The Uses of Complex Systems Thinking for Policy Planners

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Introduction

Most people are uncomfortable about bringing together complex systems thinking and policy decisions. Complexity introduces non-linearities and feedbacks that are not consistent with normal project-management methodologies relying on linear dependencies. This is compounded by reductive modelling and statistical techniques that are powerful in the planning stages of projects and policies. Further managing out of complexity is created by the decision-making process itself and how people become convinced that a policy or project will work. This chapter will consider analytical processes, planning, decision-making and project management as well as how complexity can both help and sometimes hinder.

Between 2002 and 2012, I was involved in creating London's urban plan, which entailed bringing together the spatial- and transport-planning systems. Over the decade or so since the inception of the Greater London Authority (GLA), there has been increasing integration of the planning system across these dimensions This has in itself involved the challenge of considering the feedback between the different policies and planning systems. Since each plan involves the preparation of volumes of material running to thousands of pages as well as many different models and planners, this is a challenge in itself.

Producing a volume, of course, does not produce an effective plan. That only occurs on delivery of the plan, and in the case of an urban plan, it can take many years before it is obvious which changes have

occurred. Project-delivery challenges can show the impact of feedbacks more quickly than examples drawn from planning can.

One example of project-delivery challenges is pretty recent. At Christmas 2014, Network Rail had over 2,000 projects to deliver to upgrade or maintain the railway network. As fewer people traditionally travel over Christmas, it is considered a good time to close down and undertake projects. Each individual project was planned and its risks assessed. Larger and more difficult projects were assessed to a 95 per cent probability of success. There were 60 such projects on the list, so if the analysis was correct, three might go wrong. And three did. Two of these involved London terminal stations. As a result, they got much more publicity than the third, out in the South West. In addition, the contingency plan for one of them also went wrong, resulting in media pictures of families and elderly persons unhappily locked out of a station that had become overcrowded. Government, media and public castigated the company, which has reacted by adding further links to the planning process.

This story includes a number of elements that can be traced back to complex systems processes. These include how the planning process happens, when and how decisions are made, and how projects and policies are subsequently managed. It will be a structure to inform the story of London's planning, as developed in the rest of this chapter.

Planning: Forecasting & forecastability in complex systems

At the inception of the GLA, regional planning had become a norm. Each English region had the duty to prepare a regional spatial plan. To this end, they prepared or commissioned forecasts of the future in order to fit their plan to the perceived need. Such forecasts were constrained to an overarching future for the country, so growth could only be redistributed and not created. And other policies, such as transport investments, were also perceived as a context, though they themselves were also constrained to a forecast provided at a national level.

Faith in such plans goes back decades, to a world in which it was possible to take a reductive view of planning with elements that could work independently. There are many who still have faith in such plans and the necessity of taking a 'rational' view on what is needed in their region or community. And it is clear that planning control leads to wanting to take a view on how things ought to develop. To this end, there is a huge reliance on the views of experts regarding the future. There are several specialist firms that will prepare a forecast for employment and output as well as identify growth sectors to help guide policy. I formed one of these myself back in the late 1980s.

But there is a big problem: Such forecasts are inherently uncertain and become more difficult when applied to smaller geographical areas. They may be interesting, but they cannot be a sure guide. There are many reasons for this. First, the only guide we have to the future, particularly in statistical modelling, is the past. Thus, the most rational view of the long-term future is to examine past trends. This is what underlies, for example, the London plan. Incidentally, this also requires long-term data, as a plan for the next 10 years should ideally be based on at least 30 years' worth of past data.

Such data is not generally available in anything close to a truly reliable form. We now have 40 years of data on London, but this has been compiled from a number of sources and surveys that use different data-collection methods. Moreover, some years are interpolated between years in which data was actually collected so as to provide an estimate. No one can say what the scale of errors is, but this is just the best we have.

This data must be used to construct a forecast on which to base a plan. This is essential for any activity, of course, as businesses and spatial planners need to take a view of the future in order to make decisions. The trick is to create the right framework and to have an idea of the robustness of your views and the risks of being wrong. A top-down planning system lacks these controls.

The most common way of thinking about the prospects for a local economy is to take a sector-by-sector national view and then break this down into a regional view, say, for the South East. The South East will

then acquire its share of UK growth, probably adjusted for its past changes in share. This is known as a 'shift share'.

