China’s Climate Change Dilemma: Policy and management for conditions of complexity.

Abstract: The nature of China’s climate change dilemma is well-known: Climate change is exacerbating environmental devastation in China, but expanding mitigation efforts beyond the ‘no regrets’ position would pose new challenges to continuing economic development. National environmental measures often face strong resistance from subnational authorities, which are incentivized by highly stable growth and development goals.

This paper applies complex adaptive systems theory to China’s climate change dilemma. Key insights of complexity theory – (i) the decisive role of systemic parameter settings (rule sets or minimum specifications) in shaping system behaviour and (ii) the creative capacity of non-hierarchical organization – should encourage policy responses that reset incentives and harness creativity beyond government.

Several instances are examined where incentive-focused, non-hierarchical initiatives have been effective in promoting climate-friendly behaviour. They include voluntary energy efficiency commitments undertaken by corporations, partnerships between local governments, clean-tech firms and international specialists, and ‘local issue-bundling’ to enlist public support for climate change mitigation.

Introduction: China’s climate change dilemma

China’s climate change dilemma turns on a well-known misalignment of incentives: climate change is exacerbating environmental devastation in China, but expanding mitigation efforts beyond the ‘no regrets’ position would pose new challenges to continuing economic development. National environmental measures often face strong resistance from subnational authorities, which are incentivized by highly stable growth and development goals.

This paper applies principles derived from complex systems theory to China’s climate change dilemma. The key attributes of complex adaptive systems are explained, and it is argued that human organizations, as well as whole societies, can be usefully considered as complex systems. The insights that complexity theory offers into the management of human systems are discussed.

Several case studies are examined, involving voluntary energy efficiency agreements, private-public partnership and ‘issue-bundling’ initiatives and city-to-city networks. These initiatives, characterized by new patterns of incentives and new forms of non-hierarchical organization, have been effective in promoting climate-friendly behaviour, and illustrate the potential value of policy that is consonant with the operation of complex adaptive systems. The potential for expanding complexity-appropriate policy responses is also considered.

Complex adaptive systems

Complexity is concerned with the processes by which systems change. Relevantly, there are two key propositions: 1. Systemic change will be determined by competing 'attractors' (i.e. when systemic actors are drawn or attracted by new or intensified incentives, their behaviour will correspondingly change); 2. The responses to changed attractors within a system tend to be 'nonlinear' – i.e. 'a very small change in the independent variable can result in a very large – even infinitely large – response in the dependent variable' (Priesmeyer 1992: 15, 21-22). Changed attractors may result in 'regime shift', whereby a system can 'internally switch between different self-reinforcing processes that dominate how the system functions'. 'Resilience' refers to the degree of pressure a system can sustain before such a shift takes place (Norberg & Cumming 2008: 2-3).

The concept of 'complex adaptive systems' focuses on the 'capacity of the system to change in response to prevailing (and anticipated, where possible) conditions by means of self-organization, learning, and reasoning' (Norberg & Cumming 2008: 2). Complex adaptive systems share a number of key attributes: Their components will simultaneously be members of multiple sub- and supra-systems; the behaviour of systemic actors will be governed by rule sets, or system control parameters; the systems and their members are adaptive, with both the members and the rule sets changing over time; and systemic actors will self-organize 'based on internal interaction rules and external constraints, result[ing] in more or less stable patterns, with capacity for massive change' (Minas 2005: 34-35).

This last attribute is crucial. Self-organization is driven by nonlinear feedback loops, which interact with each other (Richardson 2008: 14). Novel behaviour is thereby not compelled, but rather 'emerges as a result of the rich interaction over time of multiple component agents and of the system with its context' (Minas 2005: 35). Once system parameters change, systemic adaptation occurs 'for free' (Kauffman, in Glor 2007: 36). Adaptation does not result in an eventual, optimal state, as in Game Theory, but is rather an ongoing 'chain of responses without any obvious end' (Allen *et al* 2006: 2).

