



## Viewpoint

The future of the future city? The new urban sciences and a PEAK Urban interdisciplinary disposition<sup>☆</sup>Michael Keith<sup>a,\*</sup>, Neave O'Clery<sup>b</sup>, Sue Parnell<sup>c</sup>, Aromar Revi<sup>d</sup><sup>a</sup> Centre on Migration Policy and Society, School of Anthropology and Museum Ethnography, University of Oxford, United Kingdom of Great Britain and Northern Ireland<sup>b</sup> The Bartlett Centre for Advanced Spatial Analysis, University College London, United Kingdom of Great Britain and Northern Ireland<sup>c</sup> Department of Geography, University of Bristol, United Kingdom of Great Britain and Northern Ireland<sup>d</sup> Indian Institute for Human Settlements, Bangalore, India

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## ABSTRACT

In many domains we see a proliferation of claims made about how we can predict and measure the future city, how we make visible its form and shape its settlement. This paper synthesises contemporary debates in data analytics, anthropology, geography and the history of urban thought to consider the context of such claims making around urban futures and the promise (and promises) of attempts to make visible the urban as a 'lab' or 'observatory' through which we might 'see like a city'. Building on a 'systems of systems approach' the paper develops an original PEAK Urban conceptual framing of this new subdiscipline and addresses the potential for academic research to inform the capacity of cities to anticipate and reshape the challenges that characterise 21st century urban life through interdisciplinary and transdisciplinary engaged scholarship that situates the new urban sciences within a context of an experimental urbanism that makes visible the trade offs and the ethical dilemmas of the future city.

## 1. Conceptualising urban futures

How to map, make sense of, influence and shape the future of an increasingly urban globe? The imperative to generate new forms of urban science and action has never been more pressing. PEAK Urban is a novel approach to urban studies that asserts that in an interdisciplinary inquiry into city futures it is essential to reconcile the sciences of prediction and projection with culturally sensitive readings of the institutional architectures and urban contexts which will mediate specific technological disruptions. The former demands an understanding of rapidly growing expertise in the new urban sciences, the latter demands experimental and bespoke local engagement in city life, foregrounding the power dynamics, normative dilemmas and ethical trade-offs implicit in urban transformations.

A growing academic subdiscipline claims to theorise, explain and predict the shape of the future city (Moir et al., 2014). Exponential demographic growth driving global urbanization, particularly in China, India and Africa, generates commercial opportunities, ethical dilemmas and ecological challenges in equal measure. Although figures may lack scientific accuracy, it is estimated that investment in cities and their

infrastructure over the next decade alone is likely to be over \$20 trillion globally. It has been argued that disruptive innovation creates an emergent economic sector of 'advanced urban services' combining new technologies, new methodologies and conventional forms of city building, with a market value rising to over \$3 trillion by 2025 (Cain et al., 2014). It is also the case that a majority of people globally live in urban conditions that are at best sub-optimal, and at worst indictments of the human condition. In large parts of the world where social, economic and environmental problems are concentrated, urban population growth is outstripping formal infrastructure investment and service provision (Acuto et al., 2018). These are the same places where the majority of the world live and which will significantly, even disproportionately, determine the urban future. As the globe shifts from being a majority urban population to a predominantly urban planet one benchmark through which international agencies will measure these changes is the UN Sustainable Development Goals (SDGs). The SDGs, like other international and national targets, will be mediated by and succeed or fail in and through the development of cities. The SDG framing of the urban question (and the specifically 'urban' SDG (11)) implies a nuanced understanding of multiple dynamics and actors that

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drive cities, spawning a renaissance of urban enquiry from across diverse intellectual traditions (Parnell & Robinson, 2017). Technically, this holistic framing demands an approach that combines different forms of expertise. Normatively, it demands both a cartography of the stakeholders in city life and a recognition of the diverse interests at stake and obligations involved in realising plausible notions of sustainability. In this article we advocate that this combination might be descriptively captured by a heuristic approach that we characterise as PEAK Urban.

PEAK Urban is founded on an analytical clarity about the nature of urban life and a conceptual framing that integrates appropriate interdisciplinary scholarly inquiry and practical application. It defines a new framing of the growing sub-discipline of city futures, harnessing novel techniques in data analytics alongside a consideration of their ethical dimensions, the commensuration and trade-offs between alternative regimes of value and worth in contexts of rapid disruptive technological change, asymmetrical power relations, challenging configurations of the infrastructural and an imperative to intervene experimentally in cities structured by both shared trends and general patterns and path dependent historical and geographical specificities.

Efforts to pull in big data, to interrogate the urban nexus or to achieve fresh transdisciplinary dialogue on cities are typically achieved by drawing attention to how complex dynamics interact, often using a classic systems approach (Bai et al., 2016; Batty, 2007, 2013; Elmqvist et al., 2018). In that vein we embrace the opportunities for greater data analytics - alongside a strong focus on power, knowledge and politics. Like others we argue that situating cities as drivers of sustainable development is usefully captured by an augmented systems-based logic, coupled with a sense of moving from understanding the city as a system to a 'system of systems' approach that recognises cities as *open* rather than *closed* systems. However, our interpretation of how urban science or systems thinking might be configured, presented here as 'PEAK Urban' (Fig. 1), is directly concerned not just with acknowledging the interplay of varied urban dimensions and dynamics, but also with a translational sense of both how science lands in cities and how scholarship might promote ethically sensitive and contextually nuanced urban transformations.

