Spatial trajectories and decision-making

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Introduction

Let us start with a quick observation. The literature on land use, spatial and urban planning tends to feature phrases such as "... the urban system changed towards the postmodern city..." or "... the city aimed for a growth strategy..." as short-hand for what is essentially a very complex interaction between actors trying to achieve their goals, often contradictory, and the characteristics of the physical system or built environment. In many ways, this interaction is still something of a black box in the science of urban planning. This is at least partly due to the fact that it is simply hard to analyze that interaction, but also partly due to the fact that we as have locked ourselves up in the tightly-defined disciplinary containers where we have been trained in understanding our own topic in such a way that we don't understand it in any other way. This helps our deeper understanding of one particular aspect but in doing so we (inadvertently) forget to look at the complex interaction mentioned above.

The goal of this short working paper is to open that black box (at least a bit) and see how human agency coevolves with the physical system or built environment in shaping specific trajectories over time. In doing so, I will use a range of concepts and methods from the literature about complex systems. I would like to focus on the narrative and main argument and I will emit the more technical details. There are quite a few good books and papers on these topics so there is little use in repeating that all here. In fact, this paper also serves as a pointer to that literature.

As mentioned above, I would like to start my argument with the statement that urban planning and the urban or regional or physical systems are intertwined. Planning decisions lead to physical and social changes if they are implemented, while physical and social changes in return demand planning efforts. Demographic changes are a convenient example here. Over time, this interaction starts shaping specific trajectories of the urban or regional system. They evolve in certain ways, sometimes slow, sometimes quicker. This general argument has been furthered by among others Norgaard (Gual & Norgaard, 2010; Kallis & Norgaard, 2010; Norgaard, 1984b, 1994c, 1995a) and in the realm of urban and transport planning in my own work (Gerrits, 2008, 2011). In starting this argument, we should keep the following points in mind:

- Any planning decision builds on an existing situation, there is no such thing as a greenfield situation. Even those places that are not yet earmarked or locked in planning regimes, that *appear* greenfield, is still a place that has certain characteristics. The idea that there can be tabula rasa is a figment of imagination.
- Human agency, that is: our ability to do certain things (or not!), and our considerations leading us to do certain things (or not!) are very important in those trajectories. Nature is essentially indifferent. It is us, people, that can influence the course of nature. We do that as planners, but also as consumers, as citizens, as users etc. It is useful to remember Portugali's statement that in the city as well as outside of it, everyone is a planner (Portugali, 1997).

- In making decisions, which means anything ranging from 'real' planning decisions made by planning authorities to the daily use of the city and its surroundings, we shape the system and the urban system shapes us. Now how does that happen?

Myopic, non-ergodic behavior

The decisions I mentioned above are made at a particular point in time, in a particular place, by particular people. Urban and regional planning doesn't' 'just happen' from out of nowhere. There are people at work and they do things (Fischer, 2003; Fischer & Forester, 1987, 1993). And in doing things – in the broadest sense of the world – they are shaping trajectories.

If it is true that decisions made in a particular temporal and spatial context, it is also true that those decisions can be influenced by chance events: the occurrence of seemingly extra-ordinary circumstances (Arthur, 1994; Rescher, 1995, 1998). Being the humans that we are, we respond to those events. As such, it may very well be that that such events have an impact on the decision we made. Now, it wouldn't be important or interesting if people could predict the outcomes of all decisions. Unfortunately, they don't. People are myopic (Cohen, March, & Olsen, 1972; David, 1985; March, 1991, 1994; Simon, 1991). They respond to what is here and now and the best they can achieve is trying to grasp the immediate future. Of course, you will now strongly object and tell me that many resources are spend on predictions. I agree. I just don't think that they return future-proof results. Let me give you two examples of that.

