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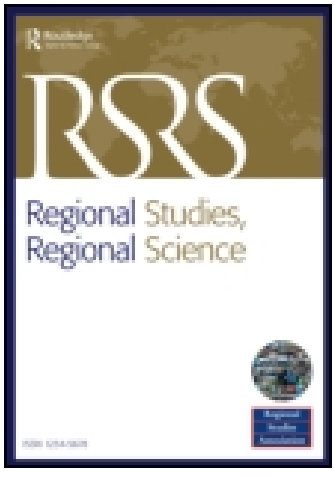

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Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards

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Since the mid-1990s a plethora of indicator projects have been developed and adopted by cities seeking to measure and monitor various aspects of urban systems. These have been accompanied by city benchmarking endeavours that seek to compare intra- and inter-urban performance. More recently, the data underpinning such projects have started to become more open to citizens, more real-time in nature generated through sensors and locative/social media, and displayed via interactive visualisations and dashboards that can be accessed via the internet. In this paper, we examine such initiatives arguing that they advance a narrowly conceived but powerful realist epistemology – the city as visualised facts – that is reshaping how managers and citizens come to know and govern cities. We set out how and to what ends indicator, benchmarking and dashboard initiatives are being employed by cities. We argue that whilst these initiatives often seek to make urban processes and performance more transparent and to improve decision making, they are also underpinned by a naive instrumental rationality, are open to manipulation by vested interests, and suffer from often unacknowledged methodological and technical issues. Drawing on our own experience of working on indicator and dashboard projects, we argue for a conceptual re-imaging of such projects as data assemblages – complex, politically-infused, socio-technical systems that, rather than reflecting cities, actively frame and produce them.

Keywords: indicators; benchmarking; dashboards; epistemology; data assemblage; governance; cities; real-time

Introduction

Since the early 20th century, social and economic indicators, such as unemployment rate, gross domestic product (GDP), gross national product (GNP), balance of payments, inflation, and the consumer price index (CPI), have been used by governments to assess how a nation is performing (Godin, 2003). Likewise, in the post-Second World War era, many supranational agencies such as the World Health Organization (WHO), the Organisation for Economic Co-operation and Development (OECD), and the United Nations Development Programme (UNDP) measure, collate, and track the performance and productivity of various health, economic, and social phenomena across nations and regions. Over the past couple of decades, the use of indicators has proliferated across public sector systems, including public administration and public services, such as health and education, as well as being used to monitor and assess various aspects of

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cities such as competitiveness, sustainability, quality of life, well-being and urban services. Many cities around the world now routinely generate suites of indicators, using them to track and trace performance, guide policy formulation, and to inform how cities are governed and regulated. Indeed, the use of urban indicators has become normalized as a de facto civic epistemology through which a public administration is measured and performance is communicated (Miller, 2005).

Since the turn of the millennium, these indicator suites have been accompanied by numerous city benchmarking projects that compare and rank the relative performance of cities against one another. Even more recently, a number of cities have sought to extend their indicator suites through the incorporation of real-time data, captured predominately through sensors, cameras, and social and locative media (frequently termed 'big data'), often under the banner of smart-city initiatives (Kitchin, 2014b). Whilst many urban indicator and benchmarking projects are relatively closed in nature, with the underlying data, methods employed, and outputs locked inside institutions and corporations (that seek to sell the data and associated software), there has been a recent move to open up the data underpinning indicators and share them with citizens through online, interactive data visualizations, often termed 'city dashboards'. These dashboards graph and map indicator data, providing detailed information about city performance and trends, without citizens needing to learn how to handle data or use specialist visualization software. These open data and dashboard initiatives are changing not only the relationship between government and the public, but also the relationships between different business units within government responsible for delivering the services being measured.

This paper provides a critical reflection on urban indicator, benchmarking and dashboard initiatives. It considers what such initiatives mean for how cities are known and governed, drawing on debates in critical data studies, critical geographical information system (GIS), urban studies, urban planning and public administration, and on our own practices of creating/managing national, regional and city indicator projects, working on national spatial data infrastructure projects and cross-jurisdictional data projects in Europe and North America for over a decade, and creating a new dashboard for Dublin. The discussion and analysis is divided into three sections. First, we detail various forms of indicators, benchmarking and dashboards being deployed by cities. Second, we discuss the drivers for these initiatives and how they are being employed by city authorities to understand, monitor, plan and regulate how cities are governed and managed. Third, we critically appraise the validity, veracity and fidelity of indicators, benchmarking and dashboard initiatives, arguing that they employ a limited instrumental rationality and promote a narrowly conceived but powerful realist epistemology – the city as visualized numbers – that whilst often useful for evidence-based decision-making, also has numerous inadequacies. Finally, we set out an alternative conceptualization for such initiatives that, rather than making grand but limited claims to showing cities as they really are, openly recognize and acknowledge: (1) the multiple, complex, interdependent nature of cities that means they cannot be simply disassembled into a collection of facts; (2) they do not merely reflect cities, but actively frame and produce them; and (3) they are not toolkits but data assemblages – complex socio-technical systems infused with politics and context.

Knowing the city: indicators, benchmarking, dashboards

Urban indicators

Indicators are recurrent quantified measures that can be tracked over time to provide information about stasis and change with respect to a particular phenomenon (Godin,

2003). They are rarely generated and used independently, but rather form part of a suite of related measures that cross-validate trends and supply holistic context. With respect to cities, indicators are understood to provide a barometer of how various aspects and parts of a city are unfolding and performing. These trends are most often revealed by charting them as graphs or maps. They can also be inserted into models of various kinds to try to explain present patterns or to simulate and predict what might happen under different circumstances and to envisage future instantiations of the city.

Urban indicator projects have proliferated since the early 1990s driven by two main forces. First, a sustainability agenda arising from the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, in 1992 and the publication of Chapter 40 of *Agenda 21*, which stated that '[i]ndicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems' (UNCED, 1992). Subsequently, many city authorities and community groups sought to define and generate indicator data that would fulfil this mandate for their territories. Second, by the rise of new managerialism and the desire to reform the public sector management of city services to make them more efficient, effective, transparent and value for money, combined with citizen and funder demands for evidence-based decision-making.

There are different types of urban indicators that vary in their rationale and how they are deployed. *Single indicators* consist of the measurement or a statistic related to a single phenomenon. For example, the total number of unemployed people or the unemployment rate where the total number of unemployed people is standardized against the total labour force. The most desirable single indicators are direct measures that are well defined and unambiguous, can be captured as a quantitative measure, and have strong representativeness (they measure what they declare to measure). They are purported to be objective, neutral and value-free, independent of external influence, traceable over time, sensitive to change, verifiable and replicable, easy to interpret, timely (produced regularly and reported with minimal delay), quick and cost-effective to collect, process and update (Bhada & Dan Hoornweg, 2009; Franceschini et al., 2007). In some cases, indicators are indirect in nature because the underlying phenomenon of interest is intangible or not directly observable. For example, the number of patent applications can be used as proxy for innovation (Gruppa & Mogee, 2004). In other cases, the cost of generating new data is too high, leading officials to pick surrogate variables from pre-existing data sets such as censuses.

