

## **Real-ising the Virtual: Digital Simulation and the Politics of Future Making**

**Hannah Knox**

The plan to demolish Toxteth Street, a row of low-quality, dark, and cramped Victorian houses in the Openshaw area of East Manchester had been many years in the making. By 2009, the phased re-location of people, some of whom had lived on the street for 40 years was already well underway. Planners had worked hard to make sure that residents were fully cognisant of the urban regeneration process that they were a part of, an ambitious plan to transform some of the most deprived parts of Manchester into safer, more healthy and more sustainable communities.

The process of public consultation had proceeded for the main part along familiar lines – public meetings, brochures, newsletters and bulletins updating residents on the planning process had been used, whilst maps of the re-landscaped neighbourhood and documentation outlining the details of planning committees and public consultation events had been placed on notice boards screwed to the walls at the end of the street. In addition, the transformation of East Manchester had seen the introduction of a new tool into the consultation exercise. A digital model of the area had been brought in, which was to serve the purpose both of capturing a visual depiction of the street as it existed prior to demolition and of envisioning the neighbourhood as it would look after regeneration. In the course of various public consultation events, those being moved into new properties had had the opportunity to take a walk through a virtual rendering of their future neighbourhood and had looked inside the visualisations of the houses they were to move into. They had been encouraged to think about the decoration they would like, and where they would put their furniture in their new houses. Consultation with residents about the changes that they would be

experiencing had been both a matter of imparting information, and of ‘winning hearts and minds’, of allaying fears about the future by ‘giving people a vision’ that they could hold on to when familiar landmarks were demolished. The digital model was seen to have played an important part in making this process a success.

The use of a digital model during the public participation exercise of the Toxteth Street redevelopment was part of a broader excitement about the possibilities that such a model of the city of Manchester could hold for the transformation of the city. Since around 2000 there had been various interrelated attempts to generate a city model which would be developed by some kind of public-private partnership and would provide the residents, planners and developers of Manchester with a unique, innovative and current digital depiction of the city. Originally pursued by researchers at Salford University and championed by a few individuals at the city council, at the time when my research on the model began it had been taken on as a public facing project by the Manchester office of the design and consultancy firm ARUP Associates.

In recent years, processes of planned social change have increasingly come to centre around the question of participation (cf Barry 2001; Marres 2008). In development settings, participatory approaches have become a dominant mode of organising knowledge and enacting transformation, with the aim that multiple points of view can be collected and incorporated into planning decisions (Green 2003). Government policy is made through processes of consultation with different parties in the hope that incorporation of a variety of views will lead to better interventions (Mosse 2004), meanwhile scientists are being asked to make themselves accountable by improving communication with the general public in whose name they act (Wynne 2004). The method of participation has become the promised panacea to social problems which in

turn are reconceived as stemming from a lack of local knowledge and a failure to communicate.

It was in relation to the question of how to engage different people in development processes that the digital model was being developed in Manchester. Its supporters imagined that it would provide a new means of communicating more effectively between planning departments and citizens in projects like the Toxteth Street redevelopment. It was also hoped that it might be used to improve communication between disciplinary experts concerned with different aspects of urban transformation, and would be able to cross over the silos of disciplinary knowledge production by locating different knowledges in the same digital space. Moreover it was seen that the model would provide a means by which cities could engage more effectively with external pressures such as those posed from the environment, government legislation and unpredictable economic markets. Finally as a tool in a broader project of social engineering the model was imagined as a new, more effective and often un-contentious means of effecting 'behaviour change' amongst populations. In many respects the model appeared to be yet another example of a more generalised attempt to incorporate publics into decision making processes. At the same time, the anticipation, excitement and sometimes ambivalence shown towards this technological means of achieving these ends was noteworthy. There was deemed to be something about the digital model which differed from previous means of interfacing between experts and their publics in the ways described above.