> The Eurotunnel can serve as an example of a megaproject driven by erroneous predictions about future use, as Flyvbjerg and colleagues argued (Flyvbjerg, Bruzelius, & Rothengatter, 2003; Flyvbjerg, Skamris Holm, & Buhl, 2005). Once opened and in operation, the Eurotunnel attracted approximately half the number of passengers originally predicted. Why was that? There are a number of reasons. Flyvbjerg et al. focus on one the positive outlook that drove the prediction, which serves as a euphemism for what they consider industrial-grade lying. The tunnel *had* to be constructed so numbers were inflated. I'm afraid that I find their conclusions convincing. But we should also not overlook the fact that the predictions were made in a world that was quite different from the one in which the actual operation took place. The plans and the predictions upon which those plans were drafted, were made before the European skies were deregulated and before the arrival of low cost carriers. The Eurotunnel had a somewhat solid business case (though not very much so) in the world in which that business case had been made: a world without companies such as EasyJet and Ryanair that seized the opportunity of deregulation. By the time the tunnel was up and running, the business case was destroyed and Eurotunnel and Eurostar, the two main companies behind it, are still staging an uphill battle in order to get healthy financially. In fact, given how things are going, I believe that Eurotunnel will always struggle to stay fit.
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> The second example concerns the planning of Makkasan site in Bangkok. In the 1950s and the 1960s, the authorities of Bangkok decided that the car was the future. Subsequently, they removed pretty much all of the rail-bound traffic and focused on motorways and cars as a driver for growth. The results were devastating and at some point in the 1980s, Bangkok could be considered as one of the most congested systems in the world. Getting railways back in the city was going to be very tough because of the financial constraints. In the early 2000s, it was decided that a public-private partnership construct would be the only way to move forward. Thus it was that the Airport Railway Link (ARL), the rail connection between the city center and the new airport, should be constructed and operated using a DBFMO-contract (Design, Build, Finance, Maintenance and Operate). The wining consortium would have to pay everything upfront but would be allowed to recoup the costs by developing the Makkasan site with a terminal building, hotels etc. However, the very act of building the ARL meant that other sites that were linked to it suddenly became very attractive. That drained all the potential for Makkasan

> and the PPP folded subsequently. In other words, building the ARL set off a cascade of unforeseen effects that threatened the construction and operation to its core (Gerrits & Marks, 2017).

These two examples demonstrate that we are simply not very good at predicting urban trajectories. I will not ignore Flybvbjerg's argument that at least some of these erroneous predictions are made on purpose to further power and deceive opponents. That is part of the story indeed. But I also would like to add that people sometimes really believe that they are correct about the future, except that they aren't. The example of the Airport Railway Link demonstrates that unforeseen futures are very possible and it can lead to unfavorable results. It is probably sheer coincidence if people get their long-term predictions right.

The discussion about chance and lack of foresight takes me to another point that has relevance for our argument: non-ergodicity (David, 1985). Non-ergodicity means that the occurrence of chance, as responded to in our decisions concerning the built environment, don't equal out in the long run. Quite the contrary: these events stay relevant throughout the trajectory; their effect won't dis appear. Let me illustrate that with another example.

> In 1999, the Dutch Parliament had to review the budget for a range of large tunnel projects in the Netherlands as part of the construction of a dedicated freight railway line called Betuweroute. This moment of decision-making coincided with the Mont Blanc tunnel disaster in which lives were lost due to failing safety equipment and inefficient procedures for the emergency services. Of course, the disaster also shook the Dutch Members of Parliament. Consequently, when the decision moment arrived, the MP's argued for a thorough revision of all the plans that were submitted in order to make sure that a Mont-Blanc type of disaster would not occur in the Netherlands. Here we notice how the particular circumstances at a given time and place have an important influence on the things being build or developed. The interesting thing, though, is that the effect of this chance event is lasting. The redesign of the tunnels as well as changes to the existing constructions were very costly and meant a set-back of the construction deadline (Algemene Rekenkamer, 2003). Future effects include a much longer time needed to repay the construction costs, extended maintenance costs, as well as the costs associated with the training of emergency crew. In addition, this being decided in the Parliament and therefore becoming law, it had also had an effect on the tunnels build later in other projects such as the high-speed railway from Amsterdam to Brussels (Gerrits & Marks, 2014).

So, in short, at any time and any place, any decision made in urban and regional planning carries the context of that particular decision with it. And that shapes the spatial trajectories over time. If that is true, and let's assume that for the moment, it means that that complex systems (i.e. coupled socio-physical systems) are sensitive to the particular and singular conditions that can resonate through the further evolution of the system. It also means that we have now introduced a degree of uncertainty, ever so slight, in the analysis and planning of such systems. While we get a rough idea of what the future will look like, this picture may be somewhat – or a lot – inaccurate. The examples mentioned above just demonstrated that. But as you will know by now, chance matters because its effects last.