Composite indicators combine several single measures using a system of weights or statistics to create a new derived measure (Maclaren, 1996). For example, a deprivation index usually combines several indicators such as household income, employment status, welfare and health status, and access to services to provide a single overall score. Similarly, geodemographic classifications combine several indicators to determine their dominant characteristics and to compare these geographically across space. Composite indicators recognize that different phenomena are interrelated and multidimensional and that no one indicator can reveal the extent or complexities underpinning an issue such as deprivation or area characteristic. Such indicators can be produced in-house, or acquired from third parties such as think tanks or consulting firms. In the latter cases, the underlying model, algorithm and data sources used to produce the index are generally unavailable to officials as they constitute propriety intellectual property.

These indicators can be deployed in different ways. The first is as *descriptive or contextual indicators* wherein indicators are seen as providing key insights into

particular phenomenon within and between places. In these cases, indicators are viewed as vital sources of evidence for democratic debate and policy formulation with respect to specific issues, such as planning, environmental and social issues, economic performance, and to assess needs and redistribute resources (Innes & Booher, 2000; Maclaren, 1996; Van Assche, Block, & Reynaert, 2010). Federations, such as the European Union and Canada, for example, determine the amount of jurisdictionally bound spending or transfer payments based on a set of indicators representing population characteristics. Descriptive and contextual indicators are generally not used, however, in prescriptive or disciplining ways.

The second is as *diagnostic, performance and target indicators* wherein indicators are viewed as a means to diagnose a particular issue or assess performance such as effectiveness (whether goals and objectives are being met – doing the right things) and efficiency (whether getting the most output for the input – doing things right and value for investment) of a policy or programme, individual workers, departments, organizations and sectors (Franceschini et al., 2007; Holden, 2006). Targets can be absolute (to reach a defined level) or relative (to match the performance of another organization/place). Whereas the descriptive/contextual use of indicators simply charts how phenomena change over time, the diagnostic use of indicators 'require an act of scientific imagination', taking 'an extra step toward invoking theories of causality' (Holden, 2006, p. 175). In other words, it is assumed that the indicators selected can be used to diagnose the cause of the problem and to measure the impact of the potential solution, assessing whether a phenomenon is being transformed in the way desired or has reached a designated threshold or target (Maclaren, 1996; Newton, 2001). As such, the indicators provide evidential feedback loops that can be used to identify gaps between performance and expectation, formulate new interventions, and to set new goals and targets (Franceschini et al., 2007; Innes & Booher, 2000). They also often constitute part of a transparency agenda to communicate concerns to citizens and to provide them with a means to assess city management and policies (Edwards & Thomas, 2005; Miller, 2005).

The third is as *predictive and conditional indicators* wherein indicators are not just used to measure the here and now, but are used to predict and simulate future situations and performances. Here indicators are used as key inputs, along with other reference, baseline and framework data, into a variety of predictive forecasting and 'if/then' models (Maclaren, 1996). Here, there is an attempt to use suites of timely, well-defined data to model aspects of urban systems and city life with the aim of drawing insights that can be utilized to change present practices to ensure future desired outcomes. Predictive urban analytics is presently a growing field, along with forms of predictive and anticipatory governance that aim to nip problems in the bud before they occur (Kitchin, 2014a).

City benchmarking

City benchmarking consists of comparing urban indicators within and across cities to establish how well an area/city is performing vis-à-vis other locales or against best practice. The process is often accompanied with scorecarding (Kaplan & Norton, 1992), whereby tables of rankings and ratings, along with changes in relative position, are produced to reveal which places are doing well and who has caught up or fallen behind leading places (Gruppa & Mogee, 2004). Benchmarking thus sets an aspirational and competitive agenda for areas/cities in terms of their relative performance to other locales and thus can be used to motivate policy changes deemed necessary to alter their relative

rating/ranking. It is seen as facilitating a process of learning by monitoring and comparing (Huggins, 2009; Longbottom, 2000). It is also seen as a means of holding governments and policy-makers to account for their decisions and actions. When a city is relatively highly ranked, the scores are often also used in place promotion to attract foreign direct investment and tourists, for example.

Huggins (2009) details three types of area-based benchmarking. First, performance benchmarking that compares how well a place is doing with respect to a set of prescribed indicators. Second, process benchmarking that compares the practices, structures and systems of places. Third, policy benchmarking that compares public policies that influence performance and processes with respect to outcomes and meeting prescribed expectations. Luque-Martınez and Munoz-Leiva (2005) detail that these can be benchmarked in three ways. Competitive benchmarking wherein cities are ranked and rated regardless of whether they want to participate in the process (e.g., the best or most innovative place to live). Cooperative benchmarking where cities cooperate with the benchmarker, providing necessary information but often on the basis that target cities are not direct competitors (e.g. vital signs). Collaborative benchmarking where several cities work together to produce standardized indicators and to share knowledge and resources (e.g., Federation of Canadian Municipalities [FCM] quality of life indicators).

Jones Lang LaSalle report that there are now over 150 city benchmarking initiatives that seek to compare and contrast hundreds of cities globally (Moonen & Clark, 2013). Some of these initiatives benchmark cities across a range of indicators, some focus on particular sectors such as economic performance and maybe directed at particular constituents such as economic investors, and some seek to provide a single composite score that are amalgams of a number of indicators. An example of the first kind is the Global City Indicators Facility (GCIF) (cityindicators.org), a joint project of The World Bank, UN-Habitat, the World Economic Forum, OECD, and the Government of Canada, that collects and compares indicators with respect to 20 themes centred on city characteristics, services and quality of life for 254 cities across 81 countries. GCIF have also been responsible for creating an International Organization for Standardization (ISO) standard for city benchmarking indicators (ISO 37,120:2014) designed to produce standardized global urban data that would be seen as reputable and verifiable by third parties, thus providing confidence in their use for monitoring purposes and policy development (Hoornweg et al., 2007; ISO, 2014). An example of a composite index is the A.T. Kearney Global Cities Index (2012) which produces a single city benchmark score that blends five dimensions: business activity (30%), human capital (30%), information exchange (15%), cultural experience (15%) and political engagement (10%). Some benchmarking initiatives are open and supported by open-access websites, including data visualizations, others closed and only accessible through a fee or membership (i.e. GCIF). Each initiative has a different set of comparator cities, with the rationale for inclusion varying across initiatives. In each case, however, for cities to be included comparable indicator data have to be available and this often means reliance on nationally produced statistical data.

Real-time dashboards

Visualizations have long been used to summarize and communicate data, for example using statistical charts and graphs, diagrams, and maps. Unsurprisingly then they have been a key means of analysing and interpreting indicator and benchmarking data, used to reveal the structure, pattern and trends of variables. Dashboards provide a means of collecting together and displaying a number of indicators through a common graphic

interface (Lake, 2013, compares 24 dashboards). For Few (2006, p. 34) a 'dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance'. Just as a car dashboard provides critical information needed to operate the vehicle at a glance, indicator dashboards provide key information for running companies or cities (Dubriwny & Rivards, 2004). Information is typically communicated through gauges, traffic light colours, meters, arrows, bar charts, graphs, etc. (Few, 2006).

