14. Developing a critical understanding of smart urbanism

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14.1 INTRODUCTION

Across the world, smart urbanism (SU) is emerging at the intersection of visions for the future of urban places, new technologies and infrastructures. Promoted by international organizations, the corporate sector, and national and local governments alike, the dominant vision revolves around the meshing of interactive infrastructure, high-tech urban development, the digital economy and e-citizens. SU discourses are deeply rooted in seductive and normative visions of the future where digital technology stands as the primary driver for change. SU, it is argued, provides a flexible and responsive means of addressing the challenges of urban growth and renewal, responding to climate change, and building a more socially inclusive society (European Commission, 2012). As SU finds firm ground beyond the corporate world, in the sites of communities and local organizations, these optimistic readings of the interaction between digital and urban worlds are embraced by a wide range of stakeholders – arguably following both 'top-down' and 'bottom-up' logics.

Smart urbanism – as opposed to the more technocratic concept of smart cities – refers to the ways in which digital technologies and computational logics become intertwined with everyday life, numerous socio-technical networks and the wider socio-political context of their deployment. Our conception of SU is based on a relational understanding of socio-technical change which recognizes that the logics of smart city technologies are frequently challenged, contested and disrupted when they engage with different urban contexts and social interests, and rarely deliver the vision of their designers without being recast and reconfigured. However, our collective understanding of the opportunities, challenges, and implications of SU is still limited. Research in this field is slowly emerging (Caragliu et al., 2011; Luque, 2014; Luque et al., 2014) yet fragmented along disciplinary lines (e.g. Hollands, 2008) and based on single city case studies (Mahiznan, 1999; Mejia et al., 2011). As a result, we lack both the theoretical insight and empirical evidence required to assess the implications of this potentially transformative phenomenon. Given the significant

implications of SU there is an urgent need to critically engage with why, how, for whom and with what consequences SU is emerging in different urban contexts. The rest of this chapter is structured in three sections. The following section provides an overview of the recent research literature on smart urbanism, identifying the need for a more critical assessment of the phenomenon. The third section identifies three research themes that could constitute a critical agenda. The final section concludes by identifying three future research priorities.

14.2 CRITICAL GAPS IN UNDERSTANDING SMART URBANISM

A new language of 'smartness' is reshaping debates about contemporary cities, along with a new set of programmes and practices that are intent on realizing smart urbanism. This is visible in, for example, the importance given to smart cities in the EU Strategic Energy Technology Plan (European Commission, undated), the prolific development of smart city initiatives in Asia, Australia, the US and elsewhere (e.g. EPRI, undated; SmartGrid.gov, undated), and the emergence of dedicated teams aimed at developing business opportunities in smart city technologies within global engineering, telecommunications and utilities companies such as IBM, Cisco, Toshiba, Google, General Electric, Hitachi and others (Luque, 2014). SU is projected, often following normative or teleological approaches, as a futuristic solution brought to the present to deal with a broad multiplicity of urban maladies, including issues of economic growth, transport congestion, resource constraints, climate change and even the need to expand public participation within local democratic processes, amongst others.

Taken together, these new drivers and programmes are creating a new lexicon through which the development of (smart) cities is being forged – urban apps, big data, intelligent infrastructure, city sensors, urban dashboards, smart meters, smart buildings, and smart grids, amongst others. The emergence of urban operating systems (or Urban OS) – integrated information packages made of hardware, software and digital platforms offering capabilities for the integration and control of a multiplicity of urban functions – consolidates a computational logic of urban control. This underpins a novel set of governing rationalities and operational techniques that make up the emerging 'smart' forms of urbanization (Marvin and Luque-Ayala, 2017). Historically grounded within military, logistics and corporate contexts (cf. Light, 2003; Cowan, 2014; Kallinikos, 2007), the techniques and rationalities of the Urban OS lead to a more audited, rationally managed, efficient, controlled and commodified city.