Society and organisations as complex adaptive systems

The insights derived from complexity theory have been applied to many disciplines across the physical, biological and social sciences, and have been useful in gaining a clearer understanding of phenomena as diverse as 'evolution, meteorology, ecology, traffic congestion on roads, traffic congestion in computer networks, urban demographics, the frequency and scale of avalanches, stock prices, and the onset of financial crisis' (Higgs 2001: 4). Complexity theory has been usefully applied also in a variety of organization science contexts, such as nascent entrepreneurship (Lichtenstein *et al* 2007), public health system reform (Minas 2005), the development of research communities (Allen *et al* 2006) and the tensions within multilateral institutions (Higgs 2001). Characterizations of organizations (and societies) as complex adaptive systems stress the diversity of systemic actors, which are 'loosely and often nonlinearly linked and [which] produce emergent patterns of systemic behavior' (Meek *et al* 2007: 25). Human complex systems, like their counterparts in nature, are characterized by multiple levels of organization – 'the individual, team,

divisional and group level and also in a much larger web of external complex adaptive systems – their economic, social and political environments' (Carlisle & McMillan 2006: 3). The inflexible application of natural science complexity models to human organization would strain those models to breaking point. Instead of testing these models to destruction, complexity has been applied to social systems as an analogical 'way of thinking' – a conceptual lens rather than a 'theory of everything' (Baskin 2007: 112).

Complex systems theory has yielded a number of insights into the management of human organization – firms, governments and whole societies:

Minimum specifications: Because '[m]anagers cannot control environments', the tendency to micromanage will often be counterproductive (Carlisle & McMillan 2006: 6). The existence of 'rigid procedures, bureaucratic regulations and hierarchical controls' tends to 'hamper' innovation (Carlisle & McMillan 2006: 5). Hierarchical organizational culture tends to discourage self-organizing innovation (Glor 2007: 44). Because causation in complex systems is nonlinear, the introduction of detailed and inflexible regulations will often produce unintended and unwelcome results. Instead, complexity suggests that

> [p]rogress towards goals that are desirable but difficult to achieve can occur through applying to the system a few simple, flexible rules, sometimes referred to as minimum specifications … Minimum specifications leave room for creativity and innovation. They encourage discussion about how they are to be achieved, thereby increasing connectedness and facilitating shared views of

> what is to be done. If minimum specifications focus on system-wide targets, they encourage generative relationships and the emergence of solutions that are relevant to local conditions (Minas 2005: 37).

Rich interactions: Minimum specifications allow systemic actors 'as much scope and support as possible to self-organize into "cells" or groups and to network' beyond conventional 'silos' (Carlisle & McMillan 2006: 7). The development of 'mission-driven network[s]' is encouraged (Meek *et al* 2007: 33). Such interactions hold out the prospect of 'yield[ing] new learning relevant for innovation' (Surie & Hazy 2006: 13). The encouragement of localized interactions, as in the PPP case study below, also allows managers to experiment with new incentive settings while limiting 'the consequences of mistakes or underdeveloped ideas' (Surie & Hazy 2006: 19).

Self-organization: Whereas, in the conventional narrative, '"change" is the dragon slain by each heroic incoming CEO [or president], or yoked to his triumphal chariot' (Hodge & Coronado 2007: 3), complexity suggests that management is essentially an enabler: by altering systemic parameters and encouraging rich interactions, managers can expedite shifts to new and more desirable 'structural attractors' (Allen *et al* 2006: 15). Complexity-aware management utilizes self-organization, rather than attempting to override it.

Emergent leadership: Finally (and most dramatically), complexity challenges conventional management thinking by holding out the possibility that leadership is itself 'an emergent event', 'in which knowledge, action preferences, and behaviors change, thereby provoking an organization to become more adaptive' (Lichtenstein *et*

al 2006: 2, 4). This possibility is illustrated by Allen's example of the emergence, in academic writing, of 'clusters' of researchers and papers which endorse particular ideas and ignore or dismiss others. The publication of a 'single "outlying" paper' can begin this process but cannot shape or direct it (Allen *et al* 2006: 15). Similarly, Kelly's account of the development of open source software concludes that innovation is driven by 'a spectrum of attitudes, techniques and tools that promote collaboration, sharing, aggregation, co-ordination, ad hocracy and a host of other newly enabled types of social co-operation' (2009: 122). The implication of this perspective is that 'leadership can occur anywhere within a social system' (Lichtenstein *et al* 2006: 4). Innovation and the setting of system parameters are not the exclusive preserve of government, as the case studies below illustrate.