Through PEAK Urban we suggest that a foundation of complex systems theory may be generative, if alone insufficient. It allows a conceptual space for the sciences of *prediction and projection* (P) that uses the potential of new forms of interoperable urban data analytics. Data analytics, alongside conventional historical analysis, political economy and cultural intelligence, exposes in new ways the dynamics of multiple (social, spatial, ecological economic, material, political) city trends and processes. This type of transdisciplinary enquiry is a necessary but not sufficient element of an alternative urban science. Especially given the rapidity of change in individual cities, across the urban system and through the composite of cities, we need to know not just what the urban is, but also what it might or could become. The change or transformation that occurs in cities and the system of cities as the product of interaction of parts of the system is characterised in PEAK Urban as forms of *urban emergence* (E). These catalytic or emergent forces arise from processes of urban mutation and combination, generated by individual and collective actions, disruptive technologies or by state and market interventions. Such patterns of emergence demand an understanding of both universal trends and bespoke local realities that are driven by the path dependencies and systemic lock ins

of particular urban forms; a process involving culturally sensitive, historically nuanced and commonly ethnographic and institutional understandings of technological and other disruptions. Building on contemporary social scientific scholarship on how we measure 'value' and 'worth', and the processes of commensuration and justification of such measures we can then make visible both the real-time uses and impacts of the *adoptions and disruptions* of new technologies. PEAK Urban's focus on adoption (A) highlights the impacts of actual spatial, political, administrative or technical choices, and trade-offs cities make in preferring one set of values to another. What states, citizens and companies collectively choose (adopt), given the specificities of their place, its resources and the interplay of urban dynamics, coagulates as the regime that shapes the future city. Urban transformation choices invariably invoke perennial ethical questions, asking in whose image the city is being remade (Harvey, 1973), where what is decided is the product of the available ideas and the power blocks that promote them. The ethical settlement that shapes the metropolis is critical to the urban future. We suggest that in a PEAK Urban framing a disposition, register and institutional form of experimental urbanism invites a process of *knowledge exchange* (K) and translational research that reframes conventional separations of basic and applied research in the academy. The growth of diverse models of urban laboratories and observatories internationally has the potential to reflect also the realities of urban politics and make visible deliberative processes and choices. We use this set of four problematics to suggest a 'PEAK Urban formation' that might offer robust insights, reflect the complex, politicised systems of the city and the multiple interests that define the parameters of an emergent new configuration of the urban sciences.

## 2. P: prediction and projection

Cities are more than concentrations of people, activities, physical structures or patterns of everyday interactions in physical space. City dynamics are multi scalar; from the neighbourhood scale to the city region through to the links between cities and nation states. Cities are territorialised condensations of flows that exceed physical or jurisdictional boundaries and link places to *sites elsewhere* (other cities but also sites where energy and food are produced, waste dumped, etc.). In other words, they are places where heterogeneous systems mingle, interact, interfere and connect to *systems elsewhere*, a territorialised system of systems. Cities are also temporally open: they are historically constituted and marked by past activities and interactions with other places; palimpsests structured over time that change incrementally and slowly. However, while path dependencies in physical structures, institutions, customs and regulation are often profound, futures remain open. In order to explore these alternative futures in new ways, a cross-disciplinary effort is needed to analyse cities as complex systems characterised by path dependence and non-equilibrium dynamics.

A key push to shift the conceptual frontier by fostering an integrative urban science is the emergence of new data sources, providing unprecedented, often real-time, information on the activities of urban dwellers. This includes tracking data derived from telecoms, mapping and transport companies, imagery via satellite and street photography, personal and environmental statistics captured by both mobile apps and fixed sensors, and social networks via online platforms. Beyond mapping the dynamics of urban life, this data can provide information on informal activities (e.g., housing, travel, business), a key component of developing cities not well-described by traditional or official data collection methods. However, despite the possibilities afforded by the introduction of such big data sets over the past decade or so, their impact on understanding cities remains limited and fragmented.

Alongside the emergence of urban 'big data', there has been a parallel push to develop methodological tools to cope with large data sets, identify patterns and relationships within this data, and build predictive models (Higham et al., 2017). This includes powerful generalisations of traditional econometrics within the realm of machine learning, capable

PEAK Urban demands synthesis of:  
 Prediction and projection in the city  
 Emergence, combination, material cities and complex systems  
 Adopting innovation and metropolitan commensuration  
 Knowledge exchange and urban (co)production

Fig. 1. A PEAK Urban framing of interdisciplinary urban futures.

of going beyond linear relationships, and ingesting large numbers of explanatory variables in order to maximise predictive power. There is much work to be done, however, to adapt these methods to policy needs, largely due to the difficulty in estimating size effects for individual variables within these frameworks (Athey, 2017). In the modelling realm, network analysis provides a uniquely powerful tool to understand and quantify such complex systems whose aggregate dynamics depends not on individual agents or homogeneous populations but on an underlying heterogeneous interconnection structure. Most network models, however, are minimalist in the sense they aim to capture specific processes (describing information exchange between people, for example), but do not scale easily to capture a large number of heterogeneous interacting agents and systems. In this endeavour, agent-based modelling, which aims to simulate the decisions of large heterogeneous populations in space, might be better-suited to multi-agent multi-system urban analysis (Batty, 2013 and 2017).

