. 32).

Argument, creativity, ordering, intelligibility, definition and linguistic production echo the previously mentioned interest of post-positivist planning theory in meaning. Along the same lines, this terminology implies the possibility of plurality, and the related need for conceptual coherency and transparency, a key concern in semantic-cognitive approaches to information science. In the past thirty years this concern has given way to the articulation of formal ontologies. Formal ontologies provide stable terms of reference for setting up and operating models, and for interoperability between information systems. More broadly they establish a semantic and conceptual consensus to support interaction and communication between both artificial and human agents (Gaio et al., 2010). Using the countable plural already gets to the point, as opposed to the uncountable ‘ontology’, often written with the upper case (Guarino, 1998; Varzi, 2019), a branch of metaphysics and philosophy studying the prerogatives of being and existence. In fact, formal ontologies appeal to pluralism because they clarify the different options available for the interpretation of a conceptualization, implying the viability of different possible conceptualizations. They are cognitive artifacts providing a representation of a domain as a structure defined by the properties set through axiomatization (Ferrario, 2006). Indeed, pluralism is not a main topic of the literature in this domain. Nonetheless, it can be considered as a background assumption for some, as confirmed by occasional direct references to pluralism and richness as attributes of a desirable ontology (Casati and Varzi, 1999, p.4). For instance, in the context of a debate on the ontological foundations of conceptual modelling, Guarino and Guizzardi (2006) stand in favour of ontological pluralism to set their work apart from ontologies committed to reductionist monism, or the idea that all aspects of being can be reduced to a single definition. Here, they also feel the urge to claim that "a non-reductionist ontology is not necessarily a non-scientific ontology" (ibidem, p. 121) to discard an evidently sticky stereotype. Looking at the idea that ontologies can commit either to monism or to pluralism, Achille Varzi (2019) brings in the dichotomy between conceptualism and realism. By this dichotomy, he explains the difference between ontologies working with conceptualizations within information science and Ontology working with the truth of being in the context of metaphysics and philosophy. In this context, he admits that both conceptualists and realists can in principle be either monist or pluralist. But then he concludes that while "the laws of being are not up for grabs […] As a matter of general attitude, conceptualists don't care about the world; they care about conceptualizations. And the laws of conceptualizations are up for grabs." (ibidem, p. 8). He also supports his statement providing the example of the DOLCE ontology (Gaio et al., 2010), explicitly developed by Guarino and colleagues "with the vision that a unique universal ontology for knowledge representation cannot exist" (Borgo and Masolo, 2009, p. 372, cit. in Varzi, 2019, p. 8). Here, a contradiction may arise between this vision and the development of foundational ontologies such as DOLCE. The attribute foundational refers to a type of formal ontologies which aims to provide a domain-independent general reference, requiring universal validity to support interaction across domains. This requirement can easily be confused with the aspiration to singularity, which is clearly contradicted by the proliferation between the mid 1990's and the late 2010's of at least ten foundational ontologies (Borgo et al., 2022; Varzi, 2019). According to Varzi

> *Such abundance of systems is by itself indicative of how much the field has grown since the early days. But each system deviates from the others in significant ways, not only by employing different methods and techniques but also, crucially, by relying on different ontological categories and principles. And herein lies the trouble* (2019, p. 8)

which Varzi describes as trying to overcome the problem of the "database Tower of Babel" (Smith, 2003, p. 158, cit. in Varzi, 2019, p. 8) by encountering a parallel problem at a higher level, the problem of the "ontology Tower of Babel" (Kusnierczyk, p. 41, cit. in Varzi, 2019, p. 8). In 2017, the FOUST workshop engaged with this proliferation to "discuss the concrete use-cases that could be employed to illustrate and elaborate the differences between the popular foundational systems in addressing basic modeling problems" (Borgo et al., 2022, p. 2). Admitting that different ontologies may be more suitable than others in each modeling case of application, this endeavor proposed a comparative framework to turn the tower of Babel into a plurality of options for knowledge engineers to choose. Ultimately, ontological pluralism appears as a necessary backdrop of the plurality of knowledge, the second dimension of pluralism discussed above.