There are two significant problems here. First, any forecast based on a model implies that what we are interested in (e.g. output) is driven by some underlying factors. So, to provide the forecast, we first need to forecast these drivers. By a process of recursion, we arrive at the drivers that the model does not forecast. These become the assumptions that create the drivers to create the drivers to create the variable of interest. These assumptions are both crucial and a matter of judgement – clearly – since they are outside the model. What they are and how they are made are the most important aspects of the forecast, and yet these assumptions are normally hidden or confusing and lack transparency.

Moreover, this whole process equally relies on the correct interpretation of 'drivers'. There are errors in any forecasting model, and not all of the history of the variable we are interested in is explained by just the drivers we have managed to identify. So, even if we have a reliable forecast of the drivers, there is still something – and potentially quite a lot – missing.

On the whole, a forecast is only likely to be right when the variable in question is not too random and when its causation is likely to be stable and direct. Merely stating this shows how unlikely this outcome is. Basing decisions on forecasts when there are circular chains of causation can be highly problematic. The same is true if structural changes are going on.

There is far too little active consideration of what we might call 'forecastability' and far too much reliance on the need to simply have a set of numbers. Looking at the percentage change in UK GDP from 1956, with each quarter as the percentage growth on the same quarter of the previous year, two things jump out: the volatility in growth and also the unusual stability of the period between 1994 and 2008. If we want to examine 'the business cycle', it isn't really obvious where we should look for it. It is hardly surprising that forecasters struggle to get the following year right and often disagree. Precisely why each turning point occurs can be established in hind-

sight, but their timing looks pretty random. Signal is dominated by noise.

Where drivers are uncertain, variable and indeed unforecastable, and where the variable of interest exhibits short-term randomness, then a trend-based approach is likely to be more valid and useful. This approach has been used for the past decade in London by identifying long-term productivity trends and using these to identify likely employment growth, in spite of the big swings in total employment. I devised this procedure after being appointed chief economist to the GLA, and it has continued to be used after my departure. Since it has abstracted from the cyclical impacts, it has both under- and over-predicted for particular years. However, it has provided a stable base for forecasting that has moved in only a narrow band as the London economy has evolved over the last decade or so, even through the financial crisis. In the first incarnation of the analysis, data was only available for 2000; but as time has gone on and more data has been gathered, the forecasts have proved reliable over the long term, even though they do not capture short-term movements.[12]

However, this is a high-level, top-down view with some uncertainties and ranges within it. For planning purposes and to control planning permissions, a more local view is needed. But that local situation is in turn affected by the planning and other decisions that have been and are being made. Any forecast is immediately contingent on other policies. For example, site availability and transport constraints play an important role in governing the outcomes. In London, we addressed this by developing a process of triangulation. This looks at the growth in a local borough that could be brought about by a site's identified capacity for development as well as by the transport plans currently in place.

This adds an important element of feedback. Site availability and transport changes are governed by policies that are themselves made by planners and rest on forecasts of the future. The idea is that this process allows for some debate about more local areas within the top-

12 For the latest projections, see GLA Economics 2013.

down picture, such as whether they have the capacity to grow faster than their history suggests or whether their growth might be slowed by some constraints. The process has generated some rules for making up or down adjustments, and in some individual boroughs, the differences can be substantial.

For example, the trend in employment in Croydon, a borough in South London, has been downward for some years. But it has transport capacity and site availability. The overall judgement is that this should make it possible for Croydon to reverse its past trend over the next 20 years. The rules that bring the three pictures together, however, are exactly that – and we do not really know whether it will be possible for Croydon to buck its past trend and whether the investment to make it happen will actually come forward.

Even the attempt to open up the local projection process to triangulation does not always help to open up the discussion. For example, the developers of a large airspace above a central London station were concerned that the London numbers apparently suggest that there is only a 'need' for 7,000 jobs there, based on the projections for financial and business services and the local triangulation process. This illustrates how hard it is to escape the belief that we can plan correctly.

Being prepared to accept that linear forecasting models are unreliable, and that forecasts need risk statements, is a step on the way to accepting that the system of interest is complex, and that non-linearities and feedbacks are endemic to its operation. But it does involve abandoning the belief in a 'correct' plan.

Analytical processes: The limits of cost-benefit analysis

The belief in planning is also a belief in a reductive and deductive thought process in which every phenomenon has a driver or set of drivers, and that these can be effectively separated. This separation allows planners to think about transport systems separately from economic systems and to behave as if they were independent of one

another. The reductive model is strongly embedded in our thinking, particularly for economists and planners. From Descartes to Dawkins (see Dawkins 1989), the idea that phenomena have causes that can be identified and allocated has been a very powerful one. The techniques of econometrics and multiple regression analysis focus on identifying the relationships between independent variables that determine the performance of a dependent one. The allocation of effect amongst the independent variables is a matter for much debate and technique. In a complex system, such historical allocation can become arbitrary.