Analytical dashboards extend well beyond a single summary screen to act as a console for navigating, drilling down into, visualizing and making sense of numerous layers of interconnected data, enabling summary-to-detail exploration within a single visualization system (Dubriwny & Rivards, 2004). Such dashboards act as cognitive tools that improve the user's 'span of control' over a large repository of voluminous, varied and quickly transitioning data (Brath & Peters, 2004), enabling domains to be explored and interpreted in an easily digestible and intuitive way without the need for specialist analytics skills (the systems are point and click and require no knowledge of how to produce such graphics or coding). They can also facilitate the exporting of visualizations for use in documents, or sharing via social media, or accessing the underlying data for importing into other analytical packages.

Traditionally, dashboards displayed fixed graphics, but more recently they have become more interactive in nature with users able to interact with the data, changing the mode of display and selecting and querying data. Moreover, data can be simultaneously visualized in a number of ways, for example as a table, graph and map, with queries in the different panes replicated across them so that clicking on a data cell highlights the same data point on the graph and the area it refers to on the map. Dashboards have also been extended to visualize real-time data, thus enabling the dynamic nature of urban phenomenon, such as traffic flow or air quality or specific events, to be tracked and compared over time and space in the here-and-now.

Dynamic dashboards are often on display on computer monitors in modern control rooms, summarizing graphically a system in flux for human operators, or are sometimes

Figure 1. The Centro de Operacoes Prefeitura do Rio in Rio de Janeiro, Brazil.
Source: http://ipprio.rio.rj.gov.br/centro-de-operacoes-rio-usa-mapas-feitos-pelo-ipp/.

found in public spaces to communicate information to citizens (e.g., the iPad wall in the Mayor of London's office; Gray, Milton, & Hudson-Smith, 2013). Since the NASA Moon landing broadcasts, such displays have become iconic and sublime representations of how the control of domains is maintained (Mosco, 2004). Today's urban control rooms usually relate to a single domain such as traffic or security or weather. In the case of Rio de Janeiro, however, the live data streams are from 30 agencies, including traffic and public transport, municipal and utility services, emergency services, weather feeds, and information sent in by employees and the public via telephone, internet and radio, are fed into a single data analytics centre where they are visualized in a myriad of ways (Figure 1) (Singer, 2012). Similar centres are now being developed elsewhere, accompanied by a range of apps for citizens to access and utilize some streams of data. With respect to the latter, a number of prototype open access real-time dashboards have been developed (e.g., CASA's London City Dashboard, a single screen dashboard; http://citydashboard.org/london/) (Figure 2), some of which mix traditional indicator visualizations with new real-time data to provide a comprehensive city overview composed of both administrative and operational data (e.g., Dublin Dashboard, an analytical dashboard, which launched in September 2014; http://www.dublindashboard.ie) (Figure 3). The power of such dashboards is that they quickly and effectively provide city managers and, to a lesser extent, citizens with up-to-date detailed information about different aspects of urban systems and milieu, and how they are changing over time and space.

Governing the city using indicators, benchmarking, dashboards

For their advocates, the power of indicators, benchmarking and dashboards is that they reveal in detail and very clearly the state of play of cities. They enable one to know the

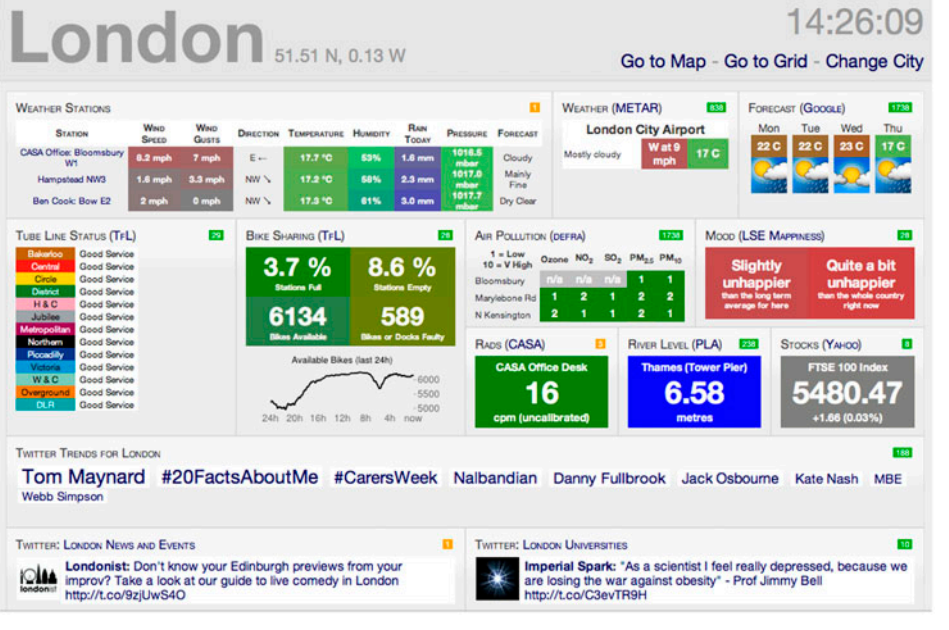

Figure 2. CASA's London City Dashboard.
Source: http://citydashboard.org/london/.