This is the city as a logistical entity, digitally redesigned for the purpose of maintaining circulations and flows (Luque-Ayala and Marvin, 2016). It is in this context that the mayor of Rio de Janeiro, for example, turned to IBM for designing and delivering its *Centro de Operaçoes Rio*, a city-wide control room – globally regarded as an exemplar smart city initiative – aimed at digitally integrating urban functions whilst managing both the emergency and the everyday. Similarly, the City of Chicago has developed a new set of advanced mathematical and statistical capabilities, turning its *WindyGrid* programme into the world's first citywide real-time urban analytics platform. New York City has turned to the expertise of cloud-based solutions firm Socrata for the development and operation of *NYC Open Data*, its municipal data platform, and, with the help of an active civic hacking community, recombines urban data towards generating novel ways of understanding, visualizing and imagining the urban. Barcelona has deployed *Sentilo*, a municipal 'open source sensor and actuator platform', agglomerating the data generated by hundreds of municipally owned sensors, from parking to waste and air quality, opening – yet unknown – possibilities for the recombination of the city's ecological data. The smart city, with its computational logics and still under-examined governing rationalities and techniques, is mobilized by formal and informal stakeholders alike. As such, SU is neither top-down nor bottom-up. In Taipei and Hong Kong, for example, civic hackers have mobilized forms of digital resistance by deploying data-sharing platforms in support of the Sunflower Revolution and the Umbrella Movement. While often radical in ambition and scope, this shift to 'smart' logics is accompanied by new expectations of network flexibility, demand responsiveness, green growth, new services and connected communities. These expectations, in turn, are driving investments and reshaping policy priorities leading to the accelerated implementation of SU globally.

Yet, the potential, limitations and broader implications of these transformations have seldom been critically examined. Existing research in the field has focused on the technical, engineering and economic dimensions of smart systems (Jamasb and Pollitt, 2011; Bakıcı et al., 2013; Alawadhi et al., 2012; Wade et al., 2010). This research tends to have a 'problem solving' focus, with limited critical analysis (Hollands, 2008) and primarily concerned with achieving optimal outcomes for smart systems under current technical, political and market conditions (NEDO, 2011; Kanter and Litow, 2009; Leydesdorff and Deakin, 2011; Batty et al., 2012). Whilst urban studies has a long tradition of critically examining the interface between space and digital technologies (Graham, 2002; Graham and Marvin 1996; Boyer, 1992; Crang, 2010; Crang and Graham, 2007; Thrift and French, 2002), and information studies has targeted the city as one

of its key domains of study (Forlano, 2009; Foth, 2009; Galloway, 2004; Middleton and Bryne, 2011), narratives and practices around notions of 'smartness' have been largely absent. In this context a number of practitioners and scholars have started to question the problem-solving powers of 'smart', by asking questions around democracy and citizenship (Townsend, 2013; Greenfield, 2013; Halpern et al., 2013), drawing attention to the specific mechanisms through which code operates (Kitchin and Dodge, 2011), pointing to the risks of big data and a city with 'sensory capabilities' (Thrift, 2014a, 2014b; Klauser and Albrechtslund, 2014) and examining how smart rationalities and techniques alter contemporary functionings of power, space and regulation (Klauser, 2013). More recently, scholars working on the interface between politics, life and the environment – drawing on post-structuralist thinking and often outside the world of Urban Geography – have been examining the ways in which the material manifestations of such smart logics (through, for example, the ubiquity of environmental sensors and dashboards) are transforming modes of governing both the city and its population as a whole (Braun, 2014; Gabrys, 2014).

We argue that, with the exception of some of the works cited above alongside a slowly growing body of critical works on the smart city, understandings of SU lack a critical perspective compounded by an undue emphasis on technological solutions that disregard the social and political domains. As evidenced by the analysis of multiple other design-based and techno-utopian interventions in urban systems, such as grid-based infrastructures (Hughes, 1983; Nye, 1999; Graham and Marvin, 1996, 2001), modernist urban planning (Sandercock, 1998) and new urbanism (Harvey, 1997), the urban plays a critical role in shaping, translating, and contesting the desired – and often failed – transformation. Urban studies scholars have previously alerted us to the extent to which contemporary understandings of the city have tended to neglect the material, technological and environmental dimension (Monstadt, 2009). In response, there has been growing interest in the political ecologies and cyborgian nature of cities (Gandy, 2005; Heynen et al., 2006) as well as in the social and political dynamics of infrastructure, urban sustainability and low carbon transitions (Bulkeley et al., 2011; Hodson and Marvin, 2010; McFarlane and Rutherford, 2008).These perspectives, when viewed through the lens of the claims enacted by SU, highlight the need for a more in-depth examination of the manner in which the transformational potential of SU is created. Such claims and potential, fundamentally produced with and through digital technologies operating under specific political rationalities and governmental techniques (Klauser et al., 2014), remain beyond the reach of social science at present.

