Policy Design, Planning, and Management in Global Systems Science

Book Chapter

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Policy Design, Planning, and Management in Global Systems Science

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Abstract

Policy Design is defined to be a new area of inquiry that takes the methods of design into the world of social, economic and environmental policy. Policy exists at many levels and it is increasingly recognized that policies applied to one system may impact on policies applied to other systems. The European Commission suggest a 'science of global systems' to improve the way that science can help inform policy and societal responses to global challenges such as climate change, global financial crises, global pandemics, city growth and migration patterns. The new science requires radically novel ideas and thinking to embed scientific evidence into the policy and societal processes. It is here argued that Policy Design in the context of planning and management is an essential part of the methodology of Global System Science.

[1] Motivation

Policy Design is defined to be a new area of inquiry that takes the methods and traditions of design into the world of social, economic and environmental policy (Johnson & Cook, 2013). In the sense of Herbert Simon (1969), policy involves a vision of the future as it *ought* to be, and policy is a *science of the artificial*. Inescapably, policy is *designing the future*. Of the many specialist design domains, city planning best exemplifies this. Cities are planned, designed and managed but never finished. They are regulated but not controlled, and their precise state at any point in time is not predictable in the sense of conventional science. The essential feature of policy design is that emerging needs and requirement are satisficed by an iterative process in which possible solutions are generated and evaluated until a satisfactory solution is found or the requirements are reformulated. Design is a coevolutionary process that delivers what we think we want from a process that investigates what is possible. Design is heuristic and cannot guarantee optimum solutions, or even good solutions, but it is the only way we know for creating well-working systems that don't already exist.

Policy exists at many levels and it is increasingly being recognized that policies applied to one system may impact on policies applied to other systems. For example, in the UK policies to manage the health and welfare of an aging population have become coupled to policies for managing accident and emergency admissions to hospital. In the face of the economic crisis, cuts to one system have caused a crisis in the other. In another case a European policy to reduce the consumption of fossil fuels by incentivising the production of biofuels in one country caused starvation in another (Foley, 2011).

> "Challenges such as climate change, financial crises, or containment of pandemics all suffer from the intrinsic difficulty that they generate strong inter-dependencies between different social, technological, and environmental systems. When trying to deal with them, different groups tend to address individual systems, rather than multiple interrelated systems, and thereby they typically fail to achieve systemic change. The vision of a science of global systems is that scientific knowledge could act as a catalyst to stimulate creative policy responses to such global challenges, and indeed changes in society in general. A *global systems science* (GSS) emphasises a 'systems' approach to develop scientific evidence in support of system-wide policy options across different domains. … GSS also recognises the immense potential for the engagement of civic society throughout the process of decision making by gathering and analysing evidence. A better understanding of this science of global systems will lead to better evidence-based policy decision making." (Bishop et al, 2013).

Design in the context of planning and management is of central importance to the development of Global System Science. *Without embracing design the new science of global systems will fail to deliver the holistic solutions so urgently required*.

[2] Design and the science of multilevel social systems

Of necessity, Global System Science must be a science of multilevel systems, capable of integrating theories and knowledge from the individual person to the Anthropocene, "the current epoch in which humans and societies have become a global geophysical force" (Steffen *et al*, 2007). Through many intermediate levels of systems, subsystems and supersystems, almost every individual person has an impact on global systems, and global systems have an impact on almost every individual person.

Policy strives to make global systems behave differently to how they might behave if left alone. Thus the systems created by policy are *artificial* in the sense of Simon (1969), and they are designed.

The process of designing can be considered to include the generation of new scientific knowledge. For example, there was no science of aeronautics before the invention of flying machines, no science of computer viruses before the invention of computer networks, and no science of human-robot interaction before the invention of robots. We cannot have a science of systems whose components have not been invented.

In this respect the science of social systems is different to traditional science. Whereas the latter is cumulative with new knowledge adding to and reinforcing existing knowledge, human systems become *different* system when new things are invented. Thus a science of human behavior that was a relevant and 'correct' story of human behavior in the past may not be a relevant and 'correct' story of human behavior today. For example, to what extent is the behavior of people using FaceBook explained by behaviours from the past. Also, some contemporary behaviours were impossible in the past, *e.g.* crowd-sourced measures of 'liking', and leisure travelling by the masses. Unlike the traditional science, we need custom-designed social sciences to fit the social world as it evolves.