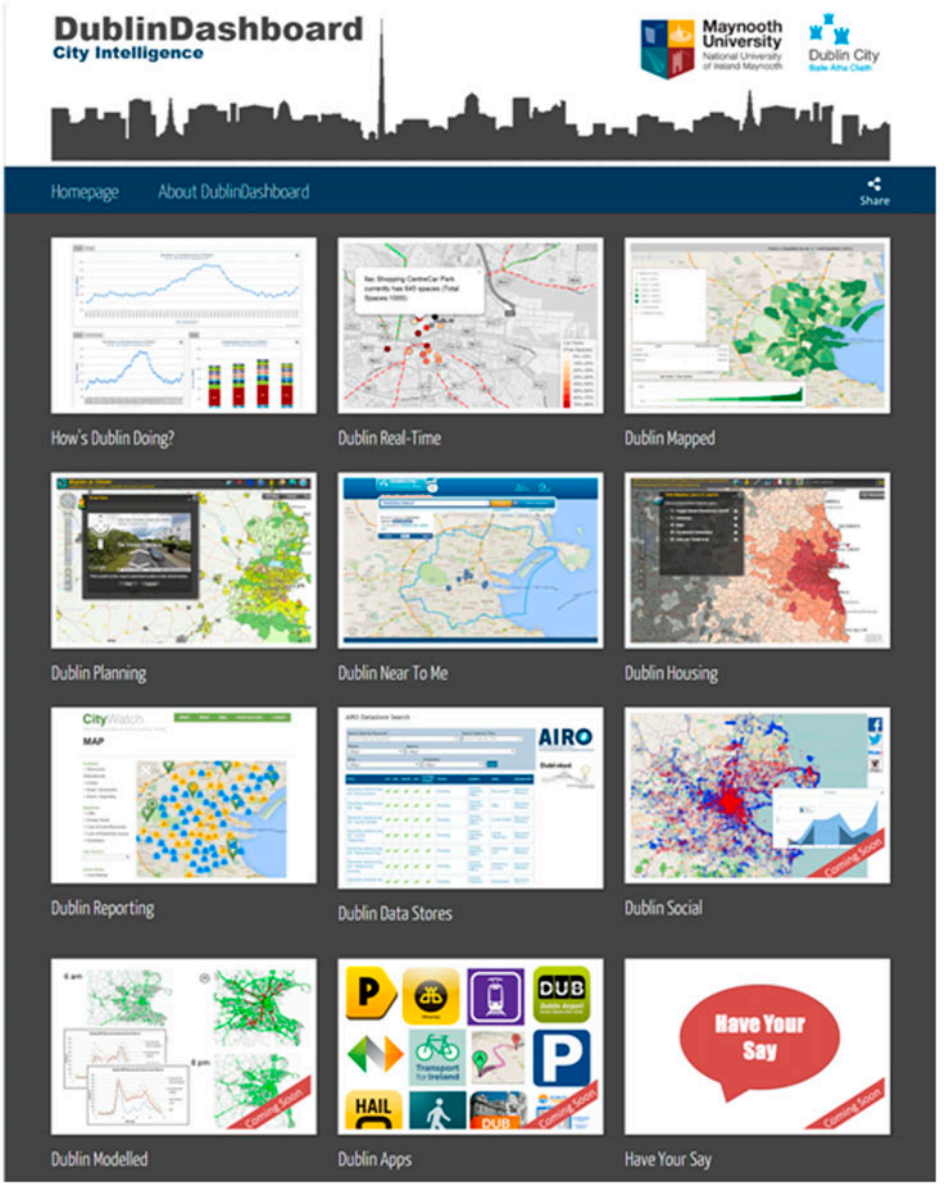

Figure 3. Dublin Dashboard.
Source: http://www.dublindashboard.ie/.

city *as it actually is* through objective, trustworthy, factual data that can be statistically analysed and visualized to reveal patterns and trends and to assess how it is performing vis-à-vis other places. Indicator data provide a rational, neutral, comprehensive, and commonsensical evidential basis for monitoring and evaluating the effectiveness of urban services and policy, to develop new interventions, and to learn and manage through measurement. They thus provide a powerful realist epistemology that not only shapes how we understand cities, but also is easily translatable into a means for assessing and formulating how cities are managed and governed. In general, how cities view

indicators, benchmarking and dashboards, the kinds of indicators and systems they deploy, and how they employ them falls into two broad camps, both of which reveal the inherent tension in such initiatives between facilitating empowerment, democracy, accountability and transparency, and enacting regulation, control, efficiency and effectiveness (de Waal, 2014; Hezri & Dovers, 2006).

First, some municipalities use indicator and benchmarking initiatives to underpin forms of new managerialism, wherein they are used to guide operational practices with respect to specified targets and to provide evidence of the success or failure of schemes, policies, units and personnel, with the performance being used to discipline underperformance, reward those meeting and exceeding targets, and to guide new strategies, policy, and budgeting (Craglia, Leontidou, Nuvolati, & Schweikart, 2004). Just as the dials and displays of an airline cockpit provide detailed data about an aeroplane and its flight, indicators, benchmarks and dashboards provide city managers with data about the city and its management (Edwards & Thomas, 2005). Within such a framework cities are understood to consist of a set of knowable and manageable systems that act in 'rational, mechanical, linear and hierarchical' ways and 'can be steered and controlled with strong leadership, solid coordination, powerful (planning) instruments and/or high-quality guidance information' (Block & Van Assche, 2010, p. 3). Here, indicators are employed instrumentally, used to conduct management by measurement, wherein indicators form a key means of determining whether a strategy is working, following the doctrine of Franceschini et al. (2007, p.9) that '[a] strategy without indicators is useless; indicators without a strategy are meaningless'. Such a view is supported by a technocratic rationality which believes that 'more and better knowledge will positively influence the actions taken by decision-makers' (Hezri & Dovers, 2006, p. 88), as well as driving process and organizational efficiencies and increases in the performance, quality, and productivity of city staff and services.

In such cases, diagnostic, performance and target indicators, as well as competitive city benchmarking, are heavily utilized. For example, since 1990 all Oregon state agencies and departments have used the continual monitoring of performance and target indicators to assess and guide city management with respect to budgeting and policy-making (Brugmann, 1997). Likewise, in New York, Michael Bloomberg's administration ran the city like a data-driven corporation, each division set performance targets against which they were measured (Brash, 2011) and, like Rio de Janeiro, established a data analytics hub (Office of Policy and Strategic Planning for New York City) to monitor the city actively, undertake evidence-based resource allocation and predict future scenarios (Feuer, 2013). Similarly, since 1999, Baltimore has used a system called CitiStat actively to guide the development of new policies and programmes and to then monitor and assess the success of their implementation by measuring and tracking indicators. Every week city managers meet in a specially designed room using dashboards to review performance and set new targets for the city as a whole and for each department, and discipline underachievement (Gullino, 2009; see also Edwards and Thomas, 2005, for a discussion of weekly review meetings of the Atlanta Dashboard by the mayor's cabinet). In this sense, CitiStat adopts a balanced scorecard approach to city management, a means by which the complexity of governing a large, diverse system can be handled and data-driven decisions taken. CitiStat, and systems like it, have been deployed in dozens of US cities, directly influencing how city services are delivered.

Second, some municipalities use indicators in a more contextual way to provide robust and clear city intelligence, which complements a variety of other information, to help inform policy-making and implementation. In these cases, cities are understood to

consist of multiple, complex, interdependent systems that influence each other in often unpredictable ways. Moreover, governance is seen as being complex and multilevel in nature requiring consensus-building and cooperation across actors and scales, with the performance of systems and staff not easily reducible to performance metrics and targets. In other words, the city is not a machine like an aeroplane that can be fine-tuned and managed through a set of simple indicator-informed levers, nor can it be disassembled into its component parts and fixed (Innes & Booher, 2000). As such, indicators are but one element, albeit an important one given their factual, standardized, time-series nature, in a tangled web of processes that help guide strategic decision-making, acting as a common source of information and learning tools about elements of a city, rather than being an evaluation tool of operational programmes or departments or the primary driver of policy and action (Block & Van Assche, 2010). A longstanding example of such an approach is that employed within the Flanders area of Belgium, where since the late 1990s a number of cities have employed a common City Monitor for Sustainable Urban Development, consisting of nearly 200 indicators, to provide contextual evidence for policy-making (Block & Van Assche, 2010, Van Assche et al., 2010). Similarly, the Boston Metropolitan Area Planning Council employs a regionally integrated government and citizen led indicator and mapping initiative to identify and inform complex policy issues.

In these cases, indicators function as a source of useful, contextual information and enhance processes of 'mapping' (charting what the state of play is) 'weaving' (enabling the binding together diverse forms of knowledge) and 'steering' (providing a course for navigation) (Parsons, 2004), facilitating coordination, integration and interaction across departments and stakeholders by providing a common trusted and authoritative data set for the city. Indicator initiatives provide evidence that reduces uncertainty and insecurity in decision-making, enabling the maintenance of stability and control, and improve the quantity and quality of democratic debate concerning policy (Parsons, 2004; Van Assche et al., 2010). In other words, indicators act to provide a normative and rational bridge between knowledge and policy (Hezri & Dovers, 2006). They are not, however, used to direct in very instrumental, mechanistic ways management practices. Indeed, Innes and Booher (2000) argue that indicators should not be used simplistically to measure policy interventions as they are too generic and narrow and policy's effects are diverse and complex. Moreover,

> indicators do not show the causes of problems, only their existence. They show trends in conditions but they do not tell us what to do. Just like a high temperature is a symptom but not the cause nor the disease. They are *indicators*, not answers. Their purpose is to help all of us reflect, experiment and improve (p. 183, original emphasis)

not to monitor, assess, reward or punish.

