

Complexity at the Social Science Interface:

Introduction to a Special Issue on Complexity Science and Social Policy

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Abstract

This paper introduces a special issue of *Complexity* dedicated to the increasingly important element of complexity science that engages with social policy. We introduce and frame an emerging research agenda that seeks to enhance social policy by working at the interface between the social sciences and the physical sciences (including mathematics and computer science), and term this research area the “social science interface” by analogy with research at the life sciences interface. We locate and exemplify the contribution of complexity science at this new interface before summarising the contributions collected in this special issue and identifying some common themes that run through them.

Introduction

Coping with the global-scale social policy challenges of financial instability, food security, disease and healthcare, climate change, sustainability, demographic change and migration, pervasive web and information technology, transnational governance and security, among others, will involve dealing effectively with large-scale complex systems made up of many parts interacting and adapting in sometimes subtle ways over significant timescales. People are perhaps the most critically important components of all of these systems. This means that their study is a topic for social science.

However, the issues involved in each of these policy areas transcend disciplinary boundaries and making progress will require a significant interdisciplinary effort. Much of the research that is required to address them is taking place at a new interface, where collaboration between economists, demographers, sociologists, etc., is supported and catalysed by tools and concepts from the physical sciences, mathematics, computer science and engineering. In the same way that research at the life sciences interface has revolutionised biology and medicine since the turn of the century, research at the “social sciences interface” has the potential to transform our ability to answer questions about important social, socio-economic, socio-ecological and socio-technological systems.

This special issue brings together current research papers that share a complex systems perspective and bring complexity science tools to bear on important issues in social policy. In this introduction we briefly frame the special issue before describing some of the contributions made by the papers collected within it.

The relevance of complex systems thinking to policy is not new. Perhaps one of the most interesting (and certainly one of the most systemic) examples of this type of interaction took place in Chile in the 1970s, before the coup that brought Pinochet to power (see Beckett, 2008, for a more complete

account). In 1971, the recently elected Allende government employed cybernetician Stafford Beer to develop policies and decentralised systems that could effectively support a new Chilean administration attempting to reorganise national infrastructure from the bottom up. In response, Beer invented and implemented Cybersyn, a kind of national scale proto-internet built from telex machines and a single computer, designed to support the flow of information and control across Chile: an electronic “nervous system” for the entire country. The biologically inspired, network-centric thinking that motivated Cybersyn found an enthusiastic supporter in Allende who imagined, with Beer, taking steps towards a more truly decentralised power structure. Although Cybersyn was successfully implemented, the national experiment in cybernetic government proved short-lived as the military coup of 1973 ousted Allende’s administration from power and Cybersyn was destroyed.

There are many other instances of systems thinking interfacing with social policy on a variety of fronts and at a variety of levels: from Alfred Marshall’s imagined use of automated evolutionary machinery to drive the economy of 1860s Victorian England (Bullock, 2008), through policy-relevant cybernetic models such as that underpinning *Limits to Growth* (1972) and Schelling’s (1971) work on segregation, to more recent attempts to shape, e.g., education policy through the lens of complex systems ideas (Cummins, 2014).

With the rising salience of the significant systemic problems that must be tackled by contemporary social policy, a sense of expectation around complexity science has arisen that has not been felt since the middle of the last century. Against the backdrop of the 2007 financial disaster, Farmer & Foley (2008) argue for the use of agent-based models of economic and financial systems as tools for regulators and policy makers. Ramalingam (2013) makes a similar argument in the context of international development, suggesting that complexity scientists must “seize their moment to shape policy” (Ramalingam, 2014). Finally, Cummings (2013), in an (unpublished) wide-reaching exploration of the UK’s education system and its shortcomings written while he was an advisor to the UK government’s education department, repeatedly returns to systems science as a framework

within which to reimagine a modern “Odyssean curriculum”; one required in order to equip the next generation with the tools that they will need in order to deal with the systemic problems that they will likely inherit.