Design is the process that takes new parts and assembles them into new wholes, takes existing parts and assembles them into new wholes, or identifies non-existing parts that are required to complete the construction of new wholes. Design builds the knowledge about the parts and the wholes they form.

Design is the first step in creating scientific knowledge about the relationships between the parts and wholes of artificial systems.

In this respect design is fundamental to a scientific understanding of the multilevel dynamics of the social systems we create and try to manage.

In 2009 an Expert Report of the European Commission asserted that

> "*we have no scientific formalism for representing the bottom-up and top-down dynamics of multilevel systems from micro-levels to macro-levels through meso-levels.* This scientific deficit manifests itself across the sciences. In biology there is no formalism able to integrate the dynamics of cells with the dynamics of organs or the dynamics of the whole body. Instead we have many partial models that fit together, at best, descriptively. In geography and environmental planning we have no formalism that can integrate the choices and behaviour of individuals at the microlevel with the emergence of cities across the globe. In social and political science we have no formalism that can explain why the values and beliefs of individuals aggregate into mutually destructive policies at national level … For all these systems, complex systems science gives reasons why their behaviours are hard to predict. Conventional science assumes that subsystems can be isolated, but complex systems science shows that they may coupled by *weak links*. This makes subsystems with *ill-defined boundaries* that are hard to identify and model. These subsystems *evolve* and *coevolve* in ways that can only be predicted by modelling their *interactions*. These interactions do not just occur at particular levels of representation, *bottom-up* dynamics can cause macroscopic changes, and *top- down* macroscopic dynamics can cause microscopic changes. ... *Creating a formalism for multilevel systems of systems of systems and demonstrating its applicability is on the critical path for science. It is necessary if not sufficient to make progress in many domains. It requires an essential paradigm shift for complex systems science and ICT.*" (Johnson et al, 2009)

Design has been characterized as building abstract representations of multilevel systems, from the parts to whole (Johnson, 2013, 2014). At the lowest level are tangible components such bricks and window frames in the design of buildings, or components such chips and capacitors in the design of electrical circuits. In these cases the designer knows the available components at the microlevel and knows the required behavior of the whole system at the macrolevel. Typically a designer conceives subsystems at intermediate levels. These subsystems are abstract and only exist in terms of representations such as annotated drawings and other documentation, or models inside computers. Initially they may be sketches where the parts are not precisely instantiated with existing components, and some components may themselves be sketches of things that do not yet exist. As the subsystems becomes better defined the designer hypothesises their behavior in terms of their lower level components and the context of higher level assemblies. These hypotheses depend on theories of the system dynamics, and often they are tested by real or computer simulated prototype models. In this respect they resemble scientific experiments in the process of building and testing theories.

In design it sometimes happens that assumptions made about higher level abstract subsystems are incorrect. Sometimes subsystems simply don't fit together because their geometries are incompatible. Sometimes they don't fit together because their interacting dynamics cause problems such as unexpected and unacceptable vibrations. Sometimes they don't fit together because unexpected emergent properties violate the requirements, for example in architecture an important space may be compromised by the noise of air conditioning fans. In such cases the 'theory' of the object being designed did not predict these observations, and as Popper suggested for traditional science, the theory has to be rejected. Since the theory of the design does not match observation, the theory has to be amended. In design this can include imaginative 'fixes' so that local changes in the details of the subsystems can overcome the problem, *e.g.* a stronger bracket, a higher wall, more memory, or filing down proud edges. Sometimes these local changes cause unexpected problems elsewhere in the system that may or more not be fixed by local changes. At worst the design has to be abandoned with the loss of all previous work. When this happens late in the design process it can be very expensive in terms of lost work, and it can have severe impact on the schedule leading to expensive delays or even cancellation of the project.

When the design process does not experience such problems, or overcomes them, the design process is one of conceiving intermediate level systems and making them well defined in terms of the components, how those components are to be assembled, the emergent behavior of the intermediate level system, and the dynamics of the interaction of the subsystem with subsystems at low levels, with subsystems at its own level, and with higher level super-subsystems. As the design process proceeds these subsystems become better instantiated. The lower level subsystems are instantiated with real components so that they too become tangible. As these tangible subsystems are assembled higher level intermediate structures become tangible, until eventually the description of the whole system is instantiated with real parts and specifications for their assembly, and it can be built or fabricated.