Moving to the problem of uncertainty or unpredictability in urban and environmental modeling, Batty and Torrens (2001) place the shift from a certain to an uncertain world, at least in human perception, in the second half of the XX century CE. They trace back to this shift the "growing need [...] for ever more complex models and the increasing difficulties in their validation" (ibidem, p. 4). As a result, they stress, "our science has become less orientated to prediction but more an aid to understanding, to structure debate" (ibidem) through a plurality of what-if scenarios whose purpose shall become more akin to exploration and calibration rather than prediction. According to Peter Allen (2021), this exploration shall be approached as an unending process of sense-making. As he puts it,

> *there is no scientific or unique way to modify our beliefs when they have failed, and so we are condemned to carry on throughout our lifetime trying to make sense of what is going on, what it means and what might happen. […] even though the development and use of interpretive frameworks is always going to be imperfect, it is still better to have this framework than not to have it. Acting without any model to test is simply trial and error without any learning (Allen, 2021, p. 87).*

In the field of environmental planning, Borri et al. (2006) point to the reconsideration of cybernetic models with their linear and deterministic logic, which is ill-prepared to deal with probabilistic and chaotic phenomena. Their reference to cybernetics recalls Friedmann's description of system engineering. While all these sources refer to complexity, they focus on different qualities, emergence and heterogeneity. Batty and Torrens, together with Allen, explicitly build on complexity science to simulate the emergent properties of complex systems. Borri et al.

focus on the "pluri-logic procedures" (ibidem, p. 563) of multi-agent planning situations in the context of participatory decision support systems. In line with previous observations on the plurality of decision-making agents and of knowledge, Borri et al. touch upon the first two dimensions of pluralism discussed in this article in contrast to positivist reliance on technocratic decision-making and the objectivity of expert knowledge. In both cases plurality undermines determinism, yet the focus of complexity science goes to the extensive plurality of states intended as the responses of the system to its environment. This plurality of states determines systemic uncertainty and unpredictability (Batty, Torrens, 2001), the third dimension of pluralism discussed in this article. Both focuses substantiate the finding that modeling has gone a long way compared to Friedmann's account of system engineering, and that it did so in different dimensions. Complexity science contributed to pluralist breakthroughs in system thinking related to the dimension of uncertainty. The engagement with uncertainty can be better understood in the context of the shifts occurred between the original understanding of systems, and therefore the type of models built to represent them, and the new understanding inspired by complexity science. Batty and Torrens (2001) explain this shift by the three key principles of model-building which grounded the assumption of certainty in the early days of system engineering. The first principle is about system boundaries and the crisp separation between a system and its environment, the inside and the outside. The second principle is about equilibrium and the stability and linearity of trajectories of change within the system. The third principle is the homogeneity, regularity and order exhibited by the elements of the system. Just like the three dimensions of pluralism, these three principles can also be placed along a circle of mutual influence. As put by Batty and Torrens

> *these principles did once appear to be implementable for urban systems but it is now easy to argue that none of these apply to even the simplest system of interest to policy-makers. Systems of any interest are impossible to close, their usual state is far from-equilibrium; often no such equilibrium ever exists. They are composed of heterogeneous agents and objects, indeed their very richness comes from such heterogeneity (ibidem, p. 4).*

These insights call into question the notions of open and closed systems in system theory. A discussion on openness and closure is particularly relevant to the study of urban systems, given the consensus on the explosions and implosions characterizing urbanization processes (Batty, 2022; Brenner, ed. 2014) and the intense debate in urban studies on the extent and scales of urbanization (Brenner, 2018; Schmid, 2018). The notion of open systems, lacking fixed limitations to the exchanges with their environment, exacerbates the aggregation problem typical of general system theory (Batty, 2000). This problem is the result of this theory attempt "to counter science's long-standing quest to reduce everything to fundamental particles" (Batty, 2000, p.167). Such reduction requires explaining the process through which a number of parts come together to form a whole, but also admitting that this does not happen once and for all. According to Batty, the lack of this explanation leaves system theories of the city describing "wholes in terms of an equilibrium which could not cope with any form of change other than that with the most local impacts" (ibidem). Over the last four decades, complexity theories of cities developed the study of cities as complex adaptive systems in constant flux and mostly far away from equilibrium. In these systems, the evolutionary process of adaptation drives the emergence of new variables, levels of organization and new boundaries according to non-linear trajectories and evolving combinations of heterogeneous elements (Portugali, 2021). Cities, economies, and ecologies are a typical example of these kinds of "systems whose structure is emergent […] where new and surprising elements evolve within their structure. […] This newness and surprise [...is] unusual enough to be largely inexplicable using our traditional approaches." (Batty, 2000, p.168). This dynamic understanding of urban and environmental systems, their heterogeneity, their constant renewal, makes any boundary between the outside and the inside a feature of a frozen cross section in time. Considering disequilibrium "the 'normal' mode in which systems in general operate" (ibidem) adds a diachronic notion of plurality to the previously addressed synchronic ones. In this sense, complex adaptive systems require models tracking discontinuities, positive and negative feedbacks in the evolution of a system, comparing different possible explanations of divergent trajectories of change in distinct yet apparently similar locations (Batty, 2000). Such models ought to be both diachronically and diatopically pluralist to attend the principle of non-causality, described by Yuval Portugali as the impossibility of establishing a direct correspondence between ifs and thens.