With the recent release of new high-resolution data and the advent of new tools, there are three key opportunities. The first, potentially high-impact approach, is the application of new datasets and novel tools to interrogate existing paradigms and theories concerning the functioning of cities across the academic and policy spectrum. Finding supporting evidence, or lack thereof, for established theories is an important contribution, particularly in the policy arena where theories abound but evidence can be scant. Secondly, there is potential to uncover new perspectives on the functioning of cities, and their constituent interacting systems. Third there is the imperative to integrate fresh insights into the existing intelligence on urban processes generated across a wide range of disciplines from art to zoology.

Uncovering the social, physical and economic forces that drive cities demands interdisciplinary scholarship that crosses social science, natural sciences and the humanities. For example, many theories emphasise the role of cities in facilitating social interactions, particularly those of the accidental kind. Inspiration for analysing social networks at the urban level can be derived from the urbanist Jane Jacobs, who emphasized that cities thrive through facilitating and fostering a diverse ecology of social interactions. While capturing social interactions in the real-world has traditionally been difficult, recent moves to open up anonymized mobile telecoms data to the academic community have begun to shed light on the complex social structure of societies. It turns out that larger cities foster disproportionately more densely connected communication networks (Schlöpfer et al., 2014), and that the structure of social connections is important for socio-economic outcomes (Eagle, Macy, & Claxton, 2010). In terms of information spread, social networks are robust to the removal of strong ties (found within densely connected clusters) but vulnerable to the removal of weak links (that connect clusters) (Onnela et al., 2007). This result is consistent with the theory that information gets trapped in clusters formed of like-minded people, a phenomenon known as homophily (McPherson, Smith-Lovin, & Cook, 2001) which poses a particular challenge to policy-makers (and society at large).

In a second, connected, strand of work, efforts are under way to connect socioeconomic outcomes with physical form through mobility patterns. In a similar way that social ties to communities outside your own facilitate opportunities, access to diverse environments is connected to higher socioeconomic outcomes. The internal heterogeneity of cities, in terms of unequal access to places, can be explored using individual-level travel movements collected from mobile phones. Some illuminating work to date suggests that travel patterns within a city are highly predictable (Gonzalez, Hidalgo, & Barabasi, 2008), and that that patterns of mobility differ drastically across socioeconomic classes (Lotero, Hurtado, Floría, & Gómez-Gardeñes, 2016).

Finally, while not all are happy to conflate urbanism and economic vitality or agglomerations, within the wide cohort of urban specialists who do there are a number of theories on what makes cities economically successful. In part this strand of contemporary research might be most closely associated with the work of economists and geographers

who identify spatial patterning over time to generate predicted urban configurations of land use and populations and explain spatial mismatches. In the broad field of *new economic geography* both geographers and economists have tried to identify regular, repeated and predictable *spatial patterns* of closed systems of urban growth. Economists such as Fujita, Krugman and Venables echoed the mid 20th century mathematical geometries of Walter Christaller and August Losch in their analysis of central place theory and the spatial organisation of the economy to predict how city growth succumbs to 21st century empirical laws of urban hierarchy (Fujita, Krugman, & Venables, 1999). This engagement of neoclassical economists with practical imperatives to make sense of the interrelationship of global urban growth and economic productivity has generated both policy momentum from organisations such as the World Bank and a revitalisation of the sub discipline of urban economics in the last two decades (Glaeser, 2011; Glaeser & Joshi-Ghani, 2015). At times in overlapping literatures geographers, taking their steer from the rapid restructuring of Los Angeles in the late 20th century, have also tried to synthesise spatial imperatives and institutional formation in predicting emerging trends of urban economies (e.g. Nathan & Overman, 2013; Storper, Kemeny, Osman, & Naji, 2015).

Focusing on the drivers of urban industry structure and the growth of firms and jobs, a tension exists between the Jacobian emphasis on diversity, and the Marshallian focus on (firm) similarity (Beaudry & Schiffauerova, 2009). Alfred Marshall ascribed the agglomeration benefits of cities to the ability of (similar) firms to pool labour, share customers and suppliers, and benefit from knowledge spill-overs. This view is inextricably linked to notions of path dependence in industrial diversification and economic development, embedded in the study of regional economic geography and economic complexity, whereby cities build on existing capabilities (embedded knowledge and skills) to move into new economic activities (Hildago et al., 2007; Frenken et al., 2007). Traditionally, efforts to model the branching dynamics of cities relied on network science and econometrics applied to administrative data on workers, firms and patents. Recently, however, there has been a push to utilize mobility data to quantify the spatial/temporal scale of knowledge and skill-pooling effects (O'Clery & Lora, 2016; O'Clery et al., 2019), and patent data to look at the extensive margin of knowledge production and distribution (Balland et al., 2017). Finally, driven by an emerging ability to directly capture human and economic activity from imagery and satellite data, it has been shown that both night-time lights and pixel density are correlated with income and productivity (Henderson, Storeygard, & Weil, 2012).