Within this context, a critical assessment of SU is needed. From one perspective, SU may serve to further deepen the splintering of urban networks that dominated the last part of the twentieth century for many cities, creating deep divides between those with access to 'smart' and those without (Datta, 2016). Alternatively, in some guises, SU may serve to promote more 'community', 'civic' or 'metropolitan' forms of service provision and urban life (SENSEable City Lab, undated; Map Kibera, undated). Beyond this, 'smart' might be interpreted as yet another strand in the consolidation of dominant circuits of capital and a neo-liberal governmentality (Vanolo, 2013) or as a new governmental form altogether (Gabrys, 2014). Internationally comparative research is critical in order to develop a nuanced understanding of how and why this varies across urban contexts. Understanding these processes will enable us to consider the current trajectories of SU and examine what the potential trajectories for SU are in cities where it has yet to become established. The limits of current disciplinary approaches mean that addressing the critical challenges of SU cannot be achieved without a step-change in thinking.

14.3 TOWARDS A CRITICAL AGENDA: EMERGING THEMES AND CONTEMPORARY ISSUES

In developing a response to these gaps in the existing research landscape there are three key challenges. The first of these is to develop an interdisciplinary conceptual approach for the analysis of SU. This means examining how SU is currently conceptualized within the sciences and social sciences, identifying areas for agreement, dialogue and dissent. It also means considering what theorizations of the co-constitution of social and technical systems offer for the conceptualization of SU. Second, there is a need to analyse the social and political implications of implementing smart logics – both materially and discursively – to examine how specific urban conditions enable and constrain SU transitions and to co-produce alternative pathways. Understanding the potential and implications of the transition to SU, and the possibilities for creating more sustainable and socially inclusive pathways, requires the intensive examination of how SU is produced and reproduced in particular urban contexts. Third, new knowledge about the forms, dynamics, and consequences of SU in an internationally comparative context needs to be generated. There is a lack of comparative analysis and a dearth of knowledge about the range of urban contexts within which SU is emerging. Far from being passive backdrops, cities variously complicate, enable, disrupt, resist, and translate SU.

14.3.1 Critical Abilities and Knowledge

Unpacking 'smart' starts with the development of an overview of the key debates, players and practices involved in the development of SU strategies – inevitably developed through coalitions between municipalities, civic technologists and ICT companies. This requires placing particular attention on the urban implications of a multiplicity of 'coded objects' and 'coded infrastructures' (Kitchin, 2014), but also on the ways in which digital systems are 'un-black boxing' urban infrastructures (by, for example, creating new forms of infrastructural visibility and involving users in their functioning) and the parallel 're-black boxing' occuring through the digitalization of infrastructural processes via software, code and algorithms (Luque-Ayala and Marvin, 2016). The discussion around these implications goes beyond traditional academic subjects within the IT–urban interface, such as urban surveillance and the promise of real-time analytics, touching upon debates around the role of the smart city in an era of austerity, the ways by which data – rather than materiality – shape the city (Shepard, 2014), and the presence of mainstream as well as alternative ways in which smart urbanism is being implemented in cities, by communities and across infrastructural grids (Luque et al., 2014). New research abilities are likely to be required for critically unpacking the emerging broad trends within the field of SU, such as the role of social media in the constitution of smart cities, the emergence of digital mechanisms for the establishment of forms of accountability in urban service provision, the challenges associated with ensuring inclusivity and public trust within smart technologies, and the digital transformation of urban ecological flows (e.g. flows of energy, waste and water). Most importantly, it requires transcending a disciplinary understanding of the role of digital systems in the city, which, often framed by surveillance studies, limits its reading of the smart city to an extension of a Foucauldian panopticon. Rather, we argue that SU is governmental in nature (Luque-Ayala and Marvin, 2016). Operating through a productive and creative understanding of power, SU governs through the freedoms and capacities of the governed (Foucault, 2007) and 'regulate[s] freedom as contingency through the principle of economy' (Dillon, 2015, p. 48).

Inevitably, advancing a critical agenda around SU involves embracing the tensions between corporate perspectives and critical research on smart cities. Critical research perspectives have become focused on the claims being made by corporate smart city initiatives, in particular highlighting the rather narrow range of stakeholders involved, the focus on economic and market making as opposed to wider social or environmental priorities, the claims of transformation that would result from technological

applications, and the attempt to lock-in cities around selected proprietary technologies (Söderström et al., 2014; McNeill, 2016). Yet, representatives from the user and developer communities counter these views by arguing that, within the corporate sector, there is much more uncertainty about how smart urban technologies might be developed, what role they should play in corporate strategy and what their potential benefits and profitability are in an urban context. Rather than the smart agenda being closed and locked-in to a particular logic of development, there is a recognition of the need for a more experimental character, and companies involved in the 'rollout' of SU are still learning about whether it is possible to develop the urban sector as a viable market segment. These tensions point to how there is no wider societal (or research) context within which the uncertainties and risks associated with smart urbanism are being identified and discussed, and instead these are largely taking place separately inside the academy and corporates.