In both cases – new managerialism and contextual policy formulation – indicators, benchmarks and dashboards form key elements in the move towards data-driven, evidence-based governance and policy formulation; a means to replace anecdote and forms of clientelism, cronyism and localism, which have plagued decision-making and the management and regulation of many cities, with a more rigorous, transparent realist epistemology. They are a key part of the attempt to manage 'what might be termed the epistemological economy – the relationship between the supply and demand for policy-relevant knowledge' and new forms of management (Parsons, 2004, p. 45; see also Miller, 2005). But what are the limitations and dangers of such an epistemological lens?

A critical intervention

Moving beyond a realist ontology and epistemology

Indicator, benchmarking and dashboard initiatives implicitly assume a realist ontology and epistemology that supposes the existence of an external reality that operates independently of an observer and which can be objectively and accurately measured and tracked to reveal the world as it actually is through descriptive statistics and visual representations, such as graphs and maps (Astleithner & Hamedinger, 2003). They thus advance a particular way of knowing a city, that of visualized facts. Here, indicator data are understood to be essential in nature; that is, fully representative of that which is being measured (they faithfully capture its essence and are independent of the measuring process) (Desrosières, 1998). Indicator data, it is posited, can be unproblematically abstracted from the world in neutral, value-free and objective ways and be benchmarked against each other. A fact is after all a fact and can be accurately measured – there are *x* number of people living in a city; *x* percentage of them are unemployed; there are *x* number of deaths due to different illnesses; the trains are on average *x* minutes late; the level of pollution consists of *x* parts per million; etc. And a rate of unemployment in one city can be accurately compared with other cities. In cases where people play a central role in data collection it is assumed that a form of mechanical objectivity is deployed that adheres to defined rules and rigorous, systematic method to produce distant, detached, impartial and transparent data that are free of researcher bias and preferences, and are independent of local customs, culture, knowledge and context (Porter, 1995). Indicator and benchmark data are thus assumed to have no inherent politics or ulterior agenda and can be taken at face value (Kitchin, 2014a). From this perspective, indicator, benchmarking and dashboard initiatives are powerful toolkits for transforming the city into atomized factual elements that can be tracked and traced, visualized and analysed, interpreted and acted upon.

In contrast, a critical understanding of data recognizes that data do not exist independently of the ideas, instruments, practices, contexts, knowledges and systems used to generate, process and analyse them, regardless of them often being presented in this manner (Lauriault, 2012; Ribes & Jackson, 2013). Data are generated as the product of many minds working within diverse situations, framed and shaped within contexts and structures (Kitchin, 2014a). How we conceive of data, how we measure them and what we do with them actively frames the nature of data. Data do not pre-exist their generation; they do not arise from nowhere. Data are epistemological units, made to have a representational form that enables epistemological work, and data about the same phenomena can be measured and recorded in numerous ways, each providing a different set of data that can be analysed and interpreted through varying means (Poovey, 1998).

How data are generated, then, is not inevitable: protocols, organizational processes, measurement scales, categories, and standards are designed, negotiated and debated. Consequently, how data are ontologically defined and delimited is not a neutral, technical process, but a normative, political, and ethical one that is often contested and has consequences for subsequent analysis, interpretation and action (Bowker & Star, 1999). Or as Bowker (2005) puts it, data are never raw, but always already cooked. Similarly, databases and data infrastructures, such as indicator and benchmarking initiatives, are not neutral, technical means of assembling, processing and displaying data, but are bundles of contingent and relational processes that shape their constitution and operation (Kitchin & Dodge, 2011; Star & Ruhleder, 1996). They are complex socio-technical systems that do not simply reflect the world, but actively produce it (Kitchin, 2014,

Lauriault, 2012). They exemplify technopolitical regimes 'grounded in institutions […] consist[ing] of linked sets of people, engineering and industrial practices, technological artefacts, political programs, and institutional ideologies which act together to govern technological development' (Hecht, 2001, p. 257) and enable the administering at a distance of sovereign power and forms of biopower; that is, the exercise of legal and administrative control over people and their environs.

From these perspectives, indicator, benchmarking and dashboard initiatives are not merely toolkits. Instead, such initiatives constitute what Kitchin (2014a, p. 24) terms a 'data assemblage', a socio-technical system composed of many apparatuses and elements that are thoroughly entwined (Table 1). The apparatuses and their elements frame the nature, operation and work of an indicator initiative. And as new ideas and knowledges emerge, technologies are invented, skill sets develop, debates take place, and the form of city governance alters, the data assemblage evolves and mutates. As Astleithner and Hamedinger (2003, p. 629) contend, indicator projects

> evolve out of policy-making processes and the debates on them are dynamic sites of conflict and cooperation between policy actors. Indicator sets are embedded in specific situational contexts, in which actors define the form, function and role of indicator sets as part of policy-making processes.

This is why there are so many different types of such projects, using alternative amalgams of indicators, operating in different ways, for varying purposes (Mori & Christodoulou, 2012). In other words, indicator initiatives are never neutral, essential,

Table 1. Apparatuses and elements of a data assemblage.

Apparatuses	Elements
Systems of thought	Modes of thinking, philosophies, theories, models, ideologies, rationalities, etc.
Forms of knowledge	Research texts, manuals, magazines, websites, experience, word of mouth, chat forums, etc.
Finance	Business models, investment, venture capital, grants, philanthropy, profit, etc.
Political economy	Policy, tax regimes, public and political opinion, ethical considerations, etc.
Governmentalities and legalities	Data standards, file formats, system requirements, protocols, regulations, laws, licensing, intellectual property regimes, etc.
Materialities and infrastructures	Paper/pens, computers, digital devices, sensors, scanners, databases, networks, servers, etc.
Practices	Techniques, ways of doing, learned behaviours, scientific conventions, etc.
Organizations and institutions	Archives, experts, corporations, consultants, manufacturers, retailers, government agencies, universities, conferences, clubs and societies, committees and boards, communities of practice, etc.
Subjectivities and communities	Of data producers, curators, managers, analysts, scientists, politicians, users, citizens, etc.
Places	Labs, offices, field sites, data centres, server farms, business parks, etc., and their agglomerations
Marketplace	For data, its derivatives (e.g., text, tables, graphs, maps), analysts, analytic software, interpretations, etc.

Source: Kitchin (2014), p. 25.

objective, but are rather contingent, relational and contextual; their data never raw but always cooked to some recipe by chefs embedded within institutions that have certain aspirations and goals and operate within wider frameworks.

Indicator, benchmarking and dashboard initiatives inherently express a normative notion about what should be measured, for what reasons, and what they should tell us, and are full of values and judgements shaped by a range of views and contexts. There is a politics to indicator and benchmark selection, their communication and visualization, their deployment, and their use. For example, in some initiatives indicator selection is stakeholder-led and/or community-participatory-led through open debate at invited or public meetings, or consultancy firms or 'independent' think tanks. Here, there is a tension between participatory and consensus based approaches to deciding on what measures best reveal the state and development of a city versus centralized, technocratic approaches (Block & Van Assche, 2010; Beilin & Hunter, 2011). In all cases, selection is framed by whether the desired data are readily available and the contingencies and costs of filling any gaps. The selection of indicators can then be principle based or politically driven (to forward or defend a particular agenda, or to enact a compromise vis-à-vis other selections) or data driven (selecting because it exists or omitting because it does not) or economically motivated (created by a sector that stands to benefit from their adoption).