While these layers are not exhaustive and there is the usual distortion in the literature to cases in advanced capitalist nations and the enduring problem of making the informal city legible, the interplay of the social, physical and economic systems underlying the functioning of cities have begun to interact in the academic sphere. There are, however, very few attempts to build a whole system, or system of systems, framework to study cities (Batty, 2013). A notable exception, emerging from econophysics, is that of the work of Geoffrey West and Luis Bettencourt on urban scaling (Bettencourt, Lobo, Helbing, Kühnert, & West, 2007). The key idea behind this model is that, through its connectivity structure, a city is more than the sum of its parts: the larger a city is (in terms of population), the proportionally more it benefits from these interactions in terms of a range of variables including employment, income, education, innovation, wages and crime. Although much of this work has been pioneered in the global north, its catalytic potential relevance for cities with extreme poverty and high population growth rates is immediately apparent. However, the ability to 'predict' urban futures rests on both the recurrence of 'patterns' that are similar (as in the new economic geography) and also a paradox of prediction in the new urban sciences. Existing praxis that predicts pattern from urban hierarchy cannot address the multiple speeds at which cities move or account for exogenous forces, such as war.

Complex systems theory recognises the importance of modelling,

predicting and testing while at the same time acknowledging its contingent value, its finite half-life in systems that mutate at varying speeds. Pete Allen, a theoretical physicist by background, has argued that for this reason it is essential to distinguish between the degree to which it is possible to project trends into the future based on modelling and rely on certain forms of system prediction (Allen, 2015). For Allen in complex systems the value of such material diminishes according to the time scales of systemic evolution that form the basis of probabilistic system dynamics. While models may be used to generalise rank size rules and power laws and even do planning experiments, the innate determinism is qualified by systemic evolution and disruption. Because complex systems are open and not closed they are never stable in the long run. Equilibrium is rarely found in the short run, never present in the long run. For Allen, forecasting may be valuable in the short run, diminishingly so as systems evolve, simultaneously both valorising and qualifying the quantitative modelling of urban form and pattern. Depending on the pace of systemic evolution the 'short run' may describe a period of time vulnerable to intervention but measured in years, days and hours varies enormously between systems. So while it is possible to harness data analytics, model changing urban reality and reveal possible emergent configurations of current structures, Allen argues that models or interpretative frameworks do not make formal predictions as such. For him they are instruments of reflection precisely because the mutable form of complex systems makes the inference and attributions of causality ever more challenging.

Ironically, while our ability to collect, model and analyse real time data has grown exponentially, at the same time our ability to predict longer term trends has in some important domains diminished rapidly because of the impending arrival and speed of disruptive technologies and climate change. And so a paradox of the new urban sciences is that at the same time as it is possible to predict more and more about the short-term futures of the city, we may know less and less about long term patterns. These will be structured by accelerating processes of disruptive technological change and ecosystem instabilities such as biodiversity loss. Hence, cities are characterised by *emergent* forms of novelty and combinations of material infrastructures, economic configuration and cultural mutation.

### 3. E: emergent urbanisms

Newness or innovation comes into the world most often through the urban. *Emergence* is a term that travels across very different traditions of academic inquiry. It is at the heart of potentially productive interdisciplinary urban scholarship that crosses the conventions of natural science, social science and the humanities. In philosophical enquiry the notion of emergence draws on biological metaphors of how new ecosystems develop. In mathematical theory emergence is a property of complex systems that disrupts the ontology of the system itself through its novelty.

To take just one example the tendency towards hierarchy in urban systems is at times considered geometrically and spatially. So for Batty in the new urban sciences "objects which are irregular .... and which manifest self-similarity, are fractals whose dimension lies between the dimension they are defined by and the dimension of the space they are trying to fill" (Batty, 2009, 5). Fractals have a regular geometry composed of irregular parts repeated at successive scales which generate novelty and are configured by the dimension of the space new combinations are scaled across.

Other forms of complexity theory emphasise alternative dynamics of combination and ontological instability generating novelty. But equally in contemporary humanities, anthropological and social theory a similar logic that foregrounds the *propensity of things*, infrastructures and objects (Appadurai, 1985; Julien, 1995) generates an equivalent but differently nuanced framing. Cities have a propensity to combine material forms, cultural norms and technological change in novel ways. Salman Rushdie long ago observed in mapping the generative powers of

multicultural London that 'newness comes into the world' through the patterns of cultural combination of geographies of here and elsewhere mediated by city flux (Keith, 2003). Diasporic and frequently colonial historical links connect cities relationally such as Delhi, London, New York or Shanghai to sustained networks across the globe. They create multi-scalar force fields of cultural mutation, hybridization and combination mediated by both the micro neighbourhoods and macro regional economies of the city. Cities are consequently invariably incomplete (Sassen, 2016), always in the making. Sennett and Urry assert that these forms of making recombine built form and cultural practice in a manifestation of the process of emergence akin to non-linear systems where known and determinate beginnings can wind up producing unforeseen or unpredictable results, equivalent to 'chaos' in a complex system" (Sennett, 2014, 1; Urry, 2016) Cities are consequently systems rarely characterised by equilibrium, more often by *autopoiesis*.