14.3.2 Politics of the Implementation of Smart

Understanding the politics of the implementation of SU requires exploring how the smart city is constituted discursively, techno-materially and spatially. Discursively, SU is constructed through the constitution of technology as an obligatory passage point (Söderström et al., 2014), and the development of a new moral order through technological parameters (Vanolo, 2013). It would be a mistake to assume that all SU discourses are the same. For example, the different rationalities underpinning SU (e.g. IBM versus Google) are likely to embed different approaches to the interface between 'smartness' and citizenship (McNeill, 2016; Gabrys, 2014), uncovering a differentiated politics of 'smart'. Spatially, SU is underpinned by a combination of decentralization and centralization, with the emergence of new nodes of control such as highly specialized control rooms (Gordon et al., 2013; Mattern, 2015; Luque-Ayala and Marvin, 2016). Here it is possible to identify the dominance of a particular representation of smart urbanism around future paths and promises. Such populist utopian scenarios are unhelpful, as they miss the socio-political dimensions of smart urbanism and overlook how these emerging narratives of the city are aligned towards particular techno-entrepreneurial interests (Hollands, 2015). Narratives around 'smart' are too often embedded within a universalizing neo-liberal project, subscribing to a language of efficiency, optimization, entrepreneurialism and growth. In practice, their 'rollout' is characterized by multiple trajectories, disparate alternatives and, at times, resistance. There is an underlying assumption that SU implies changing dynamics of power. Yet, based on our own research

interviews and conversations with practitioners, private corporate stakeholders involved in developing smart urbanism rather than speaking about promises manifest concerns about risks, uncertainties and the limited potential of alternatives. This evidences clear contradictions and tension in how smart technologies are being mobilized.

14.3.3 An Understanding of Smart Across Contrasting Geographies

Finally, a critical research agenda around SU demands exploring the different ways in which its rationalities, techniques and subjectivities are being rolled-out across contrasting geographies. This approach calls for a specific understanding of how smart logics configure space, discussing the broad ways in which SU projects relate to both urban form and social problematics (Wigg, 2014). But beyond such major interventions, it also suggests querying the intricate and minor ways in which SU shapes everyday life and constitutes unexceptional and quotidian spaces in the city (Shepard, 2014). Whilst notions of optimization and risk avoidance tend to play a key role in the rollout of SU, not all forms of SU respond to such drivers. SU technologies play a role in enabling digital connectivity and, through this, the development of a digital geography of the city (which ranges from Internet access to e-governance, amongst others). Community stakeholders often embrace SU for a variety of purposes beyond an incessant search for optimization and efficiency, including political resistance (as in the cases of Hong Kong and Taipei, described previously), the deployment of art installations that operate as digital monitoring devices for resource quality and consumption (Calvillo, 2012) and the appropriation and enjoyment of public space through digital gaming (Invisible Playground, 2014). At the same time, social media and apps may also misrepresent or hide the social geography of the city, a process that could have significant implications in hindering democracy and participation or in creating new forms of digital exclusion. Data flows in the smart city do not accurately reflect the social world. Instead, as exemplified in 2012 by how Twitter messages created the false assumption that Manhattan was the critical nexus of Hurricane Sandy, there 'are significant gaps, with little or no signal coming from particular communities' (Crawford, 2013, no pagination).

Such geographically orientated lines of research are of particular importance when considering SU as a global phenomenon. SU logics extend across the global North and South, yet, with limited exceptions (see Odendaal, 2006, 2016; Datta, 2016; Luque-Ayala and Marvin, 2016), there is a limited understanding of the different ways in which SU agendas are being rolled out in cities of the global South. Existing work on ICTs in the Global South already raises questions around the apparent fit

between development priorities and the smart agenda. In a South African context Odendaal (2006) has demonstrated the complex ways in which digital technologies have unexpected consequences that can also reinforce existing social disparities. The rollout of smart technologies may further exacerbate these tendencies associated with digital and mobile technologies. In more recent work on the early development of a program for 100 smart cities in India, Datta shows how the first mover city of Dholera exemplifies a new model of entrepreneurial urbanism with only a weak commitment to enhanced social justice (Datta, 2016).

14.4 CONCLUSIONS

This chapter has focused on a wider set of debates about the potential development and societal implications of smart urbanism. We have grouped these together within three particular sets of issues that deserve further inquiry through a critical research agenda: the development of ways of theorizing and conceptualizing SU; an examination of its normative nature and of the extent to which alternative understandings of the city can be developed through SU; and the advancement of a comparative approach around the multiple and varied practices around SU.