Moreover, indicator, benchmarking and dashboard initiatives have a deep normative effect, being used to shape city governance, modify institutional behaviour, condition workers, influence decision-making, and shape spending patterns (Franceschini et al., 2007). In this sense, they do not simply act as a camera reflecting the world as it is, but rather act as an engine shaping the world in diverse ways (MacKenzie, 2008). They not only represent urban systems, but also help produce them. As Hezri (2004) details, indicators can be used in many different ways that are all politically charged: instrumentally (e.g., for problem solving and decision-making), conceptually (e.g., understand and interpret a situation), tactically (e.g., for delaying a strategy, substitute for action, deflect criticism), symbolically (e.g., to provide reassurance or place promotion), and politically (e.g., ammunition to support a particular position). It is also a way to manage at a distance and to alleviate officials from taking full responsibility for the actions they may take, or supports them to make hard decisions and avoid backlash. In other words, indicator measurements, benchmark scorecards and dashboard visualizations are diversely performative, providing an instrumental, technocratic means of viewing and evaluating urban systems and addressing problems, though Hezri and Dovers (2006, p. 95) note that their effects are often quite subtle, with information creeping and percolating through policy systems, influencing decisions by 'becoming embedded in the thought, practices, and institutions' of users and seeping into actions. In so doing they become a normalized way of thinking about and performing governance.

This performativity can be both productive and counterproductive, and paradoxically can have both effects simultaneously. For example, a set of indicators might increase productivity, but also alienate and demoralize staff leading to employee churn. Moreover, the use of indicators can lead to all kinds of unanticipated effects. Salmon (2014), for example, details that once data-driven forms of management are implemented they rarely deliver the benefits expected and often produce new issues. He draws on Campbell's (1976) Law to explain this: 'The more any quantitative social indicator is used for social decision-making, the more subject it will be to corruption pressures and the more apt it will be to distort and corrupt the social processes it is intended to monitor.' In other words, once introduced city managers start to game the system in rational,

self-interested but often unpredictable ways to influence indicator measurements. As Edwards and Thomas (2005, p. 371) note: 'the more managers must expose to public scrutiny, the more they may be tempted to spin data to make departmental performance appear more positive than it is'. Similarly, Margetts, Perri, and Hood (2010) detail the unintended and unanticipated effects associated with modernization projects that paradoxically work to undermine the very outcome they were initiated to produce.

A key element of the normative framing and effects of indicators, benchmarking and dashboards is their instrumental rationality, which is based on a combined and narrowly framed 'episteme (scientific knowledge) and teche (practical instrumental knowledge)', which works to marginalize and replace 'phronesis (knowledge derived from practice and deliberation) and metis (knowledge based on experience)' (Parsons, 2004, p. 49). Hard facts trump other kinds of knowing, and undermine and displace other scientific forms of urban knowledge that are less systematic and continuous, such as policy analysis, interviews, focus groups, surveys, etc. However, whilst this instrumental rationality challenges anecdotal forms of evidence and planning it also suffers from a number of shortcomings.

First, it is highly reductionist atomizing complex, contingent relationships into simplified, one-dimensional measures that cannot provide a full and multidimensional picture of the city, even when combined into composite indices (Astleithner and Hamedinger (2003). Second, it decontextualizes a city from history, its political economy, the wider set of social, economic and environmental relations that frame its development, and its hinterland and wider interconnections and interdependencies that stretches out over space and time (cities are open not closed systems; Craglia et al., 2004; Mori & Christodoulou, 2012). In so doing it suggests that knowing a city can be obtained from merely the summing of its measures, whereas in reality it requires much more. Third, it enables longitudinal analysis but presumes that patterns and trends can be redirected through quick acting policy levers, often ignoring the temporal register of urban processes (that different processes and policies work at different speeds). Indicators demand work in the here and now, but some policy might take decades to mature.

Fourth, it assumes a universalism in the validity of measures and method across place – that it should be possible to measure, visualize and compare the same facts between cities in a standardized fashion. This is particularly the case with urban benchmarking projects that presume that it makes perfect sense to compare Manchester, Bogota, Delhi, Tokyo, Rome, Nairobi, etc.; all cities with different histories and trajectories, varying political economies and varieties of capitalism, different forms of state apparatus and governance structures, different policies and ambitions across dimensions (quality of life, competiveness, sustainability, etc.), and different access to resources and capacities. Benchmarking assumes there is a normative standard by which they should be judged, some ideal state they are all seeking to achieve, rather than acknowledging that phenomenon in different jurisdictions/places differ from one another often for good reasons, and that how indicators relate to policy-making in one place may produce poor policy in another or simply foster imitation and copying rather than fostering policy grounded in the strengths and needs of that locale (Huggins, 2009; Gruppa & Mogee, 2004). Moreover, benchmarking is a zero-sum game in that cities are rated and ranked, with only one city being able to occupy each place, so that despite the fact that they may have improved their performance they are still lowly ranked vis-à-vis other locales; instead it makes more sense to compare a city to a benchmark fixed in time relating to that city (Greene, Tracey, & Cowling, 2007).

This instrumental rationality extends to how indicator and benchmarking data are visualized and communicated through dashboards. Without the graphics and maps of urban dashboards it would be all but impossible to manage and make sense of so much data, especially real-time data. Dashboards facilitate the illusion that it is possible to 'picture the totality of the urban domain', to translate the messiness and complexities of cities into rational, detailed, systematic, ordered forms of knowledge (Mattern, 2014). They empower city managers and citizens 'with fresh eyes designed to interpret and manipulate data, to see more and understand faster' (Pryke, 2010, p. 428). Yet, at the same time, dashboards use a global scopic system of generalized visual forms that occludes local forms of knowledge and keep black-boxed the algorithms, databases, software and design decisions that shape the interface's look and feel and operation. Indeed, whilst dashboards can be illuminating, they define and structure their inputs and outputs, highlight and obfuscate particular dimensions of the city, and frame how urban data are engaged with by users (Mattern, 2014); they consist of a 'set of conditions, structured relations, that allow certain behaviours, actions, readings, events to occur' (Drucker, 2013). As such, a dashboard seeks to act as a translator, not simply a mirror, setting the forms and parameters for how data are communicated and thus what the user can see and engage with. This translation is ideologically framed and inherently political, shaping what questions can be asked of the underlying data and what answers can be obtained (Galloway, 2012). After all, a city dashboard forms a communicative protocol (Franceschini et al., 2007) about that city, so how the dashboard is presented and what it presents is full of political considerations (and all kinds of technical, design, social and political negotiations take place in building them).

