LAND RE-USE, COMPLEXITY AND ACTOR-NETWORKS:
A FRAMEWORK FOR RESEARCH

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Abstract: This paper will present a conceptual framework for the examination of land redevelopment based on a complex systems/networks approach.

As Alvin Toffler insightfully noted, modern scientific enquiry has become exceptionally good at splitting problems into pieces but has forgotten how to put the pieces back together. Twenty-five years after his remarks, governments and corporations faced with the requirements of sustainability are struggling to promote an 'integrated' or 'holistic' approach to tackling problems. Despite the talk, both practice and research provide few platforms that allow for 'joined up' thinking and action.

With socio-economic phenomena, such as land redevelopment, promising prospects open up when we assume that their constituents can make up complex systems whose emergent properties are more than the sum of the parts and whose behaviour is inherently difficult to predict. A review of previous research shows that it has mainly focused on idealised, 'mechanical' views of property development processes that fail to recognise in full the relationships between actors, the structures created and their emergent qualities. When reality failed to live up to the expectations of these theoretical constructs then somebody had to be blamed for it: planners, developers, politicians.

However, from a 'synthetic' point of view the agents and networks involved in property development can be seen as constituents of structures that perform complex processes. These structures interact, forming new more complex structures and networks. Redevelopment then can be conceptualised as a process of transformation: a complex system, a 'dissipative' structure involving developers, planners, landowners, state agencies etc., unlocks the potential of previously used sites, transforms space towards a higher order of complexity and 'consumes' but also 'creates' different forms of capital in the process.

Analysis of network relations point toward the 'dualism' of structure and agency in these processes of system transformation and change. Insights from actor network theory can be conjoined with notions of complexity and chaos to build an understanding of the ways in which actors actively seek to shape these structures and systems, whilst at the same time are recursively shaped by them in their strategies and actions.

This approach transcends the blame game and allows for inter-disciplinary inputs to be placed within a broader explanatory framework that does away with many past dichotomies. Better understanding of the interactions between actors and the emergent qualities of the networks they form can improve our comprehension of the complex socio-spatial phenomena that redevelopment comprises. The insights that this framework provides when applied in UK institutional investment into redevelopment are considered to be significant.

Keywords: chaos theory, complex systems, actor-networks, redevelopment, land re-use.

1. Introduction

The interest in developing a 'holistic' understanding of property development is not purely academic. Sustainability concerns are now part of mainstream policy agenda, the imperatives for 'socially responsible investment' are exerting increasing influence on geographical and sectoral capital flows, whilst corporate training courses and educational programmes focus as much upon human resource management as they do upon the techniques of financial appraisal or portfolio construction. Real estate development and investment now comes with a host of economic, social, environmental and ethical 'baggage'. These kinds of linkage (beyond the purely economic) give increasing credence to the view of Guy and Harris (1997) who have argued that property markets should be viewed

as, "cultural entities, shaped as much by tradition, taste, technological and social innovation as by immediate levels of availability and demand" (ibid, p. 126). In order to research this 'new' world of development and investment and explore its dynamics, we need to consider what sort of conceptual framework would be flexible enough to take all these different factors, actors and their interrelationships into account without collapsing under their sheer complexity and dynamism.

Our approach to this task starts with a relatively simple conceptual suggestion: if investors, developers, commercial agents, and others involved in the production of the built environment build and work through networks, which are tied with other similar networks, creating 'networks of networks', then perhaps beliefs, ideas, practices and new 'ways of doing things' can be 'constructed' and distributed this way, thus facilitating the creation and evolution of new 'development paradigms'. To give a crude example, which we are currently exploring, investing in brownfield redevelopment schemes can start as a niche market but then have the potential to spread through a process of imitation, learning, adaptation, evolution and extinction of the actors and networks involved.

Although the focus of our research is on real estate investors and their treatment of commercial space built on previously used land, we believe that the framework can be used to explore network dynamics in any arena of real estate development. However, and in the immediate context of real estate investment processes, we need to find out how investors construct (and deconstruct) their networks, how they participate in those networks, the structure and the nature of those networks and how they relate and affect space. We might have investors participating in more than one network (i.e. networks of investors only and wider networks involved in the production of the built environment) some of them will act as major nodes or 'network-builders', linking up the whole structure together, whilst others will be peripheral or 'un-enrolled'. This then is the nature of the conceptual 'hunch' that has stimulated us to explore these issues. The hunch is, however, not without precedent.