Path-dependency in trajectories

The narrative so far may give the impression that trajectories are completely random but that is not the case, of course. In fact, the trajectories that start to emerge over a longer period of time can be quite stable, they feature a certain degree of path-dependency. We should remember the points mentioned in the introduction that any spatial plan, project or program builds on an existing physical and social situation that has considerable impact on what we can and cannot do. In other words: the existing situation determines our degrees of freedom or the options available to us in the space of possibilities. In short, "[p]ath-dependency and lock-in refer to the idea that even very small unpredictable events may cause a system, by optimising at the local level, to get on a path that is practically impossible to leave. In other words, small (historical) micro-evolutionary changes cause a system to lock itself into a certain outcome based on continuous rational decisions made in the past; i.e. irreversible adaptation." (Gerrits & Marks, 2008). Path-dependency is an important explanation in the general understanding or experience that it is actually quite difficult to change an existing situation. As an explanandum, it has made its way in the analysis of economic systems (Arthur, 1994; Arthur & Durlauf, 1997; David, 1985). It has also proven its relevance to other domains, such as political science (Pierson, 2000). For instance, we have used it to explain in what ways the geometry of the Zeeland delta in the Netherlands limited the options available to decision-makers when deciding about the future of the brackish water systems in the delta (Gerrits & Marks, 2008).

> Rotterdam, my hometown, can serve as a nice example of the mechanisms and effects of path-dependency. For long, Rotterdam was a rather insignificant town, overshadowed by other towns with direct maritime access such as Dordrecht. This changed in the 19^{th} century when the Nieuwe Waterweg was opened. It is man-made channel providing direct and convenient access to the North Sea, which promoted trade and turned Rotterdam in a true port city. The real boom came in the 1950s and 1960s when the post-war reconstruction of Europe meant a considerable influx of materials as well as outflow of migrants to the new world. The port expanded rapidly and so did its workforce. By the 1980s, it had become the world's largest port and an economic powerhouse for the Netherlands. But it didn't just stay that way forever.
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> The first major change was the introduction of the shipping container and other innovations aimed at bringing the costs down. The container in particular meant that one didn't need a considerable workforce to load or unload cargo. The result was massive unemployment. The second change was the disappearance of traditional industries such shipbuilding because there were other places in the world where that could be done at a much cheaper price. Of course, deindustrialization was a much broader development that has hit about every place in Europe. But it was particularly fierce in cities and regions that were fully reliant on heavy industries such as Rotterdam, or Coventry or the entire Rhine-Ruhr Area.
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> So Rotterdam, as many of these other places, became post-industrial. Or did it? Well, not quite. Despite these massive changes, the city is still a traditional port city except now that very few people actually work there due to automation and other efficiency gains. We have all been told that the future is in green energy and ICT and other innovations. So why is it didn't the decision-makers move in that direction when they saw the writing on the wall? Simply, because the costs of changing right now (monetary but also expressed in other aspects) are much higher than the immediate returns of changing the trajectory, even though the alternative trajectory will probably deliver higher returns in the long run. So we can observe in Rotterdam that, despite all good intentions from planners and stakeholders alike, most of the decisions are made with the express purpose of reinforcing the current situation. For example, the main thrust is to extent the port and to make transfer of goods even more efficient than it already is – even though most of the profits now go to foreign companies that have bought many of the Dutch companies operating in the port. Another example was the decision to reinforce the fossil-fuel industry, e.g. by building new coal-fired power plants in addition to existing ones. Naturally, a few windmills have been placed but one can't escape the feeling that it is all rather limited. And in the city itself, we can observe how the population itself – while more ethnically more diverse than before – is still as (relatively) poor and uneducated as in the 1960s. The city also suffers from the Red Queen effect (Sementelli, 2007): even if things are changing, other cities are changing faster.

In short: path-dependency is real. And while the example above pointed at the negative consequences, it can also be beneficial. For example, engineering firms and other companies dealing with technology, as well as research institutes in Bavaria, have benefited from path-dependency. In many ways, it is much easier for them to remain the go-to shop for innovative technologies than it will be for other regions to get in that niche. This effect has been observed elsewhere, too (Boschma, Minondo, & Navarro, 2011; Neffke, Henning, & Boschma, 2011).