The purpose of this chapter is to explore the ways in which the digital model was thus being mobilised as a novel means of interfacing between experts and publics. In what follows I pay particular attention to the relational commitments of the digital model itself. Recent work on digital media has begun to suggest that new information

collation and interrogation techniques are having the effect of reorganizing relations between subjects, objects and information (see Savage *et al.* 2010). As I follow the ways in which the digital model of Manchester draws upon and extends the possibilities afforded by emerging techniques of data organization and interrogation, I look at some of the intended and unintended effects of this work, and in doing so point to some of the political implications of the model as a contemporary means through which a certain form of participatory politics is being enacted.

### **The Model as Interface**

During the course of my research on the digital model, its developers were in discussion with an astonishing range of potential users. Meetings were held with the principle of a new school who wished to generate a model to market the school to future pupils, with the developer of a new healthcare facility who needed to visualise the re-design of hospital wards, with the manager of the visitor centre at the Manchester City Football Stadium, with a radical artist based in London, another art group based in China, with property developers, architects, and academics working in departments of engineering and urban regeneration. Indeed my own involvement in the digital model came as part of an experimental collaborative exercise which aimed to explore the mutual benefits of a conversation between engineers and anthropologists for understanding the persuasive effects of digital models in public consultation exercises.

One of the key intended beneficiaries at the time of research was Manchester City Council. Much emphasis was placed by the engineers developing the model on the need to argue the case for why the digital model could be of use to the city council, not least because it was envisaged that at some point in the future, the core of the city model would be transferred over to the council who were its primary intended recipients. ARUP Manchester, who were developing the model saw it primarily as a research and development tool. No other cities were known to have successfully developed a complete digital model which mapped the urban environment using the engineering techniques that the Manchester model had used. In this sense the project to model Manchester was an experiment oriented towards the exploration of new technological possibilities and their imagined social effects<sup>1</sup>. The resulting model that would be the outcome of these experiments was both a potential blueprint that could be used for other city models, and a useful and functioning tool that could be used within Manchester to assist in its future development.

Given the experimental nature of the project, even the uses to which the model might be put within the council were not fixed. However there were particular uses that were seen as more likely than others. For example, the engineers developing the model were excited at the potential that the model held for assisting the council in responding to external pressures associated with a need to reduce their carbon emissions in line with the UK target of a 50% reduction by 2050. In a key meeting with the city council, the engineers demonstrated how the model might become a key resource in collating and re-presenting already existing data on the energy efficiency of council owned buildings. They showed how the data analysis and scenario modelling capabilities of the model could provide a series of suggested interventions

and modifications to buildings, based on different calculations of relative cost vs. relative reduction in carbon emissions.

The people working at the council who were at the meeting were not easily convinced. The convenor of the meeting who was a champion of the model within the council, explained to me later that people working at the council had been through several recent changes to information systems and were sceptical of the benefits of introducing yet another new system into the workplace. They were concerned about the cost of transferring data into the model, and unsure of the benefits that they would be able to get out of it.

In turn, the engineers who had designed the model were frustrated at this attitude. They saw in this response a misunderstanding amongst council employees that this was simply another IT system. For the engineers it was something radically different. Its difference lay in its capacity to draw together the disparate knowledges and data sources existing at the council and to put them together into a single system<sup>ii</sup>. Whilst they acknowledged that work would need to be done to make these data compatible, the potential of the new relations that would be produced between previously siloed databases truly excited them<sup>iii</sup>.

This work of translating the benefits of the model was an issue to a greater or lesser extent in each of the meetings that I attended. Another meeting, this time with the head of the visitor centre at the City of Manchester stadium, revolved around a quite different use for the model – not of data analysis but of providing visitors to the stadium site with an affectively charged interaction with the stadium site. The City of Manchester Stadium sits at the heart of the regeneration area of East Manchester, and dominates the landscape. Located on the site of former Bradford Colliery and

Brickworks, the space was cleared and the stadium built for the 2002 Commonwealth Games. As well as including the stadium which is now home to Manchester City Football club, the site also houses a velodrome, a training football pitch and acres of car parking space. The whole area is known by developers as 'Sport City'.