In anthropology what is known as the 'ontological turn' of the early 2000s tried – at times contentiously – to suggest that, in opposition to 20th century separations of interpretive (cultural) anthropology on one hand and cognitive anthropology on the other, a focus on the status of the material objects observed generates a technology of description which allows anthropologists to make sense of their ethnographic material in new and experimental ways (Henare, Holbraad, & Wastell, 2007; Palacek & Risjord, 2012; Pedersen, 2012). Supplemented at times by slightly different philosophical routes, this produced a genre of anthropological writing that addresses the fashion in which material objects and the built environment do not straightforwardly *determine* social form, but through their mediation in urban space become implicated in new combinations of culture and infrastructure that characterise both the dynamics of the 21st century metropolis and these forms of city emergence (Harvey & Knox, 2016; Larkin, 2014; Simone, 2018). This 'infrastructural turn' in the social sciences, picked up in the urban studies of geography and sociology in the last decade complicates conventional relations between political and economic forces, material and semiotic meanings of environmental and climate change, and the optics of figure and ground, stocks and flows in the ways we make urban systems visible (Harvey, Jensen, & Morita, 2017). In urban geography, this is echoed in what is at times described as non-representational theory (Amin & Thrift, 2016), in part building on Bruno Latour's influential actor network theory that foregrounds 'assemblages' associating humans and non-humans to form precarious wholes. The relationality of urban form, city culture, and metropolitan power, and the path dependent propensity of things to develop in context, is an enduring focus of both urban geographical and historical enquiry (Jacobs, 2012).

For planners and architects this spatial fix where form, function and meaning are intertwined and co-dependent define disciplinary rationales, providing a language of urban design that is only intermittently but productively brought to bear on the global urban process. Undocumented and unaccounted for urban actors and forces (especially in rapidly evolving and data poor places) challenge the legibility of cities. Metropolitan governance institutions in turn struggle to deal with the deep differences and conflicting rationalities that emerge in and across urban scales. This now includes the imperative of rethinking global urbanism in the face of the climate crisis and its planning imperatives – from the south and in ways that will preclude the lock in of unsustainable and inequitable urban investments (Bhan, Srinivas, & Watson, 2018; Watson, 2006, 2009).

Consequently, a focus on urban path dependency and lock in foregrounds the unique aspects of city development, building on an open systems science of cities but limiting the value of comparison and qualifying a sense of 'solutions' for urban problems that might be translated straightforwardly from the global north to the global south or from one side of the Atlantic to the rest of the world. Recognising the emergent properties of cities demands that we prefigure an analytical disposition that recognises the productivity and lessons that might be learned by comparing city experiences with a sense of engagement of



knowledge exchange and ‘problem solution’ that is localised.

Analogous to the study of phase transitions in statistical physics, in urban processes of (re)combination tipping points can amplify seemingly minor changes to have profound social consequences. Forms of evolution generate pathways of change that cannot always be reversed, hence the cybernetic notion of path dependency becomes relevant to a social science of the metropolis, and a historical analysis of the ‘lock ins’ of the system become central to an understanding of the dynamics of urban change. These processes of emergence, technological change and combination are at the heart of what the late John Urry (2016) and others characterised as ‘socio-material systems’ but the logic might be expanded to socio-institutional systems too.

A sense of emerging urban transformation that invariably *builds on* something contrasts with both the notion of city making as entirely predetermined by its past or as a *tabula rasa*, where the city is created fresh from a blank canvas. Even where a major new town or city historically is created in Washington DC, Brasilia, Islamabad or in 21st century Xiong’An in China it will always sit within an urban hierarchy that is relational and fluid. From the smallest unit to the grand plan, attempts to *design* the city necessarily invoke many different skills and many different *values*. Drawing liberally on the social theory of Peter Sloterdijk, Bruno Latour (2008) asserted that we need to understand five principles of such design that combine humility, attentiveness to detail, a recognition that the *tabula rasa* is a fiction in any urban context, and that design always invokes symbolic meanings and an ethical as well as a functional question. Latour and Sloterdijk echo the two-thousand-year-old principles of the Roman architect Vitruvius who suggested that every building can be assessed by three measures of ‘value’: durability, utility and beauty. We may measure a building by its capacity to last (*firmitas*), a measure of whether it is functionally fit for purpose (*utilitas*) or how beautiful it is (*venustas*). But these are very different measures. They are not always commensurable one with another, we may privilege one value over the other two depending on our choice (and our ‘justifications’ of that choice) and the basis for the evaluation may change over time as public preferences shift, catalysing demands for adjustment in the urban system.

The scalar interplay of these diverse 21st century social scientific paradigmatic trajectories can be exemplified from one specific Brazilian built environment. When combining professional expertise and personal experience in both architectural practice and as the mayor of the Brazilian city of Curitiba, Jaime Lerner argued that ‘strategic punctual interventions’ might define a form of *urban acupuncture* where new combinations of built form and social life perform the same function as disruptive technologies; disturbing, nudging and reforming the rhythms of city socio-material systems through small tactical interventions rather than strategic *grands projets* (Lerner, 2016).

And so of great significance for the new urban sciences, this dilemma of *commensuration* is central to a scholarship of future cities (Keith, 2019); how they are planned, how they shape themselves autonomously and how they might be shaped by others, deliberately or accidentally. In the city, autonomous mutation, strategic and tactical interventions and disruptive technologies all share a propensity to generate emergent urbanisms and set up puzzles of metropolitan commensuration that are simultaneously analytical, instrumental and ethical. They demand an understanding both of how technology disrupts the logics of city form and urban life, and how we make visible and try to make commensurable the DNA of such logics in urban transformations that are always simultaneously economic, fiscal, material, social and cultural.