Some of the ideas and insights we are using, on chaos theory, complex systems and networks, have been in the social science agenda for quite a long time. There is a long history of network approaches in sociology, from Simmel's 'web of group affiliations' to recent 'structural analysis' and its variants (Wellman & Berkowitz, 1997, p.22). In economics, Schumpeter's 'creative destruction' is a good example of an early approach that in certain ways conceptualised the economy as, what we would call today, an evolving complex adaptive system. Much more recently, Ilya Prigogine explicitly referred to the similarities of his work on self-organising systems and non-equilibrium thermodynamics with the phenomena of the social world (Prigogine & Stengers, 1984). Sheller (2004, p.49) calls for a "...move beyond the overly rigid model of networks in order to grasp social communicative systems in terms that indicate their fluid morphology". From the mid-1980s, the research agenda of the Santa Fe Institute has promoted the exploration of the economy along those lines (Anderson et. al., 1988; Arthur et. al., 1997). Even more recently, physical scientists like Barabasi (2002) or Watts (1999) have begun to boldly explore the 'physical laws' of networks. As network approaches merge with chaos and complexity studies to form a new paradigm and become more mainstream on the way, we should expect to see more and more of otherwise disparate approaches or ideas coming together under the same umbrella. It is the way these ideas are used within a broader framework and the insights gained from this use that are new.

This paper has six parts. Following this contextual introduction, we take a brief look at some of the existing literature on how the development process might be conceptualised. This provides us with some criteria we need to address in our approach. Then we discuss the links between realist philosophy and chaos theory in the social sciences, mainly based on the work on Bhaskar (1978), Sayer (1992) as well as Harvey and Reed (1997). The next part presents the basic ideas behind complex adaptive systems and demonstrates the links between them and networks. We then move on to link our discussion with reference to the insights from Actor-Network Theory, which explores the relational properties of networks and seeks to break down a number of dualisms, including that between 'structure' and 'agency'. It also has things to say about how network relations link recursively with time and space. A concluding section draws out the main points of our argument and suggests a way forward in understanding development processes as a dynamic configuration of network relations.

2. Why a New Approach?

Although the developments we described in our introduction are epistemologically interesting, the two basic questions of more immediate relevance that we need to respond to are:
- why do we need yet another framework for property research?; and
- what does it have to offer to the examination of property development processes?

To answer those questions we can start with the reviews provided by Gore & Nicholson (1991), Healey and Barrett (1990) and Healey (1991) who comprehensively examined existing models of property development over a decade ago. This work argued that existing theoretical traditions were not fully able (in themselves) to link-up the different spatial scales within which property development occurred and/or were not adequately addressing the issue of structure-agency relations. Consequently, Healey (1992) proposed a new 'institutional' model of the development process in an attempt to tackle those issues.

Healey's efforts, coupled with the revival of institutional and evolutionary approaches in economics, sparked the interest of mainstream property research into institutionalism to such an extent that Ball, Lizieri and MacGregor (1998) devote a chapter of their seminal textbook to various types of institutional analysis. They recognise that, "The... omissions of the competitive approach to property markets seem good grounds to consider the relevance of a broader range of theories to property supply" (ibid, p. 107). In another paper, Ball launches a substantial counter-critique of institutional approaches (Ball, 1998) and points to various branches of the mainstream that try to incorporate institutions into their research agendas. He recognises that institutionalism could be useful, "...when studying specific aspects of property development" (ibid, p. 1515) but it still remains to be seen which aspects these might be and what approaches should be retained to complement the mainstream.

This debate between a well-established paradigm and its challengers took a new twist when Guy and Henneberry (2000) launched a constructive critique of both the mainstream and its 'alternatives' in an effort to highlight the need for a synthesis. They argued that property research is indeed in need of a synthetic approach that will be able to blend the economic and the social/cultural dimensions wrapped-up in the processes of property development. They stress that "economistic" approaches with their emphasis on methodological micro-reductionism (Auyang, 1998) and their rigid behavioural assumptions offer "a partial view... from a particular perspective" (Guy & Henneberry, 2000, p.2399). The authors used examples, such as the influence of habit-persistence in property price formation, to demonstrate that social relations can and should be taken into account in any attempt to explain property market phenomena. The importance of social relations in property investment decisions have also been argued for by many other authors, including Gallimore, Hansz and Gray (2000) and Clark (1998).