Richardson suggests that the key features of complex adaptive systems 'may be common sense to the experienced manager' (2008: 25). Perhaps so. The role of incentives in determining behaviour and the creative capacity of non-hierarchical organization are not observations unique to complexity theory. But the formalization of suppositions can itself be useful, as 'a check on our intuition. Sometimes it shows that our intuition is wrong' (Barrett 1998: 318). In any case, the complex systems perspective is arguably a 'profoundly different way' of conceptualizing management and policy, one which breaks with the received wisdom of organization science (Richardson 2008: 25). As Baskin observes, complexity – with its 'deep sense of interconnection and causality as a product of the entire system' – may resemble 'Chinese philosophy' more closely than it does the 'linear causality of traditional Western science' (2007: 112).

Rich interactions: Harnessing complexity in climate change policy

The following case studies hint at the enormous potential for effective, complexity-appropriate climate change initiatives in China. The initiatives described share several characteristics: Rather than prescribing detailed rules, they involve the setting of broad, systemic incentives; the actors involved self-organise, with minimal direction from national government; leadership, or movement towards desired ends, is indeed a collaborative rather than a centralised act; and the projects involved are (to varying degrees) localised, responding to local conditions but with the potential for expansion.

Nanjing voluntary energy efficiency agreements: Beginning with an initial phase to assess feasibility in 2005-2006, a voluntary energy efficiency programme has been developed in Nanjing. Firms entered into agreements with the Nanjing Environmental Protection Bureau (EPB) in 2008. Each committed to an energy intensity reduction target of 3-5% by 2009 on 2007 figures. This project is one of the first of its kind in mainland China and is based on the recognition that, with 'few exceptions, implementation of top–down policies at the local level is weak' (Eichhorst & Bongardt 2009: 1859). Project-designers have therefore concentrated on setting incentives to encourage effective participation.

The agreements were flexible, accounting for the actual capacity of firms to address issues, as well as particular local and sectoral requirements. Firms were motivated to participate by several factors, among which improving relations with the Nanjing EPB 'turned out to be a major driver for all of them' (Eichhorst & Bongardt 2009: 1863). Additionally, the agreements gave firms opportunities to improve their own

technical know-how, by exchanging knowledge with the public authorities on specific problems (Eichhorst & Bongardt 2009: 1857). During the pilot phase, close 'technical assistance' and 'process management' assistance were provided by Dutch SenterNovem experts (Eichhorst & Bongardt 2009: 1857). 'International expertise and experience' in reducing GHG emissions was reported as a major incentive for government in the pilot programme (Eichhorst & Bongardt 2009: 1863). Additionally, because Nanjing has prestigious 'Environmental Model City' status, its government has more than the usual incentive to achieve environmental targets.

Following the Dutch experience, each agreement focused on 'strong process management', with each company setting up an 'Energy Action Team' (with senior management participation) responsible for implementation, monitoring and liaising with the EPB (Eichhorst & Bongardt 2009: 1858). The project has been supported, rather than frustrated, by the Ministry of Environmental Protection, which has avoided detailed implementation guidelines and has 'encouraged local innovation', even allowing for 'informal contracts' between the EPB and firms (Eichhorst & Bongardt 2009: 1861).

Eichhorst and Bongardt report that the Nanjing model may be expanded to other localities if it is judged successful. In September 2008, the National Development and Reform Commission flagged the possibility of including voluntary agreements in future national energy policies. Eichhorst and Bongardt conclude that the

> partnership approach of voluntary agreements showed to have the potential to overcome both the institutional and policy barriers to implementation of top–

> down policies by developing new spaces of communication and dialogue between EPBs (environmental protection) and state-owned industry (economic development). In this context, focusing on the management procedures for implementation was essential (Eichhorst & Bongardt 2009: 1864).

The Nanjing case shows that effective voluntary agreements can align the incentives of environmental and economic agencies, attract firms to participate, encourage knowledge transfer from the West and design appropriate local solutions. The voluntary agreement model also responds to the limited reach of national command-and-control measures.

Local incentive shifts – private-public partnerships and 'issue-bundling': In mainland China, the central government has seen its ability to control emissions practices reduced by the privatisation of many polluting state-owned enterprises (Koehn 2008: 56). As a consequence, subnational government initiatives have assumed greater importance. However, subnational government agencies will often be dependant on revenues from polluting enterprises, reducing their willingness to take such initiatives.