The complexity community is responding with renewed efforts to engage with policy, in the form of new journals (e.g., *J. Policy and Complex Systems* launched this year), new handbooks (e.g., Geyer and Cairney’s forthcoming *Handbook on Complexity and Public Policy*), new meetings (e.g., the “Models for Real World Policy”¹ meeting held at the Royal Society in London, UK, this year) and considerations of the current opportunities and challenges that face the complexity science community (e.g., Edmonds and Gershenson, forthcoming).

Special Issue Contributions

In this volume, we collect together eight new papers representing a range of different activities at the social science interface: from new models and results to new methodologies, analyses and frameworks. The papers have been developed from presentations at a conference² on ‘Complexity Science and Social Science at the Interface to the Real World’ held in September 2012 at Chicheley Hall, Buckinghamshire, UK.

The value of complexity science for policy making is of two kinds. The first involves developing, mobilising and exploiting complexity science techniques and concepts in order to pursue social policy more effectively. For instance, one might develop an agent-based model to explore how the impact of a policy option might vary with the demographic make-up of populations in different parts of a country. In this role, complexity science is, by virtue of its distinctive methods and tools, acting

¹ <http://www.csrw.ac.uk/policy-conference>

² The conference was organized by the Complexity Science for the Real World Network, P.I. Nigel Gilbert, and supported by the Engineering and Physical Sciences Research Council (grant number EP/I037741/1).

to improve our ability of evaluate and deploy social policy, and as such makes a very valuable contribution. However, there is potentially a second contribution that complexity science might make to social policy, by encouraging a reassessment of the nature and prospects for social policy itself.

Squazzoni's (this volume) contribution is of this latter category, arguing that complex systems thinking can offer an alternative to the orthodox approach to social policy which, he argues, although widespread, is ineffective: namely the expectation that social behaviour can be regulated top-down by manipulating incentives. Squazzoni's argument is that we cannot expect social policies to be successful if they treat people as an aggregate, pliable mass. Through discussion of results from social experiments and computational models he draws attention to the role of social embeddedness in influencing the outcome of social policy, arguing that "conductive" policy that exploits knowledge of social norms and organisation has more potential for success than traditional top-down control.

The systems to which social policy must apply (cities, communities, markets, infrastructure, etc.) are typically not random in their organisation, but neither are they entirely regular in their structure (unlike crystals or lattices). Since the structure they do exhibit can make a difference to how they behave and how they respond to policy interventions, it is recognised as increasingly important to reflect this structure in models and analyses, often in the form of networks.

De Caux et al. (this volume) point out that there are few models capable of generating dynamic, spatially embedded social networks that can do this job. They report work on a new method of generating such social networks and demonstrate, using simulations of disease spread, that the form of the networks generated can have implications for how network-mediated social processes unfold.

Bale et al. (this volume) present a complementary study in which a social network model is used to explore the spread of innovation in domestic energy usage (rather than disease). By examining the model's sensitivity to parameters, and in particular the structural form of the social network over which innovations and information are spread and the heterogeneity in the population's behavioural "archetypes", the model can inform policy makers interested in encouraging desired behavioural change.

Varga et al. (this volume) also confront heterogeneity in a networked complex system, this time in the context of multiple interdependent infrastructure networks. National infrastructure systems (i.e., systems that support flows of energy, transport, information, communication, control, water, waste, etc.) are, in their totality, challenging to map, model, manage, or even describe clearly and unambiguously. In their paper, the authors propose to operationalise a general approach to infrastructure in terms of "conversion points" (devices or plants that extract, convert, store, transport, etc., resource). By recasting their systems in terms of this unit, the authors are able to identify generic motifs, functions, and configurations that can be used to drive the construction of workable agent-based models. Such models offer the chance to explore high-level system properties, such as system resilience, in a tractable manner.