An extended illustration is also provided in our own area of research on brownfield redevelopment. The exclusion of social relations from mainstream approaches frames the discourse with an implicit acceptance that the current structure of the market is as eternal and unchangeable as a force of nature, a 'given'. The 'Optimal Redevelopment Rule' (Brueckner, 1980; Wheaton,1982), the linear approach to development and the acceptance that the insufficient reuse of previously developed land can be tackled within the boundaries of existing market structures inevitably lead to one conclusion: if the market mechanism does not work as it is supposed to, then there must be certain 'obstacles' or 'barriers' that prevent the market mechanism from functioning 'properly'. Ideally, the only policy intervention that is acceptable is to find what these obstacles are and remove them, thus restoring market function. Lifting the barriers often includes measures to internalise externalities with the use of grants and taxes and/or an urge to de-regulate, which usually leads to attacks on the planning system.

As Ball (1998) points out though, the tendency to revert to a 'slanging match' is equally well established in institutionalist approaches influenced by structuralism. Approaches which emphasise structure in favour of agency will tend to ascribe actors to predetermined, usually conflicting, structural
roles and therefore explain behaviour only in certain pre-determined ways that may be more in accordance with theory than with empirical reality. It appears that the blame game can transcend theoretical boundaries and this is hardly good news for anyone trying to build a 'holistic' or 'integrated' understanding of the processes involved.

Returning now to our first question, we can note that the emergence of institutionalism either as a complementary or, more radically, as an alternative approach to the 'economistic' models and their notions about the nature of the market (Healey, 1991; Keogh & D' Arcy, 1999) has rocked the boat. An indication of that is the heated debate that Guy and Henneberry's paper has triggered. However, institutionalism in all its various guises has its own major deficiencies. It carries with it a lot of baggage that make most academics with an economic background wary of it, mainly its apparent lack of a solid body of theory at any level of inquiry and the subsequent lack of a quantitative element. As Hooper (1992) and Ball (2002) have pointed out, this makes it difficult to link up the different levels of inquiry and to uncover causal mechanisms without recourse to an already established theoretical body, thus leaving institutionalism open to the criticism that it is a framework in need of a theory rather than a full blown alternative paradigm. These more 'generic' aspects of institutionalism inevitably affected Healey's model, which according to Guy and Henneberry (2000, p. 2403), "... emphasises the social over the economic, the local over the regional or national and agency over structure."

This brief journey through the various approaches to property development is not intended to replicate work that has already been done. Indeed Guy and Henneberry's paper or the work of Ball (2002 and Ball et. al, 1998) as well as Healey (1990 and 1991) and Gore & Nicholson (1991) contain much more elaborate critiques of the various approaches. It was important though to stress the main issues in order to highlight what in our view is the most significant element of Guy and Henneberry's argument; the need for a 'cultural institutionalist' approach which should be, "...dynamic, deeply contextual and contingent both on the particular aims and objectives of development actors, and on a shifting market framework which may enable or constrain development strategies." Within that approach, "...one level of agency can become, in another context, the next layer of structure and so on". It also,"...allows us to understand how the property...'markets', are constructed by competing...actors at local, national and global levels and over time." The final element of this approach is an emphasis on the need to take into account "...the cultural frames through which investment strategies are made" (Guy and Henneberry 2000, p2413).

In our view, the network based approach that we will present dissolves the structure/agency dichotomy, allows for a dynamic interpretation of markets, can easily incorporate the role of 'culture' and can accommodate the transition between different spatial and temporal levels. The network approach we will develop resonates with institutional, evolutionary and behavioural insights and is based on a long quantitative and qualitative tradition. In this paper we will not attempt to build a specific model of the development process. Instead, we will try to examine several theoretical traditions in order to show how they can be combined to provide a framework with the characteristics that could bring the social and the economic elements of property research one step closer to each other in the way that Guy and Henneberry envisage.

3. Some Big Ideas to Start: Chaos Theory Through a Realist Lens

The first big idea we draw into our framework is that the world is mostly constructed from non-linear dynamical systems comprising many interacting elements (Sanders, 1998). These systems will tend to move towards attractors, 'orderly' patterns of behaviour that may be 'steady'/ predictable or may be unpredictable, 'strange attractors'. With a 'strange attractor', the attraction creates the boundaries within which the system moves but the shape of the system's motion within those boundaries is unpredictable. Non-linear dynamic systems are sensitive to initial conditions and slight changes to those conditions can produce significantly different results through positive feedback loops (negative feedback loops will lead to a form of equilibrium, or 'stabilisation'). This attribute has often captured the imagination of the public, we all have heard of butterflies flapping their wings in the Gulf of Mexico thus causing storms in New York City.