In the UK, transport planning has rested for decades on a particular view of cost-benefit analysis. This rests, in turn, on the assumptions of perfect competition and on those of welfare analysis. Under these circumstances, a free good supplied by the public sector (e.g. roads) is a welfare benefit that makes people better-off by saving them time. This view of transport provision, extended to all parts of the system in which subsidies exist and the public sector invests, has been embedded into the decision-making system for decades and has only recently been challenged.

In the first instance, this challenge has emerged around the case for Crossrail.[13] This new underground railway running east to west across London provides a key new link between Paddington and Liverpool Street as well as new connections outside the central area. The scheme, which connects Reading and Heathrow in the west to Shenfield and Abbey Wood in the east, reduces the travel time from Canary Wharf to Paddington to 17 minutes and provides additional access to the busy central business districts by using large trains similar to those on overground networks. A plan was finalised in 2004, Parliament approved it in 2008 (after a three-year process), and works started in 2009. It is now planned to open in 2018, and the project is currently well on progress, on time and on budget.

13 See House of Commons 2005 for more details on the Crossrail project, including some background on its origins and development.

Abb. Crossrail-Linie

The first plans for Crossrail were formulated nearly 50 years ago, and the current route was identified in a 1989 review titled 'The Central London Rail Study'. The project was agreed and went for permission via a Hybrid Bill in Parliament in 1991. However, this did not get government support to allow it parliamentary time and, by 1994, it had been withdrawn. The current budget is £16 billion in cash over the construction life of the project. Changing standards and requirements, re-engineering of old designs and general increases in construction costs have added to the expense (Buchanan and Volterra Consulting 2007).

Between 1992 and 1994, there were no fewer than three technical reviews: by Bechtel, by Bovis and Sir Alexander Gibb & Partners, and by Ove Arup. Although their briefs were slightly different, they all reached similar conclusions. Each cost several millions. A final third-party report in the decision process was the Eddington Report. This was a response to the case being made by the GLA for Crossrail in 2002, which challenged the prevailing model and argued that the benefits of Crossrail were in removing constraints to growth, not in saving time. We showed that additional productivity could be generated by making possible new jobs in central London, and that this was a net addition to UK output. One piece of background research for Eddington looked at growth accounting for large historical periods, and especially at the role of railways. It concluded that the spillover effects

from railways were hard to pin down, and even that the agglomerations of Manchester and Birmingham had already been set into progress by canals (see Crafts 2004). In other words, the identification of a separate impact from one investment, particularly a large one, could not be separated out.

This conclusion remains powerful. Econometric analysis rests on both reductionism and historical effects. Change that is broader and more long-term is very hard to analyse. Currently, this is under debate for Crossrail 2. This railway would improve connectivity from north to south and, like Crossrail 1, has been in debate for many years. I am considering how to integrate the benefits it brings into a view of the links between spatial and transport planning. While Crossrail 1 linked new business districts to each other and to Heathrow Airport, Crossrail 2 is as much about enabling new housing and improving poor districts to the south and the north. Like Crossrail 1, no standard models yet exist to capture these benefits, which are about spatial planning and family quality of life as much as about productivity directly.

Another example of the challenge of thinking about the benefits of transport investment is the case for high-speed rail in the UK. A new high-speed network between cities in the UK would reduce times between city centres (and their peripheries), increase capacity between cities, shift existing trips to rail and free up train paths on the existing network for commuter and freight trains. These effects can be very significant, almost doubling capacities and halving times. The proposals, however, consist of a significant and expensive change to an already well-developed system. In such a system, we might expect diminishing returns to be important and, thus, smaller schemes focused on particular bottlenecks to be the most effective, which was the conclusion reached by Eddington.

The challenge, therefore, is to identify the benefits of reinvestment in an existing system, a reinvestment that also changes that system in a significant and structural way. Thus, the addition of new capacity at new speeds is distinct from the investment in, for example, re-signalling of the existing rail system. While re-signalling is also a large pro-

ject, it has direct cost-saving implications that can be directly evaluated. The implied capacity and speed changes are also marginal and will not change the basic nature of the services.

Taken together, these mechanisms show that the assumption of ceteris paribus (other things being equal) does not hold for large schemes. Everything changes. Indeed, the whole rationale of such schemes is to change things. However, this does make for difficult decisions and uncomfortable decision-makers. It is no longer possible to rely on a set of models and a set of experts who can tell you what to do and be blamed later.

The courage to make decisions, and how that courage is generated, is where we turn next.