Kalkan, Bleda and Uyarra (this volume) exemplify the use of agent-based models (ABMs) in policy-relevant contexts, extending an ABM of innovation network dynamics in order to understand the formation of geographic clusters of economic activity. Their ambition is to inform regional policy regarding innovation and development. Cioffi-Revilla (this volume) takes a different approach, employing statistical tools (disaster force analysis and power law analysis) to identify informative trends in the occurrence of natural disasters. Here, the aim is to identify and understand trends in the onset and severity of disasters that might inform preparation and response policies.

Complex systems are inherently multi-level systems. At the minimum, a complex system can be described at one level in terms of atomic interactions and also, at a higher level, in terms of emergent systemic features that arise from these low-level interactions. The relationship between these two levels is typically opaque, at least initially, and requires careful unpicking, often in the form of bridging accounts that invoke some meso-level structures or processes that exist at an intermediate level of description (Bullock & Cliff, 2004). However, dealing with the complex systems that are relevant to social policy is typically much more complicated than this moderately familiar three-level account. Different stakeholders invoke different, mutually inconsistent articulations of the same systems. Layers of physical and environmental organisation are entwined with multiple layers of social, organisational and political agencies, changing and adapting over multiple overlapping time scales.

Forrester et al. (this volume) report from the coal face of such a system of systems (in their case an ecosystems services perspective on a Kenyan fishery system), delivering insights into the praxis that they are establishing for effective model building. Rather than attempt to directly build a “mega-model” synthesising as much of the relevant reality as possible, the authors consider a bi-modelling approach in which both top-down conceptual UML models and bottom-up agent-based models are co-created with their stakeholders in an effort to move towards simple and intelligible tools for supporting decisions.

Penn et al. (this volume) also present a methodology for mediating successfully between stakeholders and models. They employ a form of “network coding” in order to translate the results of semi-structured interviews with key industrial and political stakeholders into a network representation of the Humber region’s industrial ecology. To deal with missing data (structural holes within the network) they make use of an industrial taxonomy of “network archetypes”. The patched networks act as a locus for further stakeholder engagement and knowledge elicitation, allowing the resulting industrial ecology networks to underpin the exploration of policy-relevant scenarios, e.g.,

identification of keystone firms/technologies/sectors, resilience analysis, and the testing of potential network reconfigurations.

Conclusion

The papers contained in this special issue represent a broad range of approaches and policy areas. Contributions range from conceptual analysis and methodological advances, through agent-based models and networks science, to statistical analysis of time-series data. Policy topics span national infrastructure, industry, disease, development, and disasters. Despite this diversity there are several common themes that run through the papers.

One of these is that the works presented here do not attempt predictions or forecasts for the systems that they model. Several of the papers make explicit the notion that social systems (or socio-ecological systems, or socio-technological systems), being complex, adaptive, reflexive, etc., are not straightforwardly predictable in principle. Despite prediction often being identified erroneously as the *sine qua non* of a successful model (sometimes to be pursued even at the expense of model intelligibility, Bullock, in press), the papers collected here deliver many other types of payoff: new conceptual frameworks, insights, increased understanding, hypotheses, lessons learned, tools, techniques, and taxonomies (Epstein, 2008).

A second issue that arises several times throughout the special issue is data. The ongoing data revolution that is driving new research in many fields is also evident at the social science interface. Within the special issue, data manifests itself in different ways, whether in the form of the historical records used to parameterise models, or the expert opinions elicited from stakeholders in order to populate them. Data considerations also arise in a variety of contexts: new methods for integrating knowledge into models, new approaches to coping with poor or patchy data, and plans to expand

and build upon the datasets currently being used. In Chile, Stafford Beer had to build his own internet in order to gather the data he needed in order to fuel a complexity science policy revolution. Today the data is often ready at hand. However, just as in Beer's Chile, turning policy-relevant science into lasting policy still requires a stable and absorbent science-policy interface—one which papers such as the ones collected here are helping to bring about.

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