Sport City has become something of a draw for visitors. As home to Manchester City Football Club it is a mecca for the international fan base, and as a former site of the commonwealth games it attracts its fair share of delegates responsible for other large sporting events. As the heart of the regeneration area of East Manchester it attracts people involved in projects of regeneration, meanwhile other visitors include potential users of the site, for example organizers of pop concerts, circuses and other large public events. Yet the head of the visitor centre explained that he faces a problem when people come to visit the site. Coming with an expectation that being at the site will confer the excitement of a football match, the value-creation effects of a sports legacy program, or the social benefits of urban regeneration, what visitors are more usually faced with is a bleak expanse of empty car-parking space. Hanging baskets of flowers on the lamposts around the stadium attempt to inject some colour and life into the otherwise quiet and uninviting scene, but it is hard to impart to visitors the potential effects that the stadium is able to produce. Here, the model of the city was discussed as a means of re-connecting visitors with the affective potential of the stadium. How could it help connect people with the aroma of hot-dog stands and the hubbub of pre-match anticipation? How might it capture the histories of the site and impart the stories of local people who had benefited from its construction to interested visitors? How might it transmit the lights and music of a rock concert, or the whoosh of racing bicycles?

How indeed? Whilst the chief engineer was sure this must be possible and was enthusiastic about the possibilities of trying to manipulate the model to these ends, talk of video clips and sound recordings, quotes from residents and photographs failed to produce the same kind of enthusiasm that we saw from the engineers in the city council meeting. Here, in contrast, the passion of the potential user of the model was met with the ambivalence of the engineer. Thinking on his feet, the engineer came up with an idea himself that he thought might be possible – perhaps they could use the model to provide a way of allowing people to see what seat they had chosen and to see the view from that seat?

In both the discussion at the city council, and in the discussion with the visitor centre manager, the assumed potential of the model as interface was questioned and re-framed by the engineers who were building it. Firstly, as we have seen, the city council employees were deemed to have misunderstood the model as merely another IT system. As an interface it had been misinterpreted as a bounded tool which would mediate a pre-specified set of relations – between the finance and the planning department for example, or between people working within environmental services. In contrast the engineers saw the model as an inherently flexible resource whose power to transform came from its capacity to incorporate an as yet undefined multiplicity of data from a variety of sources which could be put into relation in previously unanticipated ways. In the second instance, the model was imagined as a tool for conjuring an affective relationship with a particular space. The interfacing capacity of the model was assumed by the visitor centre manager to lie in its ability to generate a virtual visual world, which could draw people out of the mundanity of the everyday and into the spectacle of the event. Whilst the engineer designing the model certainly did not contest its capacity to persuade and enchant through techniques of



visual representation, the suggestion of using video clips or interview quotes was superseded by the possibility of accurately locating one's place within the model.

These examples provided in this section suggest that there was something particular about the promise of the model as a new kind of digital technology which differentiated it from other previously available means of presenting and analysing information. The apparently infinitely extendable list of people who might find the model useful, itself implied an unusual mutability to this interface object which could turn its hand to any manner of interventionist projects. At the same time the extendability of the model revealed its limits in the misunderstandings and difficulties of mutual enthusiasm encountered in these meetings. To understand the basis of the promise of the model to provide a flexible and mutable new form of communication, and the politics of its limits, I turn my our attention in the following section to the relations that were built into its design.

### **Building The Model**

The digital model of Manchester is based on data collected by LiDAR, an aerial laser scanning technology which has been used to generate a topographic map of the whole of the city of Manchester. The LiDAR technique allows for a relief map to be constructed of all of the architectural and geographic features of the city landscape which are translated into a block model. This block model is linked to map data provided by Ordnance Survey (see Harvey 2009 for a more detailed account of this process) in order to fix the coordinates of the LiDAR data in geographical space. This

provides the basic structure for the city model onto which other data can be applied. Photographic data is linked into the block model through the technique of photogrammetry which correlates points on a photograph with points on the model, allowing buildings to be provided with a basic level of photographic detail. Further to this, more detail can be added in at later stages into the model – recently, for example, the developers have been working on improving the modelling of vegetation and foliage.