#### 4. A: adopting innovation and metropolitan commensuration

It is a commonplace of contemporary urban studies that we are living through a period of particularly rapid technological change. In the city the ‘internet of things’ escalates exponentially the data footprint of city populations and the propensity to link different technical

platforms that service city life. From mass transit, to smart buildings, to connected networks of service provision that sense, predict and react to flows and flux in real time for mass mobilities, urban metabolism and city governance are now structured by information management systems. The exponential increase in ‘big data’, especially for well-connected rich cities, makes visible and shapes patterns and processes susceptible to new forms of data science, enhancing the propensity to predict. Even in poor cities where connectivity is weak and energy supply is unreliable, big data is revolutionising urban intelligence through the use of satellite imagery and cellular technologies. And, so an understanding of how new technologies land in place, are adopted, governed, optimised or bypassed provides a central dynamic in the understanding and determination of city futures.

Use-based histories of technological change (in contrast to innovation-based histories) highlight the geographical variation in the uptake, value and capture of cities by specific technologies and of the alternatives that residents seek to secure their livelihoods in absence of technologies available elsewhere (Egerton, 2007). Promoting car free cities may be easier in Europe than in North America because of fundamentals of urban form as well as the existing investment in alternative forms of mass transit. It may be easier still in today’s (but not tomorrow’s) Africa, where at times absence of road infrastructure and low levels of affordability leaves little option but for the majority to walk (Keith & Santos, 2021). The future here is uncertain as with the technologies deployed in informal settlements, in which more than half the world’s urban population live, and which may appropriate new technologies in novel ways. Simply exporting technologies such as specific transit systems from global north cities to the newly emerging metropolises of the global south has produced varied, uneven and unintended consequences. Settlements may succeed in leapfrogging the lock ins of the mid 20th century planned metropolis, or reinventing old technologies to address both old environmental challenges such as sanitation and gendered menstrual hygiene regimes (Mahon & Fernandes, 2010); off grid/on grid translations or new ecological challenges such as climate change (Pieterse & Simone, 2017; Sharan, 2014). In reality, technologies do not just appear they “also disappear and reappear and mix and match across the centuries” (Egerton, 2007, xii). In contrast, the narrative tropes of innovation driven futurism are largely unchanging over time. There is a tendency for technologically determined utopias and dystopias alike to distort the analytical accuracy of technologically shaped urban futures and to overlook the path dependencies of IT choices that structure everyday city administration, such as procurement or billing (Acuto & Rayner, 2016).

And so, a focus on technologies used rather than innovations publicised reframes the balance between high profile technological novelty and vernacular and creolised technological practices and realities. The mobilities of the poor in cities of the global south may reflect extemporised forms of bus, taxi and vehicle sharing more than mass transit. Technologies of ride sharing in cities in the global south have been shaped by the path dependencies of politically controlled minibuses in 1990s Karachi, site specific motorcycle taxis in Kampala or Bangkok (Doherty, 2017; Sopranzetti, 2017). Analysis of urban futures consequently demands an understanding of *both* the potential of new technologies (that which is geographically universal and predictively behaviourist) and their use context (that which is geographically variable, path dependent and culturally mediated).

So, for example, the impact of driverless cars will depend on global manufacturing capacity, technical facility, and complementary built environment technologies. But it will also depend on local socio-material drivers structured by the nature of market formation, the legitimacy of policy tools (e.g., road pricing), culturally acceptable measures of calculable and legal risk, the informal as well as the formal modal transport shifts and a qualitative understanding of the nudges that shape city behaviours in different locations. And so potentially driverless cars might produce more or less dense urban form, more or less dependency on mass transit, depending on different combinations of

universal propensity and vernacular realities (Economist, 2018). In this context the application of the logics of, for example, the imperatives of carbon neutrality, the epistemic claims of urban economics, the legal framing of land use planning and the cultural acceptability of the calculus of risk each define areas of professional *expertise* that interact in shaping the adoption of innovation in specific urban contexts.

Some forms of expertise travel and land better than others. For example, one school of scholarship argues that an academic discipline such as neoclassical economics becomes both a way of thinking about economy and society in the abstract, and by default a way of organising it in particular geographical contexts. The conventions, paradigms, analytical and policy prescriptions of a certain kind of economic theory *performs* as well as *explains*. Analytically, it has an ability to predict the manner in which utility maximizing individuals and institutions collectively generate specific patterns of behaviour with associated macro-economic consequences. But the deployment of economic reason also travels in a particular fashion. It lands in country and begins to *organize* and make visible the economy of the almost sovereign state as much as it makes comprehensible existing and historical patterns and processes of wealth creation. *Utility* serves as a measure of *value*; maximizing utility a logic that drives powers of prediction. As always, expertise operates in the name of the particular form of reasoning that is rooted in a specific calculus of value that is captured by (sometimes competing) definitions of utility. But, as Vitruvius described, utility may be one value amongst many; one logic but not the only logic through which the predictive lens makes visible the future.