Punctuated equilibrium and hysteresis

Now, path-dependency *also* doesn't mean that everything stays the same forever. On the contrary, things can change and can change quickly due to geographical or physical changes, but above all due to changes in frames and beliefs of human actors. That takes us back to human agency. We are here in Switzerland where it has been only two centuries or so that mankind has come to view the Alps as something attractive rather than something that should be feared (Schueler, 2008). That mindset has changed tremendously and the Alps are now a prominent driver of tourism. And you make decisions because of that changed mindset. Access roads have been made, hotels have been constructed, cable cars give access to the highest peaks, parks have been designated for nature and recreation, and ski slopes have been cleared. In short, we have made many changes to the landscape and our settlements because of that changed mindset.

Trajectories are therefore neither completely random, nor completely static. They feature a punctuated nature, where periods of stasis can be interrupted by periods of quick changes. Just to make clear: when we talk about punctuated equilibrium, we talk about a specific kind of change where build of pressure on the system doesn't lead to an equally gradual change within the system (Baumgartner, 1993; Eldredge & Gould, 1972; Gersich, 1991). In fact, the pressure can mount for quite a while without any discernible change because many systems have buffers that can accommodate those pressures. This is often referred to as resilience or robustness (unfortunately, much of the literature uses these terms interchangeably). However, once that pressure has reached a certain threshold, the system will topple in a new equilibrium.

These changes, in turn, show an important but not well-understood effect: the hysteresis effect. Hysteresis explains "that a transition from one state to the other does not imply that the reverse can occur." (Graham & Seltzer, 1979). A short explanation is as follows: "Suppose that a system at time *t0* is put under continuous pressure *p*. Each system has some capacity to absorb these pressures without needing to change its structures and processes This pressure can increase for a considerable period of time *t1-n* where a constant amount of pressure (1*p*) is added at each point in time (*1-n*). A sudden transition of the system state occurs at *tn+1* at which point it shifts to a new equilibrium. Although it appears that increasing the level of pressure by a single unit (1*p*) caused the system to move to the critical threshold, this is not the case. Instead, the shift was the result of the accumulated pressure during the period before the threshold was reached. While one may argue that system transitions could be undone by reversing the last 1*p*, the hysteresis effect implies that the point at which a system loses its resilience and becomes vulnerable to the pressures that could push it into a new state lies much before the actual tipping point." (Gerrits, 2012). And that is why one is allowed to laugh when people talk about "going back to how it was". There is no such thing as returning to the past – not in philosophical terms, not in material terms. Let's add another example to our argument.

> The port of Hamburg is situated more than a 100 kilometers away from the sea, at the point where the Elbe River changes into the Unterelbe estuary. This is considered a problem by the decision-makers. The Unterelbe is relatively shallow so big ships need to ride the tidal way over the estuary in order to reach the port without problems. Over the past decades, the port authorities have undertaken regular deepening operations in which layers of sediments were removed from the estuary, thus ensuring that shipping could still take place even though the trend in ship building is towards bigger ships extending deeper in the water.

> Until recently, the deepening operations did not lead to any negative consequences for the natural system. That changed dramatically after the deepening of the mid-1990s. That particular operation removed a layer – inadvertently, I should add – that was pivotal in keeping the inflow of salt water from the North Sea in check. When that layer was removed, the estuary turned into a flood-dominant system where more sediments were transported from the sea into the port than fresh water from the Elbe River could flush out. In short, the operation aimed at a deeper port lead to a port where more, instead of fewer, sediments started to accumulate – subsequently making the port shallower. The authorities responded to this with extra dredging operations – there is always a solution to everything – but one could argue that the operation had crossed its own motive. Interestingly, it was widely recognized that putting the last layer that was removed back in place was going to be extremely difficult and it was very uncertain that it would solve the problem (Gerrits, 2010).

So, here we have it. We see the punctuated equilibrium in the fact that multiple deepening operations over a number of decades didn't lead to a gradual change to a flood-dominant estuary. The system only changed after the last deepening but the change was the aggregate result of all the deepening operations that took place. We can then see the hysteresis effect in the assessment that the operation can't be 'undone' by putting back a layer of sediments. The physical system has reached a new equilibrium where the inflow is dominant and the decision-makers have to deal with this new reality.