Before the development of the city-wide model, digital models of architectural features within Manchester did already exist but they were self-contained representations of particular buildings and spaces which tended to be discarded after the building had been constructed. The vision of the city-wide digital model was to replace this ad-hoc act of virtual construction with a technology that would incorporate all the single models built for individual projects, and would evolve with the changing city.

The dream of a continually evolving model of the city had a precursor in the form of a material model of the city, which now sits as a historical curiosity in the offices of ARUP Manchester. During the period of its use, this physical model was updated regularly by craft-workers who would remove demolished buildings and add new structures as they appeared. Like the digital model, the physical model mapped landscape and space from a birds-eye view of the city, providing an overview of the space from the privileged vantage point of an omniscient observer<sup>iv</sup>. However unlike the digital model, the scale at which the city was represented and the form of the representation was singular and fixed.

In contrast, the digital model of Manchester uses the geographical data provided by LiDAR and Ordnance Survey to organize sets of information at different levels of detail. This allows the user to move apparently seamlessly from a view of the whole city down to the level of the street and even inside some of the buildings. Whilst the experience of the user is one of greater and greater levels of magnification, the effect is in fact produced by a clever conjuring trick which substitutes different sets of data at different scales. Whilst with the physical model the act of moving closer to gain more knowledge actually reduces rather than improves our understanding of the object represented, drawing us into the object-like qualities of the representation itself – the grain of the wooden office blocks, the wire of the architectural trees, and the brush strokes on the painted roads – the substitution of data in the digital model allows for infinitely finer levels of detail to be experienced by a single user from the vantage point of a single screen.

The effect of moving across different scales is just one example of the way in which the digital model promises to incorporate and connect up multiple data sources, capturing and encapsulating them into a geographic and analytic tool. Anything that can be numerically measured or spatially plotted is thus potentially available for incorporation into the Manchester model. The team building the model includes not only engineers and programmers but acousticians, geologists, transport planners and all manner of other expert producers of data whose informational outputs are linked into the geographical data that lies at the heart of the model.

The flexibility of the model derives then, from its ambition to incorporate without limit all manner of informational data collated from any number of different sources. This ambition is intimately linked to the proliferation of data-producing technologies – from mobile phones which provide location data on users, to smart electricity

meters to the transactional data produced by online purchases, store loyalty cards and credit cards. In this respect, the digital model of Manchester can be seen as part of a broader development of technologies of data collation and analysis which are committed to the analytic and communicative potential of 'total data'.

### **The Politics of Data**

Recent developments in digital data collation have begun to be explored by a number of scholars who have become interested in the political claims made for these techniques and the social and cultural implications of their use (Thrift 2007; Amoore 2009; Knox *et al.* 2010; Savage *et al.* 2010; Ruppert 2011). Much has been made by developers and potential users of these technologies of the analytic potential of 'total data' to provide new ways of tackling long-running political and economic issues as diverse as international terrorism and consumer behaviour. According to these literatures, a key claim made on behalf of these techniques is that they offer a move away from prejudicial forms of data analysis based on a-priori categorisation of social 'types', to an inductive mode of analysis where transactional data provides a benign basis out of which patterns of behaviour can be revealed (Dodge and Kitchin 2005)<sup>v</sup>. Amoore (2009), for example, quotes US Secretary of Homeland Security Michael Chertoff to illustrate these claims as they appear in relation to border security practices,

We use this data to focus on behaviour, not race and ethnicity. In fact, what it allows us to do is move beyond crude profiling based on prejudice and look at conduct and communication and actual behaviour as a way of determining who we need to take a closer look at. (quoted in Amoore 2009:17)

Amoore warns against acceptance of the notion that calculated projections such as this are apolitical, arguing that in the context of border security, these techniques ‘simply redraw the lines between those with entitlement (to visa, to cross a border, to be in a public place without disclosure of purpose) and those without’ (Amoore 2009:18). In this respect, these techniques do not erase the politics of classification but rather relegate them into an underspecified realm of action that lies outside the control of the data analysts.