> *With machines, once you have all the ifs, you can, in principle, know all the 'thens'; with complex systems this is not so. Some say that this is because technical limitations in that complex systems have so many parts […] that identifying all ifs is technically not possible. However, in principle, if it was possible, then determining the 'thens' would be possible. Some (myself included) say that this is ontologically so – there is no limited number of 'ifs' and 'thens'; complex systems are inhexaustible (Portugali, 2021, p. 15).*

In this light, the problem of open systems expands from rethinking the relation between a system and its environment to rethinking wholeness and the process of aggregation of parts in a system. The dynamism of such aggregation creates plurality of states and uncertainty on various levels: knowledge, the relation between knowledge and decision, and between decisions and outcomes. In this light, uncertainty in complexity science, in addition to the plurality of decision-makers and knowledge(s) in participatory approaches to planning, can be considered as an herald of pluralism in system engineering and system thinking.

5. Conclusion

The legacy of positivism and the engineering mindset in planning thought has been analysed in detail elsewhere (Friedman, 1987; Davoudi, 2012). This article focuses on three tenets of this legacy, the trust in technocratic decision making, in the objectivity of expert knowledge, and in certainty. Since these tenets converge in reinforcing the reductionist idea of the singularity of truth, scientific pluralism can be considered as an antidote to positivism across domains. By comparing these original tenets to more recent advancements towards scientific pluralism in planning theory, information science and digital modelling, this article serves three needs. In the first place, the influence on planning practice of a new and on the rise scientism (Davoudi, 2012) points to the need to keep revisiting the tenets of positivism and their surviving influence in spatial planning. Moreover, the frenzy around AI developments points to the need to challenge flattening and polarized perceptions of information science applications in planning, tracking motives and attitudes behind perceptions and understandings of new discoveries and inventions. Finally, acknowledging a shared commitment to operate in multi-agent decision making environments (vs. technocratic decision), with multiple knowledges (vs. undisputable expert knowledge), and comprehensively dealing with plural system states and uncertain responses (vs. immutable laws and certainty), encourages like-minded scholars to foster pluralist approaches across domains. Such collaboration defuses both enthusiasms and anxieties regarding the augmentation of positivist planning practice through AI applications. In this light, this article goes beyond "identifying and tracing [...] how theories are transformed, mediated and used" (Allmendinger, 2002, p. 89). It wishes to trigger a conversation to lay a common ground for inter-operability, mutual influences and integration of efforts across domains.