Two developments have had the effect of incentivizing subnational governments to improve local energy practices. The first development resets economic incentives. Following China's accession to the WTO, local governments have been empowered to solicit and authorise foreign and joint-venture investments in green technologies. Such investment creates employment and can further innovation. For example, provincial governments have subsidised Suntech silicon photovoltaic cell factories in their localities. Governments have also been active in securing the capital and

knowledge transfer necessary for localized wind turbine projects. The injection of foreign capital and technology, together with the growing ability of clean energy installations to provide employment and efficient energy, weakens government dependence on polluting installations (Koehn 2008: 69).

The second development concerns the political pressures on subnational governments. Concerns over public health and environmental degradation are responsible for many of the thousands of protests that occur in China each year. Koehn suggests that this mounting unrest has 'opened a new window for subnational framing of GHG-emission mitigation' (Koehn 2008: 63-64). For example, officials from Liaoning province and Benxi city linked emissions mitigation with public health concerns. Citing inordinately high respiratory disease rates in industrial areas of Benxi, the officials launched a 'green schools' initiative and transformed the city, which previously 'could not be seen on satellite images due to the heavy smog', into a 'model' for 'source-point pollution control and prevention' (Koehn 2008: 68). The motivation of avoiding local unrest is likely to grow if China's environmental problems intensify. Importantly, the urge to act is complemented by other incentives, notably the desire to earn 'model city'-style plaudits from provincial and national authorities. As the Benxi example shows, popular unrest can create new opportunities for policy entrepreneurs in subnational governments to further their agenda.

In both developments, emerging attractors (WTO accession and the availability of foreign capital and expertise in the first case and intensifying health concerns in the second case) have prompted a nonlinear response: the creation of climate-friendly projects. The nature and strength of such emerging attractors will vary from place to

place, as will the degree of resistance to them (determined, *inter alia*, by the reliance of subnational governments on revenues from polluting firms).

City-to-city networks: Local governments have also begun to engage in a form of *ad hoc* subnational diplomacy, forming associations amongst themselves to reduce GHG emissions. Two such initiatives are the Cities for Climate Protection (CCP) programme and the C40 Cities Climate Leadership Group (C40).

The CCP programme is run by the International Council for Local Environmental Initiatives (ICLEI), which was established in 1990. The CCP programme was established in 1993 and involves more than 676 local authorities from around the world. The total area that they cover accounts for over eight percent of global GHG emissions (Betsill & Bulkeley 2006: 143).

CCP participants commit to five 'milestones': (1) Conduct a baseline emissions inventory and forecast; (2) Adopt an emissions reduction target for the forecast year; (3) Develop a Local Action Plan; (4) Implement policies and measures; and (5) Monitor and verify results. In return, participants receive ICLEI support in the form of software for monitoring GHG emissions and information regarding best practices.

There are indications that the CCP programme has value. Its United States participants reduced their GHG emissions by an average of 100,000 metric tonnes per city in 1999. Australian participants reduced emissions by 78,182 metric tonnes during 2000-2001. In both countries, GHG emissions increased on average during these periods (Betsill & Bulkeley 2006: 144). In 2007, ICLEI released a 'local

government operations protocol for the quantification and reporting of greenhouse gas inventories' (Dodman 2009: 188).

Betsill and Bulkeley argue that the CCP programme exemplifies 'a new form of environmental governance', by creating 'a new sphere of authority through which the governance of climate change is taking place and which is not bound to a particular scale' (Betsill & Bulkeley 2006: 144, 151). Certainly, in some senses, the CCP programme challenges the traditional state-centric model of organization. CCP bypasses states in an issue area of national concern. Further, by creating linkages across national borders and establishing regional secretariats, ICLEI could be depicted as usurping the national government prerogative of conducting external affairs. Rather than perceiving a threat, however, national governments should look on the activities of ICLEI and its peers as necessary complements to their own efforts, adding a 'crucial layer to the complexity of global climate governance' (Pattberg & Stripple 2008: 379). Self-organizing public networks have stepped into the breach left by inadequate national leadership. By their very existence, they demonstrate that if the old ways of command-and-control management worked, they would have worked by now.

Currently, no Chinese municipality participates in the CCP programme. CCP participation has the potential to augment subnational government initiatives of the kind described above. Additionally, there is scope for Chinese municipalities to create their own networks, if political considerations preclude involvement in the CCP.