Rather than think of dashboards in terms of what they are, following Kitchin and Dodge's (2007, 2011) reconceptualization of maps and software, and Drucker (2013) revisioning of interfaces, it is more productive to think about what they do. From this perspectives, dashboards are more than translators of urban data; they are not 'stable and self-evident, whose meaning can be fixed simply by a detailed reading of its elements' but 'space[s] of affordances and possibilities' (Drucker, 2013). Whilst their makers might seek to craft and control their look and feel, and envisage them as detached, passive or neutral instruments that communicate the world as it is, dashboards are much more active and unfold in multifarious ways. They are ontogenetic and performative – always in the process of becoming, of taking place. They do not simply represent urban phenomena, but generate new visions and understandings of the city and alter the 'contours and trajectories of knowledge formation' (Pryke, 2010, p. 436). They are not merely a conduit for meaning, but are constitutive of and actively produce meaning. Rather than reveal the world as it is, dashboards produce and shape the world; and where they are used to create urban policy they precede the world, as an architectural plan precedes a new building. They are always then open to resistance and rupture, to alternative interpretations and to be put to work in diverse and unforeseen ways. Understood in this way, dashboard visualizations should not be naively accepted and interpreted as neutral, apolitical communication tools, but as active, ideologically loaded engineered devices.

Recognizing and dealing with technical and methodological issues

Beyond their assumed instrumental rationality, indicators, benchmarking and dashboards also have a number of technical and methodological issues that are often overlooked or ignored. The data are often taken at face value, viewed as unambiguous and accurate

measures, however the situation is much messier and complicated (Böhringer & Jochem, 2007). As with all data, because they are inherently abstracted, generalized and approximated through their production, there are always questions concerning data veracity and quality and how accurately (precision) and faithfully (fidelity) the data represent what they are meant to (especially when using samples and proxies), and how clean (error and gap free), untainted (bias free), consistent (few discrepancies), and reliable (the measurement instrument consistently produces the same quality of results) the data are (Goodchild, 2009; Kitchin, 2014a). Within statistical agencies and research teams considerable attention is thus directed at minimizing and assessing the level of uncertainty introduced by such issues and there is a clear recognition that indicator data come with health warnings, with the extent of concern varying across data sets.

The level of truthfulness and trustworthiness of data also varies over time and place due to different measurement regimes and their changing nature (as technologies, practices and personnel alter) (Ribes & Jackson, 2013). It is quite clear, for example, that the veracity of data generated through census and household surveys varies within and between jurisdictions. The validity of making comparisons between places can thus be brought into question with concerns as to whether like is being compared to like. This is one of the reasons that there is great emphasis at present at seeking standardization of measures at the regional and global scale (Bhada & Dan Hoornweg, 2009). For example, the European Union through its INSPIRE directive seeks to harmonize data across its 28 member countries.

Further, there are a number of other issues caused by spatial resolution, aggregation and creating composite scores that produce a range of ecological fallacies. A well-known

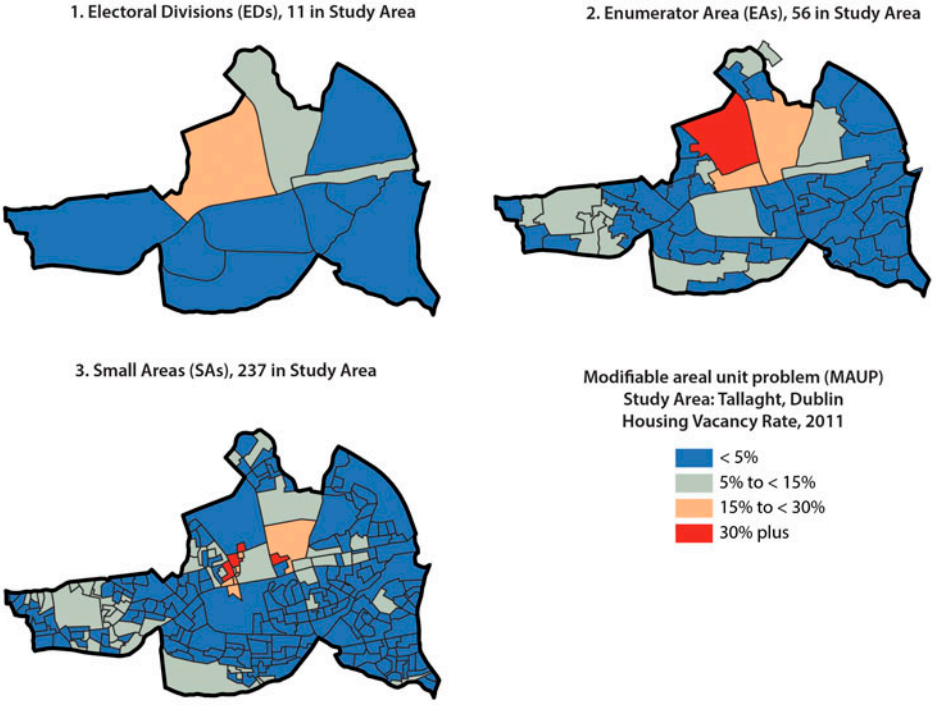

Figure 4. Modifiable areal unit problem (MAUP): mapping the same indicator at three different scales.

problem within spatially based research that compares places is the modifiable areal unit problem (MAUP) (Openshaw, 1984; Wrigley, 1995). For collecting and reporting data about locales, the world is divided up into statistical geographies, for example, postcodes that nest in wards, that nest in counties, that nest in regions, within countries. These statistical geographies are relatively arbitrary and the world could be divided up in any number of ways – zones are modifiable – as illustrated by gerrymandering. And changing the pattern and scaling of the zones changes the pattern of aggregated observations, often in quite dramatic ways as illustrated in Figure 4, which shows the same housing vacancy indicator data in three different, nested statistical geographies (Electoral Division area, Enumerator Area, Small Area). Determining where to invest area-based policy interventions would vary depending on which map was used. Decisions over the statistical geography of a city can then have dramatic effects on how that city is understood and governed. Another example, with respect to city benchmarking concerns the geographical limits of a city and the extent to which it encompasses its hinterland (Craglia et al., 2004, Mori & Christodoulou, 2012). For example, whether data refer to Dublin City Council, Dublin County or the Greater Dublin Area can make an enormous difference to the ranking of Dublin on scorecards as the underlying population and economy changes markedly. The same effects occur with respect to aggregating data into different categories. What these scaling and aggregation effects produce are a range of ecological fallacies, wherein false conclusions can be drawn about a place due to how the data are collated, categorized and presented. Moreover, it is possible to game exercises such as city benchmarking by simply altering the area or populations or industries, etc., to which the data refer.

Similar issues exist with respect to composite indicators. Because composite indicators consist of amalgams of indicators, which are assigned different weights, changes to the set of indicators included or the relative weightings can have a profound effect on the resulting score. Indeed, many composite indicators are highly sensitive to adjustments and thus are vulnerable to manipulation (either through tinkering with the algorithm or by gaming the data) (Huggins, 2003; Gruppa & Mogee, 2004). It is also inevitable that the selection of indicators, parameters, weightings inherently tend to favour some locales over others, giving them a natural advantage. Further, many composite indicators show no indication that they have sought to deal with issues such as normalizing the data onto a common geographic, time or threshold scales, setting the weightings to reflect importance and prioritize key interrelationships, or accounting for multicollinearity between variables or conflicts in their commensurability (Huggins, 2003; Böhringer & Jochem, 2007). As such, they lack a sound scientific base from which to draw conclusions. Prior to making interpretations it is thus important to fully understand the methodology used in the calculation of composite indices, including: 'the predetermined boundaries of the system; the data included in the analysis; the normalization and weighting methods; the aggregation method; […] the comparability of results across systems' (Mayer, 2008, p. 287) and the 'error structure [in] sampling, selection, measurement, and subsequent handling' (Holton, 1978, p. 17). In the case of composite city benchmarking, it is also important to recognize the effects of differences in data quality and veracity across places, such as non-standardization of data measures (Gruppa & Mogee, 2004).