The construction of the first instantiated system is an experiment testing the hypothesis that it will meet specification. As noted above, if the experiment fails the theory of the design has to be modified. If the experiment succeeds the system has a 'design life' in which evolutionary changes are made to the design, and the life of each individual instance has to be managed from cradle to grave. For example, the owner of a motor car expects the design to include periodic maintenance and procedures to manage the expected or unexpected failure of components, and some countries have regulations for disposal of the end of a product's life. Thus the design of a particular car is part of the design of supersystem that includes sourcing materials and components, manufacturing, marketing, support, and disposal. Such supersystems place top-down constraints on the design of the car, and they too have their dynamics.

[3] Design, planning and management

In policy, design occurs in the context of strategic or operation planning. Policy Design includes the design of the plan: it establishes how the future *ought to be*, devises a plan to achieve that future, and manages the implementation of the plan. The plan involves the creation of new systems and subsystems, and these must be designed. After a system or subsystem has been created it needs to be managed, and the design includes determining how this will be done.

Design is the process that begins with knowledge of existing things at the microlevel, defined requirements of a system at the macrolevel, and builds a multilevel representation of a ‘possible’ system by hypothesising and instantiating subsystems at intermediate meso levels. In the simplest cases this leads to the fabrication of a prototype that can be tested. In manufacturing industries the prototype may the first of millions, *e.g.* motor cars, it may the first of thousands, *e.g.* aeroplanes, while in architecture the prototype may be the only one ever built, *e.g.* iconic buildings such as the Sydney Opera House and the Guggenheim Museum in Bilbao.

In all these cases the construction of the prototype is part of the design process. The experiments on prototypes such as cars and planes test many emergent properties and in the most benign cases lead to small changes that overcome problems or lead to improvements.

Generally design is part of a planning process that begins with an idea of how the system *ought* to be and initiates the design process to investigate how the system *might* be. The planning system may even commission more than one design. Once a decision has been made on which design to implement, a plan must be made to implement the design. For products this involves planning production lines, distribution and maintenance systems, and so on. For buildings it involves obtaining consents, preparing the site, commissioning architects to oversee the project, etc., and planning the project in time over months or years.

In cities the planning process provides a context for design. Most cities have planning departments working with other departments to consider the physical infrastructure in the context of how people will function within that infrastructure. The details of the administrative structure differ, but planning departments may have day-to-day management responsibilities for services such as the maintenance of the transport infrastructure and provision of public transportation.

In cities with elected mayors, the incumbent usually strives to make the city as it *ought* to be, according to their political outlook and constituency. This includes managing day to day things such as public transport at an acceptable level of service but also strategic things such as enabling sufficient economic activity to provide the jobs and the wealth necessary to support the city’s tax base. To be re-elected the mayor must deliver sufficiently on the expectations of the voters within a budget that the citizens will tolerate.

Planning and management in cities are characterised by making small local changes in the infrastructure to maintain normal activities, making continuous small or large changes in the context of an existing plan, and occasionally proposing large discontinuous strategic changes as a new ‘masterplan’ for part or all of the city. For example, a run down port may identified for redevelopment, a new transportation plan may address chronic congestion, or a new housing project may address unsatisfied demand for housing. All of these changes at all levels involve design.

At the microlevel urban design can be poor and not serve communities well. In response to this organisations such as the Glass-House (http://www.theglasshouse.org.uk) take a bottom-up approach “supporting and promoting public participation and leadership in the design of the built environment. We provide independent advice, training and hands-on support to community groups and organisations, housing associations, developers, local authorities and other stakeholders, to help them work more effectively together to create better quality places and spaces.”

The mesolevels of city design are typically planned, designed managed by elected councils and mayors, as discussed above. It is being increasingly realized that wealth and wellbeing at national and international level are generated at the level of cities, and that cities perform best when they are autonomous and freed from top-down central control:

> “Following a commission from the Prime Minister, Lord Heseltine presented his report *No Stone Unturned* to the Chancellor of the Exchequer and Secretary of State for Business, Innovation and Skills on 31 October 2012. [It] makes a series of recommendations in all aspects of government policy that affect economic growth. The

Government welcomes this report. … The core proposition … is a decentralised approach that breaks Whitehall's monopoly on resources and decision making, and empowers Local Enterprise Partnerships to drive forward growth in their local areas. … The Government confirms that it is accepting [most[] of the 89 recommendations to dramatically advance the process of decentralisation, unleash the potential of local economies, strengthen partnerships with industry and foster economic growth." (Her Majesty's Government, 2013).

