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Editorial

B Urban Analytics and City Science

Causality in urban development

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At the beginning of his book, *A Brief History of Time*, Stephen Hawking (1988: 6) says: 'If everything in the universe depends on everything else in a fundamental way, it might be impossible to get close to a full solution by investigating parts of the problem in isolation'. Although this has long been recognized in the human sciences despite the fact that many aspire to develop theories that attempt to explain the loops of causality that tie everything together, most of our models break into these loops by adopting certain basic assumptions which are, for the purposes of analysis, excluded from subsequent explanation and provide the origins for the causal logic that subsequently evolves. In short, our models usually assume a starting point where certain conditions are assumed to be 'true' and which are used to drive the explanation that depends on various chains of logic that stem from these assumed causes. Initially how good the model is thus depends on how convincing these assumptions are to those who have adopted them and indeed to those who use the model in making conditional predictions, conditional of course on the assumptions being correct, 'true'.

In city systems, these origin assumptions are something of a rite-of-passage, often remaining implicit, rarely questioned, but absolutely central to the subsequent explanation that enfolds. Yet, over the last century, these origins have changed somewhat. Strong theories pertaining to how activities located themselves in cities emerged in the early 20th century following the path of the German location theorists while various macro-economic theories of how certain industrial activities were linked to one other in terms of the way production and consumption took place, came to dominate economic policy making, particularly following the Great Depression which began in the late 1920s and only ended when the more advanced industrial economies began to prepare for war. The logic in all this thinking was that basic industries drive the economy and that such industries could only be explained in terms of the natural disposition and location of resources such as fossil fuels. In short, as these kinds of basic resources drove the economy, if the industries that depended upon them went into decline through a fall in demand, the logic was to relocate and reinvigorate those industries by explicit government policy. The basis of macro-economic policy in the US and UK was for government to provide this kind of stimulus on the assumption that demand would recover, even to the point where government itself might stimulate that demand in association with the revival of the industries in question. This was the logic behind the provision of government-funded industrial parks and trading estates in the 1930s which became the physical face of the New Deal and Keynesian-inspired economic policies.

The notion that one might stimulate demand by priming-the-pump so-to-speak – adding new industrial capacity into the economy – was largely adopted as the basis of economic policy making until the 1970s. In fact, in the post war years, western economies were strong

enough to generate their own increasing demand and the idea grew that successful wealth developed spontaneously with little government intervention. But the idea that basic industries, particularly those that traded with other industries and markets in other places, were fundamental, remained the driving force for urban development. Many of our theories and models were based on such arguments in which the economy was divided into those downstream activities which depended upon more basic, upstream activities – for example, services depending upon how profitable manufacturing for export was locally – where it was assumed that the upstream activities were those that might be subject to government intervention if they were to fall into decline, thus bolstering and protecting downstream activities. In fact, many of the early land use transportation models that we have written about many times in these editorials were largely structured around this distinction between basic – pump-priming activities – and less basic or non-basic activities that depended intrinsically on the size and quality of those basic industries that were assumed to drive the local economy.

To divide the world in this way depends on the relevance of a logic that we can conceive of the economy in this unidirectional causal way, basic industries generating non-basic. In fact, it is well known that such a division – notwithstanding the problems of making the division in the first place – is not stable over time. Traditional resources and manufacturing industries have massively declined with respect to employment over the last century while services have increased dramatically with many places now being much more dependent on services where manufacturing industries hardly exist. This on-going transition is largely due to technological innovations and increasing wealth as well as massive automation of more routine processes in manufacturing industries. There is another, even more pertinent reason why we can no longer divide the world in this way. Over the last 50 years, the world has moved from a focus on direct interventions to spur economic growth and revitalisation to much more implicit policies that attempt to stimulate growth in more indirect ways. The notion of creating an innovative culture in which new industries will grow spontaneously has overtaken the notion of direct economic stimulus. In fact, governments still occasionally support ailing manufacturing industries but so much of manufacturing has been automated, that the economic impact on employment is much lower than it was and in many western cities, the dominant industries are now services. The economy has transitioned from one with a focus on large primary industries in the early 19th century to one based on manufacturing in the late 19th and early 20th centuries to one which is now based on services. This transition now makes nonsense of the notion of dividing the economy into the traditional binary distinction of basic and non-basic. One hundred years ago, the division in this way made some sense, notwithstanding that there was considerable debate even then over the separation and the assumption that basic led to non-basic but not vice versa. Today the direction of causality would appear to be the other way around, thus demonstrating our longstanding dilemma of developing appropriate and useful theory.

In terms of the urban models that we built a generation of more ago, all knew that the quest to try and collapse everything into a form where every possible causal loop was replicated was an impossibility. Even if one could articulate the urban economy as a consistent set of relations where everything was linked to everything else, directly or indirectly, the notion that one had to simplify and abstract meant that partial models were the ultimate focus: that is models that made many assumptions and which were designed to make conditional predictions which came to be known as 'What If?' scenarios. In particular, the notion that the most complex bits of the cities might be defined and predicted exogenously to the models and the more obvious links specified as predictive relations, came to dominate

the field. In land use transportation interaction modelling, employment was always assumed to be much more complex to model than population. This was largely because populations were composed of individuals whose routine behaviours appeared a lot more predictable than the rather lumpy, somewhat disjoint way in which employment was characterised as firms, agencies, institutions and so on whose behaviour could not by any stretch of the imagination be said to be generalizable or predictable in the same way. Transport infrastructures too were seen to be components of the urban system that could not be easily predicted in terms of their location and in terms of scenarios for the future city, these were often taken as given. In short, the models that were developed were rather restricted in their focus, meaning that many important impacts could not be easily derived from their predictions, and were required to be specified using other means, often through intuition dressed up as common sense.