The C40 was formed in 2006 as a partnership between the Large Cities Climate Leadership Group and the Clinton Climate Initiative (CCI). The CCI is pledged to provide the C40 cities with emission mitigation 'solutions', including: 'Pooling the buying power of cities' (to lower the price of energy saving products); 'Mobilising expert assistance to help cities develop and implement programmes'; and 'Creat[ing] and deploy[ing] common measurement tools so that cities can establish a baseline on their greenhouse gas emissions, track reductions and share best practice'. The C40 has pooled the 'climate change action plans' of its participating cities, which include Beijing, Shanghai and Hong Kong.

Going forward: Climate change policy for complex adaptive systems

The application of complex systems theory suggests what some of the contours of China's solution to its climate change dilemma will be. Complexity also suggests what the solution will not be.

The solution will not be solely to introduce new regulations, for China already has 'some of the most advanced laws' on renewables, clean production, environmental impact assessment and pollution control (as Ministry of Environmental Protection vice minister Pan Yue says: 'In theory, we have solved the problems. Now, the challenge is to make this compulsory') (Warburton & Horn 2007: 51).

Nor is more rigorous enforcement, on its own, the appropriate solution. Such is the strength, and stability, of local economic growth incentives that the adversarial enforcement of national regulations is unlikely to succeed (and not without incurring

prohibitive costs): ‘If resistance is seen as the reason [for thwarted change] then the solution is to battle against and to overcome resistance, wherever it is to be found. However, in [complex adaptive systems], behaviour follows attractors in the system’ (Minas 2005: 37).

Additionally, complicated (and perhaps competing) regulations can have baneful consequences: the ‘[n]umerous experiments, competing standards, and alternative microlevel approaches’ adopted in China in recent years have, according to Steinfeld, compromised the ‘internalisation of the externalities associated with national energy choices’ (2008: 145).

Policy solutions, as the above case studies suggest, will involve interventions to create, identify and strengthen incentives that attract local governments, firms and civil society toward climate-friendly behaviour. Such interventions should encourage the creativity of systemic actors (in the form of, for example, non-hierarchical networks and Corporate Social Responsibility) and should allow for local variation. Policymakers should be flexible in their initiatives and be prepared to respond to inherently unpredictable outcomes, both desirable and malign.

Major trends augur well for the development of complexity-appropriate climate change policy. Intensive technology transfer and internal innovation have resulted in the development of substantial clean energy industries in China. It is now possible to speculate that China may become a market leader in energy efficiency standards:

> In setting and enforcing tough energy-efficiency standards for consumer appliances and vehicles, the government leaves foreign producers little choice but to comply and innovate. Similarly, to the extent that domestic producers are forced to meet these standards, they develop core competencies in the design, development, and production of energy-efficient products, competencies for which global markets will only grow as energy constraints become more binding on all nations in the future (Steinfeld 2008: 145-46).

A complementary development has been the rapid and impressive upgrading of China's scientific and diplomatic personnel involved in climate change. Policymakers now commonly recognise that, in the long-term, mitigating climate change and continuing economic growth are not imperatives pointing in opposite directions, but are two sides of China's developmental coin (Yu 2008: 88).

These developments have made the economic incentives favouring further clean energy development stronger, with richer creativity within the system on which to draw. This suggests that complexity-aware policy is becoming not only more appropriate, but also easier to do. While mitigation commitments beyond the 'no regrets' position have yet to be made, economic incentives are pushing China beyond the common G77 position, toward a stance that may come to be recognised as 'G77-plus'.

Conclusion

The lesson of complex systems theory is that system behaviour changes when incentives (attractors) shift, with innovation often emerging from surprising places. In climate change policy, the task of the policymaker is to devise a set of minimum specifications or rule sets that foster system connectedness and allow for the promise of non-hierarchical creativity to be realised. Innovations will emerge from the interactions of national and subnational governments, businesses, epistemic communities and civil society.

The examples of voluntary energy efficiency agreements, local issue-bundling, public-private partnerships and city-to-city networks should encourage policymakers to apply a deft, but light, touch to the climate change dilemma. In each case, creativity beyond government was harnessed – the expertise of foreign advisers, the know-how of local innovators, the pooled experience of civil societies and non-government organisations and the outrage of citizens protesting health problems. A continuing challenge is how to propagate or scale up these innovations so that they have national and supra-national impact.

If the counsel of complexity is heeded, with its stress on ‘flattening hierarchies, facilitating informal networks, and diversifying agents’ (Meek *et al* 2007: 25), people and society will play a fuller part in the development of climate change solutions.

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