14.4.1 Conceptualize and Theorize

Rolling out SU is fundamentally a political exercise. Smart urbanism operates through strategic economic interests and everyday social practices to facilitate place specific ways for the control and regulation of increasingly fragmented cities and unequal societies. Central to understanding this project is the need to explore the creation of new 'smart' subjectivities conducive to the demands of the neo-liberal city. To unpack this political nature, an innovative set of theoretical frameworks is required, examining how knowledge and expertise on smart urbanism is constructed through specific contexts with a particular history and mediated through specific institutions and power relationships. Of particular relevance are approaches that can help analysing the interrelationships between software, data and digital technologies, socio-technical infrastructures, economic competiveness, ecological resources and flows as well as urban politics and social justice. The 'promises' of flexibility, control, growth, transformation and so forth offered by smart urbanism are reshaping current and future priorities of urban governments. An emerging set of detailed conceptual work is needed to illustrate how smart technologies – data collection and analysis, software packages and digital platforms,

sensors, digital networked infrastructures and new digital systems such as sophisticated control and pricing technologies – are used to more intensively unbundle and rebundle users, space, services and networks. Further conceptual and empirical work is needed to examine what political rationalities are embedded within such responses, and which stakeholders are excluded from the future 'smart city'.

14.4.2 Normative Alternatives

The second proposed line of inquiry calls for an exploration and interrogation of the purposes of smart urbanism through an engagement with its normative nature and the possibility of constructing alternatives. At first sight, an analysis of the differential logics of smart urbanism indicates the presence of 'dominant' ('top-down', formal or supply based) versus 'alternative' ('bottom-up', informal or demand-based) discourses and approaches. Dominant logics are characterized by a rather select and exclusive group of institutions, often more supply orientated, usually concerned with growth and economic priorities and more formal modes of social organization. But the future possibilities associated with these responses are uncertain and potentially transformative. The strategies of governing through smart citizenship are open, experimental and potentially modifiable – they can be refused or reversed by citizens and potentially redirected through new forms of urbanism. While corporate and municipal interests are fostering smart citizens who are constructed as subservient to individualized and marketized social relations, there are also other forms in which SU is being rolled out through a multiplicity of dispersed and disconnected initiatives under the guidance of communities, ad-hoc volunteer groups and local organizations. Examples of this abound, including the rise and fall of amateur Wi-Fi networks providing free Internet access (Powell, 2011), community organizations using big data 'to build an economy of information more open to civic intervention' (Couldry and Powell, 2014, p. 1), attempts to bypass traditional commercial digital connectivity through user generated fixed-line broadband (Middleton and Bryne, 2011) and the informal establishment of digital sensors in urban infrastructure towards civic uses (Shepard, 2014). Thus, alternative responses are characterized by a much more diverse and inclusive range of participants, often more user or demand focused, concerned with a wider set of social and environmental priorities and with more informal modes of social organization.

However, despite differences in who is involved and their priorities, an in-depth analysis reveals much closer similarities in the technologies, techniques (discursive and material), and rationalities underpinning both

dominant and alternative smart approaches. The distinction between these two categories is often subtle, as, in practice, the landscape of SU does not follow black and white logics. Rather, it is a case of 'middleware' – establishing an analogy with the IT concept for a type of software that connects while also acting *through* and *in-between* operating systems and applications; SU is about both bridging and co-constituting. In light of the presumptions built into smart software, it is worth asking whether there are significant differences between dominant and alternative approaches, given their use of similar technological platforms, working techniques and thinking rationalities. In practice, community involvement in SU shows that notions of 'top-down' and 'bottom-up' do not adequately reflect the complexity of issues at play. Rather than idealizing such alternative modes, critical research needs to examine the challenges associated with forms of SU from the bottom-up and the risks and opportunities of sustaining informal modes of SU, whilst interrogating the very computational rationalities giving rise to such alternatives.

14.4.3 A Comparative Approach

Furthering the development of an analytical framework for SU requires a wider discussion around the potential interactions and crossovers between contrasting SU logics across geographies. Most of the research discussed in this chapter took a specific view of one single domain of smart, focused either on individual case studies or specific approaches, often in significant depth. Work has not focused on the wider landscape of SU across locations and perspectives. There is a need to explore the contradictions of smart urbanism, its differential expression across the global North and South, and the potential this creates to develop more oppositional and contested forms of knowledge alongside the subjectivities that emerge from these contexts. As previously mentioned, while the dominant logic of SU tests and explores the creation of smart subjectivities in line with the demands of the neo-liberal city, this is a complex process that does not take place in linear manners. Neo-liberalism in practice is far from uniform in time and space and varies in its responses through hybrid formations that are conditioned by particular local contexts, geopolitics and existing urban trajectories. Consequently, an agenda around how these relationships might be understood is needed for a critical understanding of SU – for example, does the voluntary work of civic hackers and other civic technologists working alongside municipal governments worldwide provide an alternative context for experimentation and testing that might be upscaled and developed in formal approaches? Who is developing the capacity for wider societal learning about the implications of smart experimentation?