Investigating, judging and dealing with these various methodological issues is often compounded by a lack of documented data lineage and metadata within initiatives. Data lineage is

> information that describes the source of the observations, data collection and compilation methodologies, conversions, transformations, analyses, and derivations to which the data have been subjected. It also provides the assumptions and the criteria applied at any stage of its life, as well as any biases. […] [L]ineage provides a data set with its pedigree and allows the user to decide on its fitness for use.(Lauriault, 2012)

It also details the provenance of the data, that is, by whom are the data generated, processed and handled. Metadata are data about data and can refer to the data themselves or the whole data set. Metadata about the data themselves includes the names and descriptions of specific fields and data definitions that help a user understand its composition. Metadata that refers to a data set as a whole can be descriptive concerning identification and discovery elements (e.g., title, author, publisher), structural referring to the organization and coverage of the data set, and administrative concerning when and how the data set was created, details of the technical aspects of the data, such as file format, and who owns and can use the data (NISO, 2004). Data lineage and metadata enable users to assess data quality and trustworthiness, and without them data can only be taken at face value.

The effect of relying on data that are poor in quality and veracity is that policy based upon them could actually make situations worse rather than better (Mayer, 2008). Regardless of such warnings, the developers of indicator, benchmark and dashboard initiatives try to gloss over the various problems afflicting them. For example, Moonen and Clark (2013, p. 4) in their assessment of 150 city benchmarking initiatives state:

> [w]here the rigour and science is open to question, the factors behind competitiveness and success can still be found for those who interpret carefully. The caveats of city indexes are, of course, cautionary, and when understood in context, the potential pitfalls can be safely navigated.

The difficulty is that the information required to interpret carefully and safely navigate such data are generally not published, with the methodology and issues concerning aggregation, weightings and statistical geography black-boxed. The effect, however, of denying various methodological issues is to retain and reinforce the line that indicators and data visualizations reveal the world as it really is; data shed their constraints, parameters and issues, and gain confidence and stature. This would be less of a problem if indicator, benchmark and dashboard initiatives could be largely ignored, but as discussed in the previous section they are having a profound effect on systems of city governance (Cortright & Mayer, 2004).

Conclusions

As noted at the start of this paper, we have over 10 years experience of creating and building local, regional and national indicator initiatives and working on cross-jurisdictional spatial data and indicator projects and dashboards. We appreciate such initiatives are necessary and useful, especially to city managers who are trying to manage and coordinate services with reduced budgets and staffing, who are subject to greater oversight and transparency, and are thus seeking detailed spatial and temporal data that fulfil their requirements and are easily digestible and communicated. That said, we know from personal experience how messy, dirty and inconsistent indicator data can be, the experimenting and debates that occur in creating composite indices, the difficulties in sourcing, aligning and harmonizing data between locales and jurisdictions, and

the complex process of negotiation and decision-making that occurs in visioning and developing initiatives in terms of selecting indicators and setting the parameters and look and feel of interfaces. Indicator, benchmarking and dashboard initiatives are contingent, relational and contextual in their unfolding and operation. They are never neutral and objective, and they never show cities as they really are, but rather enact a particular version of them whilst asserting a particular expression of power/knowledge.

And yet, indicator, benchmarking and dashboard initiatives are consistently conceived as holding a realist epistemology – as capturing and communicating the city as visualized facts; that they reflect the truth about the world. This is their promise and it is one that appeals to city managers trying to run and govern large, complex systems. They provide objective, neutral facts that are easily visualized, tracked and compared. They enable performance to be measured, assessed and judged. They provide a transparent, interactive window onto the city that is easily sharable and accessible. Unsurprisingly then they are being enfolded into city governance regimes as a vital management and regulatory toolkit. Whilst contextual approaches recognize some of the shortcomings of indicators to fully detail the complexities of the world, they still privilege a realist, quantitative epistemology, enact an instrumental rationality, and fail to recognize and denote their contingent unfolding, their inherent politics, and their technical and methodological issues.

We believe in the utility and value of indicator and dashboard initiatives – they provide detailed spatial and time-series data about various aspects of cities enabling longitudinal studies of socio-spatial, economic and environmental processes. They provide an evidence base far superior to anecdote, and have advantages over one-off studies in terms of coverage and regularity. Though we do accept that there are common issues in different cities and regions that need to be compared and communicated, we are much less convinced about the value of benchmarking exercises which are zero-sum games and assume a universal ideal against which all cities should be measured, failing to recognize that cities have different histories, geographies, aims and ambitions. But we are also aware, as set out above, that indicator and dashboard initiatives are far from perfect solutions to knowing the city and caution needs to be exercised in how they are enfolded into city governance. As such, we also believe that they need to be conceptualized and framed differently; that indicator and dashboard initiatives need to acknowledge and embrace their contingencies, shortcomings and inherent politics, and to not over-sell their utility and value. The latter is a particular issue given the rise of smart city discourses and grand claims that a new urban science – fuelled by quantitative urban indicator data –should replace traditional urban studies as it will be able to identify and solve urban problems and facilitate more efficient and effective city governance (Bettencourt, Lobo, Helbing, Kuhnert, & West, 2007; Kitchin, 2014b; Lehrer, 2010; Lohr, 2013).

Instead, we advocate for indicator and dashboard projects that openly recognize their situatedness as the product of a complex data assemblage; that are cognizant of contingencies and relational effects of project and interface design; that signal their positionality and politics; that fully document their lineage, data provenance, metadata, and levels of error and uncertainty; that recognize that they do not reflect the world as it actually is, but actively frame and produce the world. They are initiatives that do not make grand claims as to their veracity or validity, or assert their instrumental rationality and in so doing actively work to close off other ways of knowing and promote a very narrow form of power/knowledge. Instead, they recognize the multiple, complex, interdependent nature of cities which mean that they cannot be simply disassembled into a

collection of facts; that cities cannot be easily fine-tuned and managed through a limited set of indicator-informed levers; and that there are a multitude of other ways to see and understand the city that produce valuable, insightful knowledge.

It may well be the case that those who develop and promote indicator, benchmarking and dashboard initiatives are already aware of their contingencies, relationalities, politics, and technical shortcomings, but deal with them by engaging in a form of strategic essentialism that covers over or pretends they do not exist in order to promote their approach (and in the case of industry, products) and to deflect possible critique. If this is the case, then we are advocating that the fig leaf of such strategic essentialism be tugged away as the stakes with regards to how cities are managed and governed using such initiatives are too great – particularly when they are used to direct resources and formulate and implement policy. If the developers of such initiatives want to persist with the illusion that their realist epistemology reveals cities as they really are, then we contend that we need a series of studies that unpacks and exposes their data assemblages and power/knowledge. Indicator and dashboard initiatives have much to offer city managers and citizens, but they need to make fully clear what is on offer.

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