Harvey and Reed (1997) argue that a very fertile philosophical ground on which chaos theory can thrive is the critical realism of Bhaskar (1978). We agree with this epistemological link-up, since philosophical realism, starting from the work of Bhaskar, and later elaborated upon by many others, including Sayer (1992) and Lawson (1997), is indeed an approach which can accommodate chaos, complexity and networks without disregard for the particular ontological aspects of social phenomena. Neglect of those aspects would eventually lead to theories with great explanatory deficiencies. There is no need to repeat Harvey and Reed's line of argument here but one should briefly summarise the basic components.

Realism purports that the world is composed by entities which interact, resulting in layers of emergent qualities that are structured, stratified and irreducible to one another. These different ontological levels are hierarchically related through "... loosely bounded processes of determination and overdetermination." (Harvey & Reed, 1997, p.299) Because each level asymmetrically 'emerges' from another and subsequently cannot be reduced back to its constituents, the world can be seen as constantly evolving. Based on these principles, Byrne (1998) explores the idea of "nested social systems". Social systems can exist at various levels of a hierarchy, one nested within the other. The systems lower down that hierarchy are located within the 'phase space' constituted by the higher order social system of which they are part" (p.29). This means however that different types of processes and attractors might explain the evolution of social systems at various levels. Very similar concepts can be found in the literature examining complex adaptive systems (CASs), the non-linear dynamic open systems that evolve in order to adapt to the constant flows of energy and information between them and their environment. Their main characteristics are identified by Taylor (2001, p.142):
- they "comprise many different parts, which are connected in multiple ways".
- their components "interact both serially and in parallel" thus events may happen sequentially or simultaneously
- they "display spontaneous self-organisation" which blurs the borderline between the internal and the external environment,

- self-organisation gives rise to structures which "are not necessarily reducible to the interactivity of the components" of the system, and
- emergent qualities tend to cover the whole system despite their generation from local interactions,.

CASs evolve as a result of their openness and adaptiveness, they exist in the far-from-equilibrium margin between chaos and order, behaving, "orderly enough to ensure stability, yet full of flexibility and surprise" (Kauffman, 1995). According to Gell-Mann, in processes like investor behaviour, 'learning and thinking' or even 'the evolution of human societies' the common characteristic is that a CAS,

acquires information about its environment and its own interaction with that environment, identifying regularities in that information, condensing those regularities into a kind of 'schema' or model, and acting in the real world on the basis of that schema. In each case, there are various competing schemata, and the results of the action in the real world feed back to influence the competition among those schemata (Gell-Mann, 1994, p.17).

He goes on to describe how CASs process information (Figure 1), in which the system has to distinguish between randomness and regularity. Once it identifies what seems to be a regularity, it creates schemata with which it processes the flows of information from the environment in order to find the same regularity again when it occurs (patterns in the flow of information have to be converted into changes in the internal structure of the system). The schemata are competing and are constantly modified, they are used not only to interpret but also to anticipate actions coming from the environment, the survival of a schema depends on its ability to interpret existing information and predict the behaviour of the environment. With time, certain schemata will vanish and others will become dominant as a result of their performance.
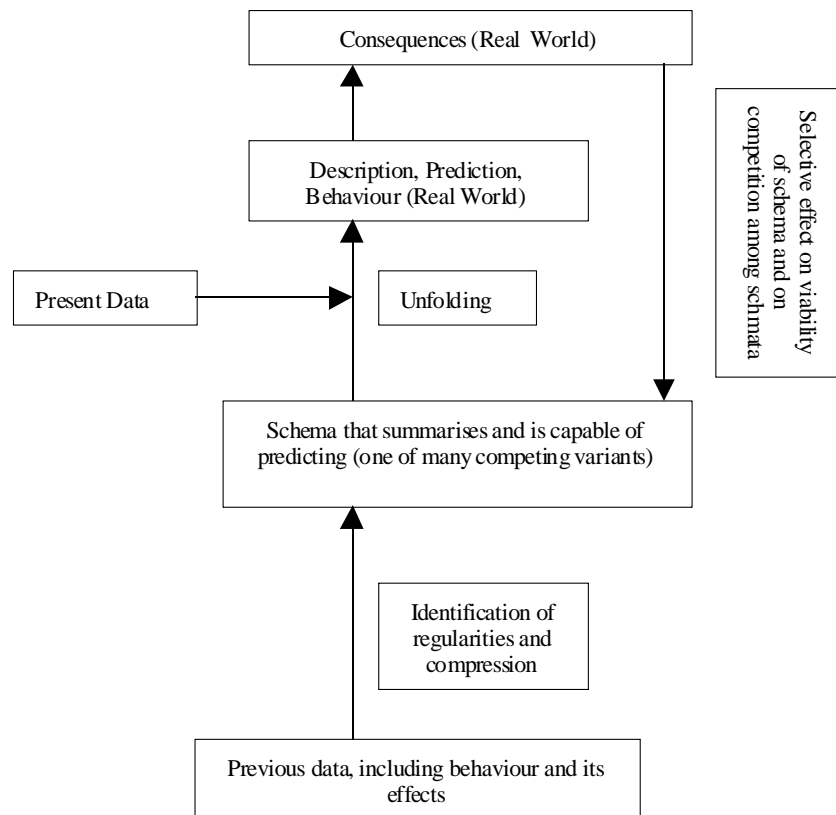
Figure 1: How a Complex Adaptive System Works (Gell-Mann, 1994, p.25)