Decision-making

In 1990, then-Prime Minister Margaret Thatcher made a decision to support the construction of the extension to the Jubilee underground line to Canary Wharf in Docklands. Construction work on Canada Square and Canary Wharf had already started in 1988, even though negotiations about how to get people in and out were still ongoing. The existing system was not going to be adequate, and the developer, Olympia & York, proposed a railway from Waterloo to Canary Wharf and Greenwich via London Bridge, which it would finance at a cost of £400 million. However, London Transport wanted something more ambitious, and proposals for extensions to the Jubilee line had been floating around for some while. The compromise was that O&Y would still contribute £400 million to a much more expensive railway extending west from Waterloo to Green Park and east from Greenwich to Stratford at a cost of £2 billion. This was agreed in 1990, even though the project passed no cost-benefit tests. The official models suggested that the project's cost would outweigh its benefits, so it was only the prime minister's intervention that pushed it through.

The rest is history. The recession of the early 1990s bankrupted O&Y, and the state bought in the project, privatising it again later. The

Jubilee line's access to Greenwich became part of the Millennium Dome project, which gave it a deadline that it struggled to meet alongside massive cost overruns, which nearly doubled the budget, to £3.5 billion. O&Y paid less than half of its agreed financial contribution.

Nevertheless, this chapter of accidents, mismanagement and poor cost-benefit ratios turned out to be a great success. More recent reworking of the numbers, using what we know about the actual costs and benefits, shows that it would now pass the official tests, which require benefits to be at least twice the costs. London has gained a new business centre that generates incomes, profits and tax revenues. Many also think it shook up the City of London itself, causing it to become more flexible in terms of allowing the kind of buildings that occupiers want.

It is easy to become convinced that decisions are made in a rational way, balancing all relevant factors and taking advice from experts into account. The expert advice given to the prime minister was against this project. She went ahead anyway, presumably because she was convinced that success would be the result of other factors. We do not know exactly what her thought process was or how she became convinced. However, we can be pretty sure that not only the criteria used in decisions, but also the processes by which these are used in them, are themselves complex. The work of David Tuckett (e.g. 2009) has focused on uncertainty in decision-making and how we develop stories that manage such uncertainty and allow us to convince ourselves that we have a reliable way to make a decision. There are a variety of mechanisms that we use to enable us to believe in our decisions, which are emotional and social as much as rational or scientific.

A fundamental and ostensibly simple rule of decision-making is to require that benefits outweigh costs. This provides a quantifiable and apparently scientific approach to a decision. Unfortunately, as pointed out in the previous section, it is not that simple. Which benefits should be evaluated? Over what time period? How should they be quantified? Having made decisions on these questions, estimation of impacts itself becomes a challenge. What is the likely future with and without the project? What assumptions are being made about the world being

modelled? Who makes the decision? What rules govern it? All of these features tend to rely on methodologies that emerge over time and become embedded in the decision-making process. But they control the outcomes without anyone being aware of it.

The decision to undertake the expensive Crossrail project wasn't just made because careful answers had been provided to all these questions – although a huge effort had indeed been made to do so. It was also taken because a wide variety of supporters brought pressure to bear and because there was an institutional structure that made it possible. The Campaign for Crossrail was supported by the GLA, business groups, transport planners and even the general public. It took time and money to organise such a campaign and, of course, the reasons for support were different for each group.

Moreover, the existence of the GLA made a crucial difference in creating an institutional focus for the project. The ability of successive mayors, of different political stamps, to access decision-makers at the highest level in central government, to take responsibility for delivery and cost overruns, and to levy additional taxes to help pay for it were all essential elements in the final decision to allow a bill to permit the scheme to be placed in parliament. Even so, the process of passing the bill into an Act of Parliament took three years, the longest period ever for such a bill.

Did analysis matter at all? Certainly, it was only one building block. And it did provide some crucial insights. It was analysis which showed that the existing growth rate would create gridlock on the Underground, with stations closed to new passengers for prolonged periods. It was analysis which showed that the scale of additional productivity could double traditional benefits based on time savings. It was analysis which showed that cities create agglomeration effects based on the networks of connections that create effective labour and product markets in addition to supporting innovation and economies of scale. Each of these became a rallying cry for different groups and, indeed, each of these is helping to produce further changes in planning and decision-making for UK cities – not just in London, but across the country.

Analysis can also help long-term thinking. Planning is a long-term activity, but governments and businesses have short-term horizons, to the next election or the next job. Strong analysis can support longer-term decision-making, whether by choosing a low discount rate or by looking at long-term trends.