What sort of intermediaries could develop the capacity and knowledge for developing active and configurational transitions? A dialogue about the multiple ways in which SU is being imagined and enacted, taking place in different urban contexts and aiming for a systematic comparison of SU, would be a significant step in this direction.

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REFERENCES

Alawadhi, S., A. Aldama-Nalda, H. Chourabi, J. R. Gil-Garcia, S. Leung, S. Mellouli, T. Nam, T. A. Pardo, H. J. Scholl and S. Walker (2012), 'Building understanding of smart city initiatives', *Electronic Government*, **7443**, 40–53.

Bakıcı, T., E. Almirall and J. Wareham (2013), 'A smart city initiative: the case of Barcelona', *Journal of the Knowledge Economy*, **4** (2), 135–148.

Batty, M., K. W. Axhausen, G. Fosca, A. Pozdnoukhov, A. Bazzani, M. Wachowicz, G. Ouzounis and Y. Portugali (2012), 'Smart cities of the future', *The European Physical Journal Special Topics*, **214**, 481–518.

Boyer, M. C. (1992), 'The imaginary real world of cybercities', *Assemblage*, **18** (August), 115–127.

Braun, B. P. (2014), 'A new urban dispositif? Governing life in an age of climate change', *Environment and Planning D: Society and Space*, **32** (1), 49–64.

Bulkeley, H., V. Castán-Broto, M. Hodson and S. Marvin (2011), *Cities and Low Carbon Transitions*, New York: Routledge.

Calvillo, N. (2012), 'The affective mesh: air components 3D visualizations as a research and communication tool', *Parsons Journal for Information Mapping*, **4** (2), 1–8.

Caragliu, A., C. Del Bo and P. Nijkamp (2011), 'Smart cities in Europe', *Journal of Urban Technology*, **18** (2), 65–82.

Couldry, N. and A. Powell (2014), 'Big data from the bottom up', *Big Data & Society*, **1** (2), 1–5.

Cowan, D. (2014), *The Deadly Life of Logistics: Mapping Violence in Global Trade*, Minneapolis: University of Minnesota Press.

Crang, M. (2010), 'Cyberspace as the new public domain', in Caroline Wanjiku Kihato, Mejgan Massoumi, Blair A. Ruble, Pép Subirós and Allison M. Garland (eds), *Urban Diversity: Space, Culture and Inclusive Pluralism in Cities Worldwide*, Baltimore, MD: Johns Hopkins University Press, pp. 99–122.

Crang, M. and S. Graham (2007), 'Sentient cities: ambient intelligence and the politics of urban space', *Information, Communication & Society*, **10** (6), 789–817.