The attempt, eventually the ability, to distinguish between randomness and regularity is a crucial for survival. If the world is structured, then regularities are a means to decipher this structure and provide insights to causal mechanisms. This in turn increases the ability to anticipate and thus boosts survivability and reduces uncertainty. In the case of property investors, such schemata would be mental constructs expressed through long-established practices, norms, rules and routines that govern their behaviour. The important thing here is that under the CAS example perfect rationality cannot exist and rule based behaviour becomes the basis of system dynamics and ultimately survival.

It is worth to devoting some space here to clarify yet another concept, that of dissipative systems. Dissipative systems are a special category of complex adaptive systems in the sense that they depend on resource inflows in order to survive. They have two main characteristics: they import, "increase and store information" or energy (and any other resource we would add) in the form of ever increasing complexity created via structuration processes and they "export disorganisation" (Harvey & Reed, 1997, p.377).

They are continuously under two influences that may cause change. Internal fluctuations that constantly test the boundaries of the system's 'phase space' and external perturbations coming from the environment. When a fluctuation, a perturbation or a combination of both are strong enough to cause a breach of boundaries then the system does not return to its original 'phase space' but reaches a bifurcation and oscillates between future possible states until it either destroys itself or it reconfigures and establishes a new 'reference state'. It will continue testing the boundaries of the new configuration around a new reference state until the right internal and external conditions allow it to begin a new transformation process. The path the system will follow each time depends on the initial conditions. Different initial conditions (different types, timings or strengths of perturbation) may lead to comparatively very different end states, even no change or, occasionally, destruction.

Millionas (1996) tries to explain why such systems should lie at the edge between order and chaos. On the one hand they should be stable enough so that each fluctuation or perturbation would not cause dramatic changes which might not be worth the risk and the energy expenditure (principle of stability). On the other hand the system should be able to switch if indeed it is worth doing so otherwise it might not survive (principle of adaptability). The only condition which allows these two principles to apply simultaneously is for a system to lie between chaos and order.

The analogy between natural dissipative systems and social dissipative systems is striking, however it is not a complete one. They are both characterised by historical specificity of "entities and events under investigation" and evolution resulting from fluctuation and/or perturbation. But there is one dissimilarity: social structures and the actions that construct and maintain them are "subjectively defined" by those who construct them. Therefore the "indeterminate" aspect of human nature has to be taken into account. "In social systems, perturbations of far-from-equilibrium conditions can originate in the values and actions of humans themselves" (Prigogine & Nicolis, 1989, p.238).

The recent shift towards brownfield redevelopment is a good example of how a combination of fluctuations and perturbations affects the web of production and consumption of the built environment. Government policies that restrict the amount of greenfield land coming forward can be seen as restricting the resource input to those dissipative systems of the web that specialised in greenfield development and depended on its inflow in order to survive and grow. It is inevitable that restriction in the resource inflow will lead certain such systems (or networks as we will start calling them in the next paragraph) to destruction, while others will have to reconfigure in order to survive. The whole process however will affect the web in its totality and in ways that can not always be anticipated.