The previous generation of land use models were thus quite limited in their abilities to forecast. It was widely regarded that housing and population with respect to their locations were largely linked to where people worked and the transportation that was available to move people around to satisfy the many service functions that were required for cities to function. In fact, when it came to housing, much of the explanation of the way housing was located was due to the nature of the development process which, like the location of employment, was often entirely dependent on a limited number of firms and agencies. Moreover, the economic rationale for location was not simply a function of transportation costs and land availability but the complex nature of the housing market, the wider urban economy, the role of ethnic divisions and a host of other factors judged to be important to predicting locations where populations were likely to reside. Aging of population, preferences for amenities of various sorts, access to health care, and more particularly to quality education, were all factors that can and do influence residential location. In short, many of our explanations and predictive models have been based on simulating the demand for activities – housing and services – while the supply of these same facilities as well as most economic activities has been much harder, often impossible to simulate.

The dilemma however is that much of what we wish to predict is supply rather than demand-orientated. However, our models are still largely geared to predicting demand with supply being fixed exogenously but much of our concern is for changes in supply. We have slowly realised that employment and housing are immensely difficult to predict largely because demand is so differently configured and represented than its supply, and for a long time it has been assumed that transportation is something that cannot be easily predicted. Our models thus make assumptions about future transportation. However, even for transport activities, there is a realisation that their supply is being influenced by subtle changes in individual preferences and our assumption that all we need to do is to specify new transportation activities and then figure out their impacts is increasingly problematic. During the last 50 years or so, there has thus been a sea change in what we consider we are able to predict, with most activities now being regarded as difficult to predict and most activities being considered to be predictable only through a complex mix of endogenous and exogenous factors. This realisation is one which has meant a retreat from prediction in the face of increasing complexity. Hawking (1988) is quite right when he says that we can never get to a complete solution by investigating the parts of the system in isolation from one another, especially as everything connects to everything else in an ever more convoluted logic. The problem with cities is that as we learn more about them, this conundrum seems ever more important.

One of the key problems dominating urban planning in the UK at present is to assess the impact of large new infrastructure projects particularly those relating to transportation. In the past, many of these were set within the wider ambit of strategic planning but currently proposals for new high speed rail and airport expansion, for example, are not embedded in any wider context. The question then becomes: 'What is the impact of these transportation proposals on the wide economy and community?' whereas in the past, we simply accepted these proposals exogenously as being the drivers of impact. It is not that we were able to assess their impact in the past any better than now but that now, we are asking questions as to how these new proposals are impacting on everything else, particularly housing and employment. Moreover, there are some schemes such as the urban development proposal for the Oxford-Milton-Keynes-Cambridge corridor that require not only the impact of new rail and road routes to be assessed but also the impact of many thousands of new houses. The key question has become: 'How can one evaluate the economic impact of these kinds of proposal?'. In other words, our exogenous variables have become endogenous and what we accepted as assumptions in the past are now regarded as the very attributes that we wish to predict.

This kind of dilemma has been recognised by many agencies that are tasked with exploring such impacts. For example, the Department of Transport in the UK is speculating out loud about new ways of extending the standard transport models and its well established investment appraisal methodology with a view to developing much more appropriate models (Department for Transport, 2018). The key question of importance is to figure out how large transport proposals impact on the economy, in particular in attracting industry and employment-related activities: in particular, answering the question: 'Will the new planned high speed rail line between London and Manchester via Birmingham (HS2) generate sufficient economic activity (and at which locations) to make the project feasible with respect to increasing job opportunities and economic prosperity?' To an extent, we know that the answers to questions like this are not really possible with any model – they are simply too complex – and thus another approach is needed. I do not have time to elaborate this here, nor is any such approach well worked out by anybody as yet but there are many straws in the wind with respect to how we might use our models to enable informed discussion about these questions. One strategy must be to build many models. Models that predict the assumptions of other models and vice versa are required so that different perspectives on the problem are needed. Many years ago, Greenberger et al. (1976) argued that any modelling involving public policy and human systems should engage the arguments of 'counter modelling' – building models that were manifestly different from one another. These often conflicted with one another in the assumptions and explanations as well as sometimes being complementary and defining different elements of the system in different ways. More recent approaches from other science and policy domains such as 'ensemble forecasting' in weather prediction and in econometric modelling extend these ideas even further.

The problems we face are that in building any one model of an urban system, this is time-consuming, expensive and always, in terms of a single model, arbitrary. Moreover, the same model can be built at different spatial scales and levels of detail in their activities and components and this expands the possible space of models in a different way. Simple back-of-the-envelope models as well as fully-fledged econometric-like, microsimulation and systems dynamics models that use extensive computation also define the range of possibilities. What we need to generate is an urgent discussion of all these ideas, something that we have been particularly bad at initiating. The biggest problem is that most of us start out by building a single model and the notion of multiple models is never uppermost in our

collective consciousness. It should be and I hope that this editorial stimulates examples of such endeavours to construct multiple models because we will only make progress in understanding and modelling urban development when we begin to compare our different approaches, systematically and rigorously.

Michael Batty
Editor

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