Crawford, K. (2013), 'The hidden biases in big data', at https://hbr.org/2013/04/the-hidden-biases-in-big-data/ (accessed 9 August 2018).
Datta, A. (2016), 'The smart entrepreneurial city: Dholera and 100 other utopias in India', in Simon Marvin, Andrés Luque-Ayala and Colin McFarlane (eds), *Smart Urbanism: Utopian Vision or False Dawn?*, Abingdon: Routledge, pp. 52–70.
Dillon, M. (2015), *Biopolitics of Security: A Political Analytic of Finitude*, Abingdon: Routledge.
EPRI (undated), 'Smart Grid Resource Center', at http://intelligrid.epri.com/contact.html (accessed 1 April 2014).
European Commission (undated), 'EU SET-Plan: Strategic Energy Technology Plan', at http://ec.europa.eu/research/energy/pdf/set-plan_en.pdf (accessed 1 April 2014).
European Commission (2012), 'European initiative on smart cities', at http://setis.ec.europa.eu/about-setis/technology-roadmap/european-initiative-on-smart-cities (accessed 9 August 2018).
Forlano, L. (2009), 'WiFi geographies: when code meets place', *The Information Society*, **25** (5), 344–352.
Foth, M. (2009), *Handbook of Research on Urban Informatics the Practice and Promise of the Real-Time City*, Hershey, PA: IGI Global.
Foucault, M. (2007), *Security, Territory, Population*, New York: Palgrave Macmillan.
Gabrys J. (2014), 'Programming environments: environmentality and citizen sensing in the smart city', *Environment and Planning D: Society and Space*, **32** (1), 30–48.
Galloway, A. (2004), 'Intimations of everyday life: ubiquitous computing and the city', *Cultural Studies*, **18** (2–3), 384–408.
Gandy, M. (2005), 'Cyborg urbanization: complexity and monstrosity in the contemporary city', *International Journal of Urban and Regional Research*, **29** (1), 26–49.
Gordon, R., B. Anderson, M. Crang and S. Marvin (2013), 'Control rooms and networked urban life', paper presented at Smart Urbanism – Utopian Vision or False Dawn? Workshop, 20–21 June 2013, Durham University.
Graham, S. (2002), 'Bridging urban digital divides? Urban polarisation and information and communications technologies (ICTs)', *Urban Studies*, **39** (1), 33–56.
Graham, S. and S. Marvin (1996), *Telecommunications and the City: Electronic Spaces, Physical Spaces*, London: Routledge.
Graham, S. and S. Marvin (2001), *Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition*, Abingdon: Routledge.
Greenfield, A. (2013), *Against the Smart City, Part I of The City is Here for You to Use*, New York: Do Projects.
Halpern, O., J. LeCavalier, N. Calvillo and W. Pietsch (2013), 'Test-bed urbanism', *Public Culture*, **25** (2), 272–306.
Harvey, D. (1997), 'The new urbanism and the communitarian trap', *Harvard Design Magazine*, **1** (3), 68–69.
Heynen, N., M. Kaika and E. Swyngedouw (eds) (2006), *In the Nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism*, Abingdon: Routledge.
Hodson, M. and S. Marvin (2010), 'Can cities shape socio-technical transitions and how would we know if they were?', *Research Policy*, **39** (4), 477–485.
Hollands, R. G. (2008), 'Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?', *City*, **12** (3), 303–320.
Hollands, R. G. (2015), 'Critical interventions into the corporate smart city', *Cambridge Journal of Regions, Economy and Society*, **8** (1), 61–77.
Hughes, T. P. (1983), *Networks of Power: Electrification in Western Society, 1880–1930*, Baltimore, MA: The Johns Hopkins University Press.
Invisible Playground (2014), 'About us', at http://www.invisibleplayground.com/en/about (accessed 9 August 2018).
Jamasb, T. and M. G. Pollitt (eds) (2011), *The Future of Electricity Demand: Customers, Citizens and Loads*, Cambridge: Cambridge University Press.
Kallinikos, J. (2007), *The Consequences of Information: Institutional Implications of*