Whereas governments can create national environments disposed to the successful development of cities, cities have to compete at a global level. The major cities of the world compete to attract multinational companies from all sectors, and they compete to attract the most talented people worldwide. Thus cities operate in the context of a global systems of cities, looking up to see the macrolevel opportunities and constraints and looking down to manage the meso and micro level needs and aspirations of their citizens.

[4] Global System Science

In response to the global financial crisis and the need to manage migration, employment, trade, pandemics, crime, and many other global systems, the European Commission (2013) has identified the need for a *Global System Science* on which to base policy and action for a wide range of problems affecting European citizens in the short and long terms.

In this context the Commission sought research proposals to "successfully embed scientific evidence in the policy processes for tackling global challenges:

"• Research grounded in theoretical foundations of, among others, systemic risk, decision making under uncertainty or conflicting evidence, mathematics and computer science for Big Data (including their characteristics), algorithmic game theory, cascading/escalating effects in networks, integration and visualisation of Big Data…

• Contributions to solving real world problems in one selected problem area - for instance tackling systemic risk in finance/economics, managing growth of cities and migration, or global pandemics – and in particular to tackle cross-cutting policy dependencies and interactions affecting the area of choice.

• Novel ideas and technologies to generate and better communicate the scientific evidence-base: advanced simulation of highly interconnected systems; mathematical and tools for analysing (often unstructured) Big Data; integration of the whole spectrum of structure and unstructured data; methods to deal with conflicting data and modeling results; novel data visualisation tools.

• Society/human-centred technologies, for instance, new approaches to allow citizens to actively participate in the policy process, to collectively gather and integrate data, analyse evidence, and novel methods to better judge and use scientific evidence: methods, e.g. games, gamification, and narratives to clearly and consistently convey data and modeling results and thereby to stimulate societal responses." (European Commission, 2013).

The expected impact of the programme is research rooted in policy needs, that promotes system thinking, and delivers consistent messages from conflicting data and model results. The research is expected to create a high level of uptake and use of GSS tools and methods in policy and societal processes, including in EC policies. It is also expected to increase the capacity of GSS to help integrate societal responses across policy domains and cross-cutting authorities by development of a system-wide integrated evidence base of data and models.

[5] Policy Design, Planning, and Management in Global Systems Science

By definition global systems are multilevel systems and to be realized as well-functioning entities they need to be designed, implemented, and managed.

Global Systems Science cannot just try understand subsystems isolated at local at levels since it must try to understand how these subsystems interact bottom-up and top down from local to global levels. A formalism for representing multilevel dynamics is necessary if not sufficient for Global Systems Science.

The design process is exactly one of creating a formalism to represent multilevel systems, where the dynamics at every level are explicit with known interactions between higher and lower levels. The blueprint for a design cannot have levels missing and interactions ignored.

Global systems such as cities are clearly designed at the micro and meso levels. There is no theory for the emergent behavior of global systems of cities and creating this science is one of the challenges set by the European Commission. If there is some advantageous way of designing the interactions of European cities it is not known. Nor is it known if policies that are advantageous to some cities may be disadvantageous to other cities or other subsystems of 'Europe'.

A major challenge for Global Systems Science is to understand the dynamics of global systems at the macro level and integrate this knowledge with the dynamics of the system at meso and macro levels. Any attempt to test this knowledge by applications involves creating real systems, *i.e.* designing and implementing them. A consequence of this is that Global Systems Science is inextricably entangled with design, and that design should be seen as part of the methodology of Global System Science.

[6] Conclusions

A new science of Global Systems has been proposed by the European Commission to enable it develop policies in response to the many European problems that involve systems operating at local, national and global levels. This science has to be transdisciplinary and integrative, able to combine heterogeneous knowledge from many source. Of necessity this science will be able to integrate the dynamics of multilevel systems at all levels.

Policy Design is the formulation of visions of hypothetical futures in the context of planning and management. It is argued that the only way to test the new science, and indeed the rationale for it, is the practical applications in which new systems are created based on it. The creation of the artificial is design. Design always involves explicit representation of systems at all levels, where the interactions between micro, meso and macrolevels are well defined and explicit. The design process provides the *method* to build multilevel systems in a disciplined and replicable way. Thus *Policy Design must be recognised as an essential part of the methodology of Global System Science.*

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