4. From Complex Adaptive Systems to Adaptive Non-linear Networks and Beyond.

We have already referred to CASs as networks and here is why. In their seminal work on network approaches, Wasserman and Faust (1994) emphasise the role of "relationships among interacting units" (ibid, p.4) as the "fundamental component of network theories" (ibid, p.4). The emphasis on dynamic interactions as the source of emergent self-organisation implies that CASs can also be examined in terms of network formation, communication and learning. However, Barabasi (2002) makes the strongest case:

> The theory of phase transitions told us loud and clear that the road from disorder to order is maintained by the powerful forces of self-organisation and is paved by power laws. It told us that power laws are not just another way of characterising a system's behaviour. They are the patent signatures of self-organisation in complex systems (ibid, p.77).

So, when power laws were discovered in certain networks this meant that they behaved like self-organising complex systems. Indeed, when Holland (1988) examines the global economy he merges CASs and networks in what he calls Adaptive Non-linear Networks (ANNs). These are embedded within wider networks of CASs that constantly provide them with flows of information to which they have to adapt. A huge web of CASs adapts to what in essence are signals from other adapting CASs in an endless process of co-evolution where the future relates to the past but can never be the same as the past. The resemblance of Holland's ideas with Byrne's 'nested social systems' is striking.

Holland, identifies many characteristics of the global economy (ibid, p117) which we could transfer into the world of property research. Following his ideas, we can claim that the web of networks of production and consumption of the built environment is:

- characterised by a large number of actors acting both in sequence and simultaneously. The actions of each unit on a particular historical period however, only depend on the interactions with a subset of those actors;
- interactions are not globally controlled but governed mainly by "mechanisms of competition and coordination" and "mediated by standard operating procedures (SOPs), assigned roles and shifting associations".
- the web is layered, in the sense that it is organised in many different levels. Structures at one level are the constituents of structures at the next higher level (as suggested in section 2). However, this is not a strict hierarchical stratification, there are all sorts of interconnections between levels than can cut through strata;
- the web is an evolving system; it evolves by adaptation through learning (see CAS learning above). This evolution affects all levels and sub-networks both simultaneously and sequentially;
- property markets are networks characterised by variety. Their various niches, a characteristic of stratified structures as we suggested in part 2 , can be occupied by properly adapted actors and networks of actors; and
- because of its continuous evolution, this web continuously provides new niches and the very act of filling a niche creates the evolutionary preconditions that lead to the creation of new niches.

By virtue of their nature ANNs, " allow for intensive nonlinear interactions among large numbers of changing agents... characterised by limited rationality, adaptation (learning) and increased returns" (Holland, 1988, p.118). Holland particularly emphasises the role of SOPs, " the prescriptions of an internal model", as the basic mechanism through which ANNs can 'anticipate' the future. These norms and routines are the result of years of learning, refined through past experiences in dealing with particular situations. Of course, the 'schema' to which the SOPs contribute is never entirely complete and therefore it is always possible to 'improve' on it.

This continuous cycle of SOP evolution has one more interesting characteristic. The effects of a multitude of interacting actors (or networks of actors) operating according to their SOPs at one level, result in much more complex effects at another level. The responses of actors at that level, operating according to their own SOPs, leads to anticipatory actions of even wider significance. These positive feedback loops are the mechanisms that keep the system constantly evolving.

Culture can be embedded in the scheme above in more than one ways. As Harvey and Reed (1997, p.306) note, "cultural systems as linguistically mediated, symbolic constellations" can also be examined using notions of ANNs. The same notions of networks and schemata through which different actors operate can easily accommodate an examination of, "...the cultural frames through which investment strategies are made" (Guy & Henneberry, 2000, p.2413). Indeed the notion of 'frames' itself is very reminiscent of our notion of schemata.

5. The Contribution of Actor-Network Theory: Building Networks Through the Space/ Time Continuum

The spatial implications of the complex systems approach are hinted at by Byrne (1998). His most important insight is the "nested hierarchy of spaces" (ibid, p.90) as a "set of nested systems each down from the world system, containing elements made up of the level below it" (ibid, p.94). This way of looking at socio-spatial complex systems allows for the re-assertion of 'where' and 'when' as a crucial factors affecting the observable and our attempts to explain it. Further insights in this area are provided by Actor-Network Theory (ANT), which provides a lens to explore the time-space dynamics of networks whilst simultaneously dissolving a number of dualisms, including that of structure and agency.