Equifinality and multifinality

We have now discussed some of the main properties of trajectories. As the final step in this paper, I would like to talk about equifinality and multifinality. Equifinality means that under different conditions, trajectories can tend towards a similar state, the so-called equifinality point. Multifinality means that similar conditions can be bring forth similar outcomes. I can't overstate the importance of these points because we are so often fooled in believing that, because two trajectories look the same, they will have emerged from the same conditions; or, conversely, that two dissimilar trajectories are brought forth under dissimilar conditions. This constitutes an enormous analytical error. As shown elsewhere (Gerrits & Verweij, 2013a, 2013b, 2016; Verweij, 2015), equifinality and multifinality are real in urban planning and we should not be let by our love for symmetry to think that the trajectories obey to that longing.

The subtle but important difference is between 'same' and 'similar'. We often treat things that are similar as same and are therefore lead to believe that the same conditions have occurred. The minor differences within these conditions can easily disappear, simply because most analytical work requires abstraction to work. But as e.g. Cilliers has argued, any model that wishes to fully represent a complex system will have to be as extended and detailed as the target system (Cilliers, 2001, 2002). Since this is practically impossible, we simplify. But in doing so, we remove some of the unique properties that are inherent to complex systems and so deny us the chance to understand the equifinal and multifinal nature of trajectories (see Gerrits & Verweij, 2013; for an extended argument about why this matters for a thorough analysis of complex systems). You know the saying that the devil is in the detail? It is.

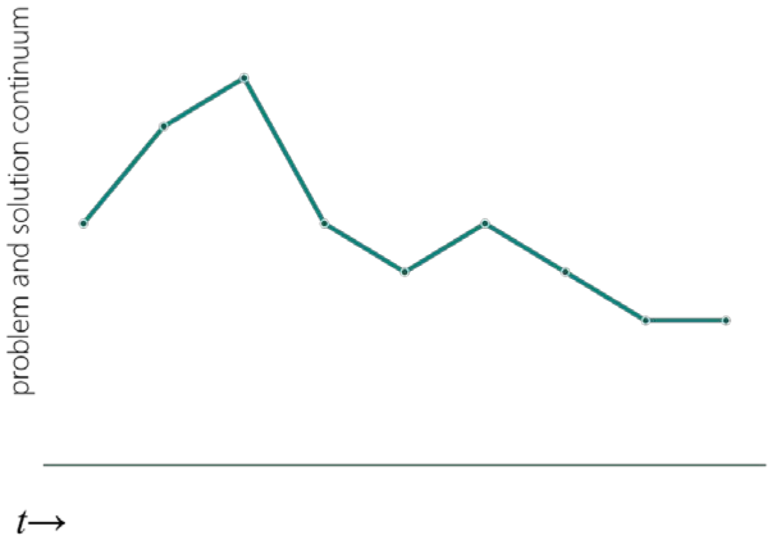

Figure 1: graphical representation of the argument in this paper

I've summarized the argument in the rather crude picture shown above (*figure 1*). It represents a trajectory – not an actual one, I should hasten to add – to show that we are dealing with systems can sometimes change, and sometimes not. They have turning points in the shape of punctuated equilibrium as well as continuities in the shape of path-dependency. We as researchers are tasked with understanding the nature of those changes and continuities. In doing that, we shouldn't just hoover at great distance from the evolutionary trajectories of these systems. We need to get into the nitty-gritty details of human agency in these the trajectories to understand how that agency is both shaping and driving those trajectories.

Note that I left the y-axis blank or at least gave it a very general description, namely problem and solution continuum. This is because I don't want to impose any format. You as a researcher will have to decide yourself what variables you will want to focus on. I myself find it really interesting to look at the problem and solution space, i.e. what is considered the problem with the current system concerning a certain issue, and how the solution space is explored and decided upon (cf. Gerrits & Marks, 2017). But you can select other dimensions, of course.

Conclusions

The main take-away from this paper is a simple one: there is a real need to understand urban trajectories as the coevolution between human actors and the built or physical environment in their full richness. This requires us to analyze the turning points and the conditions of these turning points, i.e. the exact circumstances under which changes were achieved. Naturally, such an analysis needs to be comparative as well as longitudinal. I would like to stress the need for empirical research because modeling (an all-time favorite in urban planning research) is useful but not if we forget to bridge the (rather large) gap with the real world. In the words of David Byrne, the previous speaker: we need to engage with down and dirty empiricism (Byrne, 2001, 2002).

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