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The Three Domains structure of energy-climate transitions

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ABSTRACT

This paper argues that the development of energy systems rests on a combination of three different domains of socio-economic processes and associated modes of decision-making. For shorthand these are termed 'satisficing', 'optimising', and 'transforming' domains, with corresponding underpinnings found in behavioural, neoclassical, and evolutionary economics respectively. Each domain operates at different scales of time and personal/organisational/societal decision-making, and explains different characteristics of how energy systems develop. At least since the industrial revolution, the nature of energy systems has depended on government policy, and each domain implies a need for different policy instruments; the combination of all three lays the foundations for far more coherent, effective, and mutually reinforcing policies, including those required to transform energy systems in the light of environmental constraints. The approach also provides a coherent theoretical framework for understanding the conditions under which co-benefits and 'green growth' may emerge from environmental policy.

1. Introduction

Energy and climate change raise questions of extraordinary reach and complexity. Modern energy systems have brought huge benefits, yet the way we produce and consume energy is unsustainable. Responses have been limited, contested, and as yet unequal to the challenges; despite decades of policy effort, progress seems glacial. Against this background, 'sustainability science' and transitions research has become a major research field, with much of it represented in this journal.

This research increasingly highlights issues of individual and social behaviour, and processes of change in technologies and systems. These tap into wider literatures on social science, and innovation systems, respectively. A striking feature however is the difficulty of connecting these broad areas of research to another, perhaps even larger, body of thought and literature, grounded in economic ideas of balancing aggregated costs and benefits assuming optimising behaviours and, very often, 'representative agents', and the formal expression of these ideas through mathematical representations and computational modelling.

The relative paucity of cross-references between mainstream economics and these different dimensions of sustainability/transitions research literatures (and associated behavioural and social sciences), is however striking. Indeed some of the leading transitions management literature positions itself as "contrary to neoclassical economic theory …" (Arentsen et al., 2002), for example. One of the largest social science studies, resulting in the four-volume '*Human choices and climate change*' (Rayner and Malone, 1998) produced ten core recommendations in which the closest they came to engaging with classical economic perspectives was the need to 'design policy instruments for real-world conditions rather than trying to make the world conform to a particular model'. Even the 2000-page Global Energy Assessment (GEA, 2012) seems unclear about the

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role of neoclassical models and markets in relation to energy transformation. It is almost as though processes of social and technological change and transformation exist on a different planet from that which spawned the dominant branches of mainstream economic thought and modelling.

This poses a major analytic challenge, particularly when applied to the interplay of complex systems like energy with climate change and wider aspects of sustainability. Markets in one form or another – initially informal, and later formalised in national structures of property rights and regulatory apparatus – have been a crucial feature of economic and social development. The apparent dominance of national markets, and international trade, is testament to the power of economic incentives in social, and indeed, technological processes. Theories of change and transformation which do not have a clear role for market forces thus would seem to lack an important ingredient, and fail to benefit from vast intellectual investment in the development of economic thought.

At the same time, to the extent that the wide literatures on social and technological change have developed with limited direct reference to neoclassical economic theories, this points to important factors in such change processes which are very different from the norms of mainstream economic thought; traditional economics is, likewise, seriously incomplete in the arena of understanding innovation and transitions. A testament to this is the representation of innovation as a 'residual' in the foundational model of growth theory (Solow, 1956), and uncertainty about how to represent it both in modern growth theories, and indeed in energy-climate modelling (Edenhofer et al., 2006).

The limited intellectual integration between mainstream economics and much of the sustainability/transitions literature, and associated communities, also impedes effective policy. Much 'western' policy has been guided by the theories of classical economics — which has helped to deliver many of the benefits of modern energy systems, along with their attendant problems. This is based heavily on assumptions of rational economic behaviour trading off and balancing costs and benefits. Yet there is no simple way of summarising the costs associated with changing energy systems: as outlined in this article, they seem still to embody large inefficiencies and damaging side effects, and their development comprises a complex mix of uncertainty, innovation, inertia and irreversibility, with multiple objectives to be delivered including energy access and security.

Also, all energy markets – whether competitive or not – are already intimately entwined with public regulations and publicly-governed investments in relevant sectors (eg. energy, transport and buildings infrastructures). An intellectual framework which treats perfect markets as the reference point and everything else as some kind of 'market failure' thus risks also narrowing policy understanding of issues where markets are embedded in complex physical and institutional systems. But symmetrically, a framework without a clear role for market forces is likely to have an even harder time informing and influencing coherent policy.

The different communities of mainstream economics and sustainability/transition research are, however, increasingly united by a belief that societies are not delivering a sufficient, or sufficiently effective, policy response to challenges like climate change. This paper argues that the relative paucity of progress is intimately linked to two intertwined gaps. One is the gap between important realities of energy systems (and associated global environmental challenges) and basic neoclassical assumptions of optimising, representative agent behaviour underpinning a 'first best' construct. The other gap is that between neoclassical economics and the 'alternate' analytic approaches evident in much of the sustainability literature. In that sense, failure of policy reflects inadequacies of theory, linked with insufficient attention to the empirical characteristics of energy systems and industrial innovation. At heart we argue that the most important theoretical failing concerns the (lack of) *integration* of existing ideas — and a reluctance to understand and accept the boundaries within which different theories are valid. For the world is far more complex than any single theory assumes, and sustainability challenges operate at scales which transcend anything that humanity has had to face, or even think about, before.

This is a problem, but also an opportunity. This paper summarises the main structural foundations of the authors' book *Planetary Economics* (Grubb et al., 2014), which argues that a deeper, more integrated understanding that embraces and combines at least three fundamentally different theoretical perspectives can inform more effective responses.

2. On different economic theories and processes

The literature on 'sustainable development', and related discussions of sustainability and transformations, draw upon many different theoretical frameworks and discourses. Here we are concerned with those which can be considered as involving a significant element of economic concepts and issues, broadly interpreted.

There are, and have been, many such theories. The recent popular guide to economics by Chang (2014), for example, identifies nine main classes of economic thought: behavioural, Keynesian, Austrian (Hayekian), classical, neoclassical, Marxist, Schumpeterian, developmental, and evolutionary. Each has had its adherents, and their popularity has varied over time. Some of the commonalities and differences can be quite surprising: classical, neoclassical and Marxist economics, for example, all share the similar currency of assuming the essential rationality and predictability of economic systems, even if they suggest different prognoses and policy implications. Conversely, whilst Hayekian and neoclassical economics actually start from very different philosophies, they converge on the fundamental value of markets as the central structure for economic systems.

This is not the place to discuss these different theories. Rather, we start from the recognition that the combined power of classical, neoclassical and Hayekian logic (and mathematical tractability), along with the evident failures of central planning, have given markets a dominant role in modern economic thought and policy, along with the reasoning that a 'perfect market' is the optimal state. This has thus become the 'benchmark' against which other aspects of economic systems and policy prescriptions are typically assessed. In terms of impacting upon the wider economic discourse, therefore, a key question is how sustainability and transitions literatures relate to the dominant concepts of what has become conventional economics.

In much of the economics literature, the kinds of issues often addressed in sustainability/transitions literature – like