Timothy Mitchell, working with the *longue durée* of Egyptian history argued in this vein in the landmark volume *'The rule of experts'* (Mitchell, 2002). For Mitchell, the late 20th century saw the internationalization of economic governance logics through which the rule of the *nation* was displaced by the notion of an Egyptian *economy* that was to be *developed*, creating a field of knowledge with specific boundaries, inclusions and exclusions that are blind to both the local historical past and the vernacular cultural present. In systems terms, the discipline of economics (supported by World Bank governance regimes) struggled to incorporate the path dependencies and lock ins of the political economy of Egypt. The consequences were that economics becomes as much a rationalization of or justification for state actions in the name of the economy as it is a set of interventions or propositions subject to testing, evidence, falsification or verification.

In the terms of Vitruvius, we need to place 'utility' alongside other measurements of value and worth. The city made primarily for its beauty may differ significantly from one structured by an urban form that maximizes mass transit and mobility or neighbourhoods with dwellings that prioritise measures of public health. At a time of pandemic the city is an arena in which imperatives of economic logic and public health may appear to compete. The urban commons hosts complex city systems but common pool resource problems and open system theory are not often synthesised (Keith & Santos, 2020, 2). A 21st century Vitruvius in contemporary Delhi might rationalise the city through a lens of the environmental fundamental right of the precautionary principle, climate change resilience or economic optimisation but each in turn implies a different calculus of value and worth (Sharan, 2014, 6).

In the city, the sciences of the spatial demonstrate that logics that have become the foundational rationalities of different academic disciplines are at times fundamentally incommensurable. This is not to subscribe to a form of relativism but is instead an epistemic recognition that different regimes of knowledge production rest on different constructions of the rational, they may make valid claims about the world but may also be simultaneously incommensurable one with another. For example, urban professions such as architecture (that operates through a rationality informed significantly by aesthetics), land use planning (that operates through a rationality informed by a synchronic understanding of city metabolism) and economics (that operates through a cognitive logic of utility optimization) all may be able to

analyse the present, explain the logics that flow within their paradigmatic framing and predict the immediate future with some degree of accuracy. But they may not always do so in a complementary fashion. Moreover, depending on the relative influence of the professions or the experts that circulate their particular framing, the different registers of urban knowledge expertise will have been unevenly embedded into the codes and practices of urban management and will have varied degrees of influence in the decision making corridors of the city. In this context, how we translate between different forms of knowledge production in the city, how we attempt to make different measures of value and worth commensurable, becomes itself a subject of interest.

Commensuration, in the economics of Amartya Sen (2009) and the philosophy of Martha Nussbaum (2003) becomes itself a subject of inquiry; the turn to a study of value and worth becomes a matter of major scholarly investigation (Beckert & Aspers, 2011; Stark, 2011). Likewise, in certain contexts discrete forms of academic expertise may serve as *justifications* of particular forms of action (Boltanski & Thevenot, 2006). For city scholars, how – for example – planners speak to architects about processes of economic development is not reducible to understanding different professional cultures. It is partly about the juxtaposition of architectural and economic logics, a matter of translating (attempting to make commensurable) these different logics and seeing where these engagements generate trade-offs, reconcilable realities and irreconcilable interventions. These plural epistemologies make us think differently about the many cities that might be yet to come. They raise major questions about how such complexity can be translated into public debate and policy practice, linking scientific practice and urban transformation.

## 5. K: knowledge exchange and urban (co)production

Plural epistemologies and multiple regimes of value and worth make visible the mesh of trade offs at the heart of new urban science. Commensuration and its challenges surface both an issue of analytical measurement and a configuration of alternative optimal solutions to the dilemmas of city futures. These have generated both attempts to capture or describe these alternatives through new models of experimental urbanism (Karvonen & Raven, 2016; Bulkeley and Castán Broto, 2013) and a reconsideration of the relationship between urban science and its institutional setting.

City futures emerge where knowledge and praxis – competing, contested and incommensurable – is exchanged. Compromises are achieved and solidified in a range of summative urban processes that both reflect existing metropolitan power relations and include traditional urban management platforms of the law and committee procedures. These in turn trigger the investments that produce physical and spatial products that fix the urban form and the social and economic allocations that structure urban opportunities. As regime theorists have long shown, understanding the configuration and pathways of knowledge and power into and within the city authority is a prerequisite for understanding city futures (Mossberger & Stoker, 2001). And the contours of urban knowledge production and exchange are now weighted towards information system design and strategic planning platforms such as city development or national urban policies.

In many cities elected officials and appointed professionals are no longer the dominant voices of urban arbitration between public goods and private interests as a wider template of stakeholders has emerged, either as the result of the hollowing out of the state or as participatory processes have brought civil society more directly into city decision-making. Some, such as the architect David Chipperfield (in Kretz, 2019), have characterised the 21st century as a time when the ethos of complete city planning has been displaced by the more architecturally oriented expertise of master planning smaller (and more fragmented) tracts of land than the 'whole city'. In such settings the 20th century attempt to know *the city as a whole* has been displaced by the commercial imperatives of building on specific outcomes of land assembly.

This trend in one sense epitomises the need to supplement contemporary praxis by both rethinking contemporary governance interventions in shaping the city in its entirety and the urban sciences on which such attempts are predicated. For numerous reasons then, the formats of city governance have become more open-ended and porous at the same time as the body of knowledge that decision-makers have has multiplied and become more accessible.