Indeed, the purpose of the proposed conversation requires further clarification, as highlighted, for example, with the previously mentioned Tower of Babel effect (Varzi, 2019). To begin with, the notion of pluralism, as intended here, shall be set apart from that of relativism, even though both converge on the contestation of the singularity of truth. Pluralism engages with diversity as a collaborative learning process. It expresses and clarifies axes of conflict, and develops shared vocabularies, through dialogic approaches such as the science of muddling through (Lindblom, 1959) or the device of local trading zones (Balducci and Mäntysalo, 2013). On the contrary, the relativist appeal to diversity tends to compartmentalization. It heightens risks of overlooking mutual influences and the continuity between processes of knowledge differentiation, intersection and confusion. It is inclined to losing sense of direction among "a myriad of 'language games', personal opinion and ultimately incommensurable ideology" (Allmendinger, 2002, p. 93). This distinction is key to the pursuit of interoperability between systems and knowledges. In turn, this pursuit is key to make any alternative to positivist reductionism operationally viable. In the case of AI powered planning support systems, this pursuit requires interpretative and conceptualist approaches to human-computer interaction. Pluralist approaches disentangle the wish to increase the computing abilities of machines from the positivist drive to calculate one's way to the discovery of the immutable laws prospected by Saint-Simon. Instead, they exploit the inherent mutuality of human-computer interaction to integrate hermeneutics in the very process of computation. In this sense, the post-positivist emphasis on interpretation and meaning in planning (Allmendinger, 2002; Davoudi, 2012) speak to the efforts in conceptual coherency and transparency deployed by cognitive-semantic approaches to information science. In terms of intellectual traditions, this correspondence resonates in the opposition to realism shared by interpretationism and conceptualism, as put respectively by Davoudi and Varzi, as long as there is no slip into idealism, nor into relativism. In other words, these references confirm that working with interpretation and concepts, rather than with undisputable or mutually incommensurable truths, stands as a shared endeavour across domains. Moreover, for interoperability to adapt to system change and work beyond the fixity of certainty, modeling open systems, as proposed by Peter Allen, brings to the conversation the benefits of recursive experimental learning regarding the multiple states emerging from complexity and wholeness. Overall, a pluralist commitment requires embarking on the learning processes of muddling through diversity and complexity. Indeed, interpretative and conceptualist devices pursuing conceptual coherency and transparency sustain learners' sense of direction away from the positivist mould, by making the muddling process more intelligible, and therefore liable to scrutiny.

When data-driven applications in planning support systems bypass conceptual coherency and transparency checks, they contribute to the embroilment of planning practice in the positivist mould. For example, advertising narratives about these applications tend to shift attention away from the need to monitor their procedural and material flaws. By confusing tools, means and ends, the AI for sustainable, circular or equitable, cities brands create the illusion that the proposed tools are intrinsically geared to the pursuit of allegedly good intentions. This illusion overshadows the analytical biases entrenched in the choice of data sources or in the design of the algorithmic logic, not to mention the under-researched footprint of their physical infrastructure in terms of energy and water consumption. Instead, these problems need to be reckoned with as an intrinsic liability and addressed with appropriate mitigation methods and measures. Overlooking analytical biases supports positivist assumptions that data and algorithms are factors of objectivity and certainty per se, granting validity and solidity once and for all, and ignoring the need to pursue their recursive enhancement via semantic interoperability, ergo transparency. By focusing attention on the nobility of alleged ends, these narratives reinforce the technocratic flatness of the assumption that appropriate calculation will ensure certainty in the pursuit of these ends. Overall, these brands dissimulate the fact that tools like AI have no intentions, noble or despicable as human intentions may be. These tools can be engaged for means such as monitoring through large scale data analytics based on automated sensing and data mining, or scenario building and problem solving, for example through reinforced learning. In turn, these means may work towards both intentional and unintentional, noble or despicable, ends. No matter the tools' computational capabilities, the pursuit of intentional ends, and of the ways in which means powered by AI tools are used towards these ends, are the prerogative of human agents. Moreover, this pursuit is not a matter of AI nor of human calculation. Instead it is a matter of human deliberation and sense-making (Schön, 1983; von Glasersfeld, 1995) channeled into the arguments engendering connection between encoders and decoders, writers and readers. This connection is tied to arguing and interpreting. It exceeds AI copycat competences, just like writing and reading for transformation exceeds the standardized uniformity of a large language model's outputs (Lim, 2025). Increasing the aptness of modeling tools to recursive enhancement, pluralist approaches informed by semantic-cognitive and complexity paradigms improve modeling outputs suitability to meaningful argumentation and interpretation. In this way, as proposed in this article, these approaches can steer AI capabilities in the service of post-positivist interpretative and hermeneutic planning. This proposal assumes that AI capabilities require actual integration with human capabilities, because of their intrinsic difference. It resists both enthusiastically relinquishing human capabilities by blindly relying on AI outputs, and anxiously rejecting AI as an absolute threat, implicitly framing it as a legitimate competitor.

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