For instance, although Crossrail was bedevilled by different political crosscurrents in its inception, it now enjoys cross-party support. The plan to construct the motorway network also managed to survive changes in government, even if details were redefined as the process went along. The recent report on High Speed 2, the proposed line from London to Birmingham in Phase 1 and then to Manchester and Leeds, reprinted the hand-drawn map an engineer prepared back in the early 1960s. Most of what was drawn eventually became reality. In Hong Kong, a 30-year-old transportation plan to support the economy was put in place some 20 years ago and is still on track. In France, long-term plans have supported the nuclear-energy and high-speed networks.

Analysis can also identify the key assumptions that inform a decision, though this is not always done well enough. For example, the assumptions required to define a 'do nothing' case are quite onerous, and it is exceptionally hard to prove that any investment is actually 'needed'. The role of agglomeration and other processes that happen over time are easily ignored, while the equilibrium assumptions imply that the status quo is somehow desirable.

Feedbacks, time steps and the disequilibrium of the real world are all ignored, while analysis rests on funny money rather than the real stuff that will pay for the investments. These criticisms particularly apply to transport assessments, but also to all the principles of judging 'need'. Spelling out such assumptions should be, even if it isn't always done, an essential requirement.

Spelling out assumptions could close the gap between political negotiation and technocratic decision-making. If the models were only seen as exploratory and partial, it would be much easier to use them as tools to play with rather than tools for finding answers. This would give much more potential for processes to help create consensus

rather than produce divisions, which can only be resolved by political or bureaucratic intervention.

Understanding decision-making processes and accepting that rationality is more than just economic models is one of the insights of complex systems thinking. Being able to accept uncertainty and still make judgements about appropriate actions, with the knowledge that not everything will have the desired consequences, also derives from an acceptance of complex systems thinking.

Conclusion: Shifting away from project delivery

Things do go wrong. While long-term forecasts for London's employment have shown great robustness, they have neither been right in the short term nor presented as such. Moreover, projects do not always have the intended consequence or achieve their aims within the intended time frame. For example, the Jubilee Line Extension generated far more trips than expected and, in particular, far more from east to west as well as west to east. A seventh car on the train had to be added well before plan. On the other hand, repeated attempts to reinvest in Croydon have failed to put it back on a path to employment growth.

Looking back, it was a mistake to cancel Crossrail in 1991 and the third London Airport in 1975. In each case, demand that had fallen in a period of recession picked up again, and the long-term trend reasserted itself. However, hindsight is no substitute for foresight, and foresight is often impossible in a complex world.

The lessons of planning in London over the last decade are that integration of planning and transport policy is desirable but increases the forecastability problem. We need to do more to consider 'what if's' and the potential for constraints. This is what is happening now with the consideration of Crossrail 2. The questions being asked have to do with what developments are needed to create a return on the investment and what the constraints are on generating these developments. Assessing the risks to development then becomes a picture of the benefits of the investment.

Such assessments will not remove the emotional and social nature of decision-making in which groups and individuals overcome the uncertainties behind a decision. Such uncertainties include the effect on one's career as well as the effect on a definable outcome. It is foolish to ignore this.

Events can change the risk parameters. In the example of engineering overruns on the railway at Christmas 2014, a focus on project-delivery risk appears to have obscured the need to consider contingency responses to delivery failure. This failure was compounded by external factors, such as a shortage of drivers, because of the time of year and other projects, as well as delays in decision-making to invoke contingency. A focus on project delivery impedes peripheral vision. The response has been to reconsider risk parameters and to extend the focus on contingency planning in the event of failure. This, in turn, will have an impact on future choices, plans and costs.

A similar impact is apparent in the serious technology incident suffered by Royal Bank of Scotland (RBS) in 2012. A routine upgrade of a third-party piece of software appeared to be a low-risk activity. However, the consequence of the upgrade's failure would ultimately affect all of the bank's customers, and no contingency plan appears to have existed. When the low-risk activity went wrong, as must sometimes happen, it was a very major task to undo the damage. In the case of one part of RBS, Ulster Bank, the problem continued for three weeks. The complexity element of these stories is the feedback between the narrow focus on delivery, managing the risk when things go wrong and adjusting delivery risk for the risk of consequence.

The application of conscious complexity thinking to planning is in its infancy. So far, it has succeeded in clarifying some of the links between spatial and transport policy and in helping decision-makers to think more clearly. It remains to be seen to what extent this actually leads to better decisions. A better decision requires the ability to look forward better. Complexity thinking on the whole undermines any confidence in looking forward and might undermine the ability to take decisions. Analysis does not always help.

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