In this context the move towards an experimental disposition of future cities research is not confined to the natural sciences. Contemporary engaged arts practice invokes as well as evokes response to representation and performance across the senses (and regimes of knowledge) of sight, sound, touch, taste and smell (Bull & Back, 2003). In the social sciences a longstanding tradition, perhaps most notably associated with the sociologist Harold Garfinkel in the 1960s, argued that in order to make visible normative framings and understand rules that are tacit, codes that are hidden, routines and practices that are informal rather than formalised, researchers need to intervene ethically in social settings and then observe how conventions, rules and norms assert themselves in practice in response to this disturbance (Har  , 1979).

A PEAK Urban framework both acknowledges the evolving patterns of city governance globally and builds on the logic of open systems theory to suggest that making visible the commensuration and trade offs of incommensurable knowledge systems has implications for how we seek to research urban futures and link academic practice to everyday urban life. A PEAK Urban disposition addresses the three concerns raised by Kitchin (2016) with the ethical dilemmas of new urban sciences: a conception of cities as complex systems that surface ethical dilemmas and qualify the powers of prediction, a framing of the contingent and relational nature of urban systems, processes and science; and the adoption of ethical principles designed to realize benefits of smart cities and urban science while reducing pernicious effects. Conceptually, this involves recognising that scales of speed and time are as important as scales of space and geography in making sense of emergent urban life. The imperatives of global warming move on a time scale of decades, and strategies of residence and prevention need to reflect this alongside both moral imperatives that are longstanding and immediate and economic dynamics that are pressing. Plural temporalities of different systemic changes demand recognition of ‘wicked problems’ demanding ‘clumsy’ (or bespoke) solutions that rest on what anthropologist Mary Douglas long characterised as plural rationalities (Thompson & Beck, 2014). Practically, it involves learning from and building on the numerous examples globally that increasingly try to adapt the principles of an experimental disposition to the realities of cities globally through bridging new urban science and real time policy engagement.

Existing institutional models of knowledge production in cities are recognising the implications of this logic and a burgeoning literature addresses the city as a site of micro and macro experimentation. In Europe a network of living labs (ENOLL, 2018) has built on social democratic traditions of state, market and civil society collaboration. Globally, the growth of new institutional forms of living laboratories and urban observatories is matched by claims made in the name of ‘smart cities’, and attempts to learn from models of innovation demonstrators that can be scaled up from initial intervention (FCC, 2018).

However, one international review of urban labs has pointedly stressed the diversity of their logic, their institutional base, their client differences and the timescales against which they operate. Urban Labs in the private sector are very different to those based in the academy and other forms of urban experimentation that might be found in civil society or in varied forms of public/private partnership (Marvin & Silver, 2016).

So there is some tension between aspirations of *scaling up* experimental design and the logic of a ‘place agenda’ that formulates bespoke local intervention in the city, between the city as a site of simulation and modelling and the urban domain as a space of Garfinkel disruptions

and Curitiba inspired acupunctural interventions. This is reflected in contemporary attempts in universities internationally to engage divergent, compartmentalised scholarship and insert transdisciplinary, transformative knowledge into real world engagement. ‘*Helix working*’, defined as locally bespoke collaborations between universities and their urban locations advocated by innovation policy (Goddard & Kempton, 2016; Goddard & Tewdwr-Jones, 2016) consciously undermines historical distinctions between applied and basic research, and recognises the potential of a cross-sectoral blend of the research base, private and public capital and civil society (Keith & Headlam, 2017). But it also demands a reconciliation of universal claims and local mediation in the new interdisciplinary field of city futures.

## 6. Conclusion

As the rapidly growing field of critical data studies demonstrates there are both multiple ethical dimensions of the new powers of real time data analytics of cities (Dalton, Taylor, & Thatcher, 2016; Iliadis & Russo, 2016; Ruppert, Isin, & Bigo, 2017) as well as longstanding suspicion of the utopian claims made on behalf of smart cities and big data more generally (Kitchin, 2014; Wiig & Wyly, 2016). In advocating a PEAK Urban disposition to studies of the future city we are suggesting both a careful consideration and cartography of the flows and circuits of knowledge and practice and a reconfiguration of the relationship academic research and cities themselves through a complication of the traditionally hard boundaries between basic and applied research.

The path dependencies of complex systems structure our sense of the uniqueness of place, the particularity of built environment forms and imagined city solutions. The nature of an emergent interdisciplinary city futures science implies that there are both generalisable and scalable patterns to urban change, and bespoke and path dependent trajectories. Reconciling the arithmetic complexity of the former with the contextual specificity of the latter demands three adaptations of 20th century science to 21st century demands in shaping a new field of scholarship addressing urban futures. Firstly, it involves a disposition that is experimental in the generation of knowledges of the future city structured by plural temporal rhythms and productions of space (Evans, 2011). Secondly, it demands a recognition that the logics of commensuration, with registers of value and worth that are multiple and not singular, imply that many, perhaps most, of the challenges that are faced by 21st century cities involve nuanced trade-offs and ethical dilemmas in shaping the future city more than singular solutions to shared problems. Thirdly, as a consequence of the first two of these, adaptation is an emerging trend through which city futures scholarship reshapes the relationship between university research and applied knowledge through the growth of urban laboratories and observatories that are penumbral institutions, established in the interstices and borders between public interest, ivory tower, private, public and third sectors.

## CRedit authorship contribution statement

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