Technological Change, Cheltenham, UK and Northampton, MA, USA: Edward Elgar Publishing.
Kanter, R.M. and S. Litow (2009), 'Informed and interconnected: a manifesto for smarter cities', Harvard Business School Working paper 09–141, at https://hbswk.hbs.edu/item/informed-and-interconnected-a-manifesto-for-smarter-cities (accessed 9 August 2018).
Kitchin R. (2014), 'The real-time city? Big data and smart urbanism', *GeoJournal*, **79** (1), 1–14.
Kitchin, R. and M. Dodge (2011), *Code/Space: Software and Everyday Life*, Cambridge, MA: The MIT Press.
Klauser, F. (2013), 'Through Foucault to a political geography of mediation in the information age', *Geographica Helvetica*, **68** (1), 95–104.
Klauser, F. and Albrechtslund A. (2014), 'From self-tracking to smart urban infrastructures: towards an interdisciplinary research agenda on Big Data', *Surveillance & Society*, **12** (2), 273–286.
Klauser, F., T. Paasche and O. Söderström (2014), 'Michel Foucault and the smart city: power dynamics inherent in contemporary governing through code', *Environment and Planning D*, **32** (5), 869–885.
Leydesdorff, L. and M. Deakin (2011), 'The triple-helix model of smart cities: a neo-evolutionary perspective', *Journal of Urban Technology*, **18** (2), 53–63.
Light, J. S. (2003), *From Warfare to Welfare: Defense Intellectuals and Urban Problems in Cold War America*, Baltimore, MA: The Johns Hopkins University Press.
Luque, A. (2014), 'The smart grid and the interface between energy, ICT and the city', in Tim Dixon, Malcolm Eames, Miriam Hunt and Simon Lannon (eds), *Urban Retrofitting for Sustainability: Mapping the Transition to 2050*, London: Earthscan, pp. 159–173.
Luque, A., C. McFarlane and S. Marvin (2014), 'Smart urbanism', in Mike Hodson and Simon Marvin (eds), *After Sustainable Cities?*, Abingdon: Routledge, pp. 74–90.
Luque-Ayala, A. and S. Marvin (2016), 'The maintenance of urban circulation: an operational logic of infrastructural control', *Environment and Planning D: Society and Space*, **34** (2), 191–208.
Mahiznan, A. (1999), 'Smart cities: the Singapore case', *Cities*, **16** (1), 13–18.
Map Kibera (undated), 'Putting marginalized communities on the map', at http://mapkibera.org (accessed 9 August 2018).
Marvin, S. and A. Luque-Ayala (2017), 'Urban operating systems: diagramming the city', *International Journal of Urban and Regional Research*, **41** (1), 84–104.
Mattern, S. (2015), 'Mission control: a history of the urban dashboard', *Places*, March, at: https://placesjournal.org/article/mission-control-a-history-of-the-urban-dashboard/ (accessed 9 August 2018).
McFarlane, C. and J. Rutherford (2008), 'Political infrastructures: governing and experiencing the fabric of the city', *International Journal of Urban and Regional Research*, **32** (2), 363–374.
McNeill, D. (2016), 'IBM and the visual formation of smart cities', in Simon Marvin, Andrés Luque-Ayala and Colin McFarlane (eds), *Smart Urbanism: Utopian Vision or False Dawn?*, London: Routledge, pp. 34–51.
Mejia, F., R. Glasberg, G. Tamm and G. J. Lopez (2011), 'Readiness level to adopt smart grid technologies: study for the city of Medellin', in *Conference on Innovative Smart Grid Technologies (ISGT Latin America)*, Medellin: IEEE PES, pp. 1–7.
Middleton, C. and A. Bryne (2011), 'An exploration of user-generated wireless broadband infrastructures in digital cities', *Telematics and Informatics*, **28** (3), 163–175.
Monstadt, J. (2009), 'Conceptualizing the political ecology of urban infrastructures: insights from technology and urban studies', *Environment and Planning A*, **41** (8), 1924–1942.
NEDO (2011), '2nd Annual GridWise Global Forum', at http://www.nedo.go.jp/english/whatsnew_20111116_index.html (accessed 9 August 2018).
Nye, D. E. (1999), *Consuming Power: A Social History of American Energies*, Cambridge, MA: The MIT Press.
Odendaal, N. (2006), 'Towards the digital city in South Africa: issues and constraints', *Journal of Urban Technology*, **13** (3), 29–48.

Odendaal, N. (2016), 'Getting smart about smart cities in Cape Town', in Simon Marvin, S., A. Luque-Ayala and C. McFarlane (eds), *Smart Urbanism: Utopian Vision or False Dawn?*, London: Routledge, pp. 71–87.
Powell, A. (2011), 'Metaphors, models and communicative spaces: designing local wireless infrastructure', *Canadian Journal of Communication*, **36** (1), 91–114.
Sandercock, L. (1998), *Towards Cosmopolis: Planning for Multicultural Cities*, New York: J. Wiley & Sons.
SENSEable City Lab (undated), 'Forage tracking', at http://senseable.mit.edu/foragetracking (accessed 9 August 2018).
Shepard, M. (2014), 'Beyond the smart city: everyday entanglements of technology and urban life', *Harvard Design Magazine*, **37**, 18–23.
SmartGrid.gov (undated), 'About SmartGrid.gov', at http://www.smartgrid.gov (accessed 9 August 2018).
Söderström, O., T. Paasche and F. Klauser (2014), 'Smart cities as corporate storytelling', *City*, **18** (3), 307–320.
Thrift, N. (2014a), 'The promise of urban informatics: some speculations', *Environment and Planning A*, **46** (6), 1263–1266.
Thrift, N. (2014b), 'The "sentient" city and what it may portend', *Big Data & Society*, **1** (April–June), 1–21.
Thrift, N. and S. French (2002), 'The automatic production of space', *Transactions of the Institute of British Geographers*, **27** (3), 309–335.
Townsend, A. M. (2013), *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*, New York: W.W. Norton & Company.
Vanolo, A. (2013), 'Smartmentality: the smart city as disciplinary strategy', *Urban Studies*, **51** (5), 883–898.
Wade, N. S., P. C. Taylor, P. D. Lang and P. R. Jones (2010), 'Evaluating the benefits of an electrical energy storage system in a future smart grid', *Energy Policy*, **38** (11), 7180–7188.
Wigg, A. G. (2014), *After the Smart City: Global Ambitions and Urban Policymaking in Philadelphia*, Philadelphia: Temple University.