Ruppert (2011) has also suggested that greater attention needs to be paid to the ways in which transactional data operate as tools of governance. Whilst initial concerns voiced about these technologies focused on questions of privacy and surveillance (e.g. Graham and Wood 2003; Andrejevic 2009), Ruppert argues that we need to be sensitive to the equally powerful role that they play in not only revealing, but constituting populations as subjects. Population metrics provide data which ‘identify and categorise populations of “benefits thieves”, tax dodgers, patients at risk of re-hospitalisation, security risks or frequent migrants’ (Ruppert, 2011:222). Moreover, through a focus on transactions rather than responses to survey questions, population metrics appear to be transforming the ways in which populations are enacted from an ‘interactive’ to what Ruppert calls ‘interpassive’ form of participation. In contrast to survey methods which aim to elicit the thoughts, interpretations or opinions of populations, transactional data privileges the patterns which are detectable in daily practices of purchasing, form filling and communicating, producing an outcome which is more ‘empirical and descriptive, rather than subjective and meaningful’ (Ruppert, 2011:228). To what extent, then, were these informational dynamics at play in the Manchester model?

One idea being proposed during the period of my research was that the model of Manchester could be used to monitor the carbon consumption of different businesses. A suggestion was being mooted at the time of my research that energy use of particular companies could be displayed in real-time on screens outside the building with the intention that simply the display of relative consumption of power would create a competitive environment which would encourage people to turn off lights, switch computers off at night and turn down thermostats. Here the question of how to intervene in the social was cast not as a project of social control or even discipline, but was being reconceived in line with other data collation techniques as a knowledge-based form of intervention. The question of how to intervene successfully focused on how to capture accurate information (empirics) and how to design appropriate techniques of display (description).

By acknowledging the political effects of the model to lie not in an underlying logic of control but rather in the functional project of capturing and displaying information, we can extend our understanding of the way in which the model operated as an interface object. It was in the very process of data collection and the decisions over appropriate forms of display, that the terms within which the city and its residents were expected to conceive of themselves and their concerns were reconceived. Far from operating as a simple form of translation or mediation between different political concerns, the processes through which the model was constantly brought into being was generative of questions and debate, in both predictable and unexpected ways.

As an interface object we have seen how the model was envisaged firstly as a way of *displaying* all manner of information that had been collated from a range of different

sources. Yet the practice of display itself was fraught with all kinds of interpretative difficulties that the engineers had not predicted. Despite its accuracy the computer imagery was sometimes deemed unrealistic and much to the frustration of the modellers, consulted publics were more convinced by the ‘reality’ of an artists drawing than by the digital representation of a future architectural feature. In contrast, during the Toxteth Street redevelopment the model appeared to exceed its role as descriptor of a possible future. It ending up being so convincing that the developers had to mitigate its effects by telling residents not to place too much hope that the actual redevelopment would look the same as the digital model.

The ambition of the model to provide an inductive method of *revealing* hitherto unknown connections, correlations and relationships derived from its interconnective and layering capacities. The hope was that the re-description of total data through patterns of association would produce generative forms of relationality. However, one unforeseen effect of the display of available data was the inadvertant revelation of gaps in the data. The model of East Manchester for example was striking for the unevenness in the depiction of space. Most of the area was described only through the basic block modelling produced by the LiDAR technology, which gave the effect of a uniform grey landscape. This was occasionally interspersed with areas of much more detail, such as Sport City and Toxteth Street. Inadvertantly the representational unevenness of the city model told a story of the geography of investment in urban regeneration and the politics through which the model had itself been produced. It also provided the basis for the future direction that the development of the model might take; the appearance of gaps in the model produced awareness of places where new uses for the model could be proposed or developed. As an interface object, the

model therefore not only provided the means for data analysts to reveal new relationships between datasets, but through the inadvertant revelation of gaps in the data it generated a ‘virtual’ space out of which new social and political relations would necessarily be formed.

Finally, the emergent nature of the model meant that the changes in ‘behaviour’ induced by the model would necessarily be re-incorporated into its calculations. This allowed it to constantly be re-established as a *recursive* technology of public engagement (Kelty 2008). The model was not a static instrument of data display but a mutating technique through which residents of the city were expected to be reconstituted as they simultaneously remade the object of their subjectification.

Unlike other methods of participatory planning (Green 2010), this technique did not so much rely on the incorporation of the opinions and culturally specific perspectives of stakeholders into the development process. Rather, the public appeared in the model on the one hand as inadvertant producers of data and on the other as navigators of the digital terrain which they were confronted with. Savage *et al.* (2010) have recently suggested that one of the effects of digital technologies is to displace the expertise that was previously associated with the governance of populations, ‘Publics are now enacted and enabled to intervene actively by making up their own devices as well as by contributing to the dominance of particular devices through their mass take up’ (Savage *et al.* 2010:9). In the case of Manchester’s digital model however, I suggest that the recursivity of these data-driven techniques, far from displacing the role of expertise is instead re-organizing it in new ways. The centrality of a data-driven model of intervention may disavow planning expertise based on the teachings of twentieth century sociology (Savage and Burrows 2007), but in its place it appears



to be valuing another kind of expertise oriented towards the capture and presentation of data. Finding themselves with a key role to play in this activity, it is perhaps unsurprising that engineers have begun to claim for themselves the new title of ‘information masterbuilder’ (Kolarevic 2003).

## **Conclusion**

Some time after residents living on Toxteth Street had walked their way around a digital model of their new neighbourhood, been encouraged to virtually inhabit their new homes and to imagine what their future lives might be like, a compulsory purchase order was served on their homes. Materially the model might thus appear to have been a cynical detour, a distraction from the ‘real’ politics which decides who lives where and for what purpose transformations in peoples lives are deemed necessary. However I have suggested in this chapter that if we are to understand the politics of public participation, we need to distance ourselves from the assumption that we already know the relational basis upon which politics is conducted. To this end, I have focused on various ways in which the Manchester model produced its interfacing effects.

Whilst computer technologies are often labelled as ‘interfaces’ my interest in the digital model as interface has required moving away from the assumption that we already understand the relations that the interface implies. In computing terminology the ‘interface’ is a term which is usually taken to mean the capacity of the screen to translate between the technology of circuit boards and electrical pulses as contained within the computer casing on the one hand, and the sociality of the human user, eyes

glued, fingers poised, looking at and interpreting the images on the screen on the other (e.g. Turkle 1997). In contrast I have approached the digital model by asking what relational commitments it entails and how these might help us understand the way in which it is being mobilised as an alternative means of participatory politics. Focusing on both the internal relations built into the model and its appearance within a broader project of social transformation I have explored the multiple ways in which the model operates as an interface object. This has allowed us to observe a restructuring of the relationship between humans and machines, and between experts and publics, as digital data is made to stand in for the decision-making capacities of either planners or those who are asked to participate in processes of urban transformation. At the same time, the promise of total data produces unexpected effects for both the producers and users of the interface object. In this way, techniques of data organization and presentation like Manchester's digital model appear to be producing new objects of contestation and negotiation and in new ways revealing the politics of urban transformation.

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<sup>i</sup> See Marres (2009) for a discussion of experimentation as a contemporary mode of public participation.

<sup>ii</sup> Nonetheless there are distinct similarities between the claims made for this model and those made for other business information technologies such as enterprise resource planning (ERP) systems, see for example Kallinikos (2004) and Pollock and Cornford (2004).

<sup>iii</sup> For a comparable example of the technological integration see (Green *et al.* 2005)

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<sup>iv</sup> Recall Michel De Certeau's reflections on the ecstatic pleasure of experiencing the city from the top of the world trade centre,

It transforms the bewitching world by which one was 'possessed' into a text that lies before one's eyes. It allows one to read it, to be a solar Eye, looking down like a god. The exaltation of a scopic and gnostic drive: the fiction of knowledge is related to this lust to be a viewpoint and nothing more. (de Certeau 1984:92)

<sup>v</sup> The interest in new forms of data collation and analysis has been paralleled by a reawakening of interest in the French sociologist Gabriel Tarde, and his alternative theory of the social which appears to preempt the social logic of information systems based on a notion of 'total data' (see Barry and Thrift 2007 and Latour 2010).

## References

- Amoore, L. (2009) 'Lines of sight: on the visualization of unknown futures', *Citizenship Studies*, 13(1): 17-30
- Andrejevic, M. (2009) 'Control over personal information in the database era', *Surveillance and Society*, 6(3): 322-26
- Barry, A. (2001) *Political Machines : Governing a Technological Society*, London and New York: Athlone Press.
- Barry, A. and Thrift, N. (2007) 'Gabriel Tarde: imitation, invention and economy', *Economy and Society*, 36(4): 509-525
- de Certeau, M. (1984) *The Practice of Everyday Life*, Berkeley and London: University of California Press.
- Dodge, M. and Kitchin, R. (2005) 'Codes of life: identification codes and the machine-readable world', *Environment and Planning D*, 23: 851-882
- Graham, S. and Wood, D. (2003) 'Digitizing Surveillance: Categorization, Space, Inequality', *Critical Social Policy*, 23(2): 227-248
- Green, M. (2003) 'Globalising development: policy franchising through participatory project management in "non-places"', *Critique of Anthropology*, 23(2): 123-143
- Green, M. (2010) 'Making development agents: participation as boundary object in international development', *Journal of Development Studies*, 46(7): 1240-1263
- Green, S., Harvey, P. and Knox, H. (2005) 'Scales of place and networks: an ethnography of the imperative to connect through information and communications technologies', *Current Anthropology*, 46(5): 805-826

- Harvey, P. 2009. 'Between Narrative and Number: The Case of Arup's 3d Digital City Model', *Cultural Sociology*, 3(2): 257-276
- Kallinikos, J. 2004. 'Deconstructing Information Packages: Organizational and Behavioural Implications of Erp Systems', *Information Technology & People*, 17(1): 8-30
- Kelty, C. M. (2008) *Two Bits : The Cultural Significance of Free Software*, Durham: Duke University Press.
- Knox, H., O'Doherty, D., Vurdubakis, T. and Westrup, C. (2010) 'The devil and customer relationship management', *Journal of Cultural Economy*, 3(3): 339-359
- Kolarevic, B. (2003) *Architecture in the Digital Age: Design and Manufacturing*, London: Spon.
- Latour, B. (2010) Tarde's idea of quantification' in *The Social after Gabriel Tarde: Debates and Assessments*, Candea, M. (ed.) London: Routledge.
- Marres, N. (2008) 'The making of climate publics: eco-homes as material devices of publicity', *Scandinavian Journal of Social Theory*, 16: 27-46
- Marres, N. (2009) 'Testing powers of engagement: green living experiments, the ontological turn and the undoability of involvement', *European Journal of Social Theory*, 12: 117-134
- Mosse, D. (2004) *Cultivating Development : An Ethnography of Aid Policy and Practice*, London: Pluto.
- Pollock, N. and Cornford, J. (2004) 'Erp Systems and the university as a "unique" organisation', *Information Technology & People*, 17(1): 31-52

- Ruppert, E. (2011) 'Population objects: interpassive subjects', *Sociology*, 45(2)
- Savage, M. and Burrows, R. (2007) 'The coming crisis of empirical Sociology', *Sociology*, 41: 885-900
- Savage, M., Ruppert, E. and Law, J. (2010) 'Digital devices: nine theses' *CRESC working paper series*, Manchester: University of Manchester
- Thrift, N. J. (2007) *Non-Representational Theory: Space, Politics, Affect*, London and New York, NY: Routledge.
- Turkle, S. (1997) *Life on the Screen: Identity in the Age of the Internet*, London: Phoenix 1997.
- Wynne, B. (2006) 'Public engagement as a means of restoring public trust in science - hitting the notes, but missing the music?' *Community Genetics*, 9(3): 211-220.