ANT has arisen from studies that have explored the dynamic way in which scientific ideas and discoveries have been put into effect through the building and mobilisation of networks made up of people and other 'things' (Callon, 1986; Latour 1988). ANT sees these 'heterogeneous networks' as an active process of actor enrolment in which people/things are drawn into a stable relationship or understanding with each other to pursue a particular programme or objective (e.g. manage and conserve scallops around St Breiuc; develop and sell/rent commercial property; or regenerate the Thames Gateway).

This relatively simple definition of ANT hides a number of important conceptual insights that can contribute to our understanding of system dynamics and the spatial and temporal implications/interactions that arise. The first insight is provided by ANT's rigorous application of the 'symmetry principle'. Murdoch (1997, p367) points out

that ANT, "works with no prior conception of which materials will act and which will function as simple intermediaries for the action of others". Thus, ANT will consider the role and effect of network 'actors' whether they are human or non-human. Although Murdoch later suggests that human actors may have some distinct capabilities (such as their ability to negotiate the terms of their enrolment into network relationships), the symmetry principle provides a useful starting point for exploration of this, as it breaks the dualism between mankind and nature (Murdoch, 2001). He also points out that it breaks down other important dualities that cloud our understanding of network processes, such as local/global, centre/periphery, order/disorder, structure/agency, old/new and formal/informal. ANT treats all these things as relationally fluid so that they are often combined in the same event or process. Analogies are used in the literature to illustrate this, from Serres and Latour's (1995) crumpled handkerchief in which (distant) parts of the handkerchief are brought together, to Latour's (1993) view of railway tracks as both local (consisting of sleepers, sections of track, stations, train-drivers, engineers, etc.) and global (allowing movement of people and materials from London to Beijing).

In developing this heterogeneous network perspective, ANT places emphasis on the relational properties of the network and the processes by which they mobilise and operate in order to realise their objectives. The methodological tool offered by ANT to examine these processes is 'the sociology of translation'. ANT has mapped the process of network building by identifying four main stages: problematisation, interessment, enrolment and mobilisation. *Problematisation* begins the process in which an actor (network builder) promotes or reacts to an issue, such as the use of property derivatives or the government's policy on brownfield development. *Interessement* usually takes place in which some negotiation and discussion takes place between the actors involved or likely to be involved. This moves the actors towards *enrolment* in which they sign up (or are enrolled) to an 'agreed' solution to the problem or issue. This enrolment usually draws-in material 'things' as well as human actors (e.g. buildings, computers, contaminated land, money). *Mobilisation* is when the network actors move to fulfil the 'agreed' aim. This is the phase in which the network is stabilised and begins to have enduring effects on the world. Latour (1994, p.792) suggests that, "it is the mixing of human actions and non-human materials which allow networks to both endure beyond the present and remain stable across space".

Part of the 'enduring' nature of actor networks is the way they 'inscribe' these agreements into social relations and material things (Akrich, 1992). This *inscription* or 'ordering of things' is, following Foucault, a power effect of network processes. These inscriptions range from the design of a hammer (weak inscription, because it can be used for many tasks by many actors) to that of a car production line (strong inscription) and from mobile homes (weak) to the central London office market and the way that such real estate is bought, sold and redeveloped (strong). Inscription takes place with things and with people, in the way they do things or (equally important) don't do things, but this process is rarely fully realised because people (and things?) are often able to negotiate these network effects to some (variable) extent. Indeed, it might be in the interests of the network (builder) to allow this room for manoeuvre in order secure network objectives (illustrated in the discretionary nature of the British planning system?). Although not specifically using an ANT framework, Guy (1998) has shown how 'design scripts' have been negotiated and put into effect by the actor-network involved in the development of commercial property.

Another aspect of ANT that can help us in our analysis of network processes is the role played by intermediaries. These are conceived as, 'anything passing between actors that defines the relationship between them' (Callon 1991, p134) and can include a range of material objects (e.g. money, policy statements, valuation reports, letters, legal contracts, etc.) or other actors (e.g. some of the work undertaken by property agents, news reporters, property researchers or environmental consultants). These intermediaries do important work in stabilising the network and extending it through the enrolment of other actors. They can, of course, also disturb or destabilise the network.

ANT also provides us with some understanding of the spatial patterning of network effects. Murdoch (1997) explores this in some depth, drawing out a number of implications. First of all, he stresses ANT's relational view of space (and time) stating that, "a network perspective cannot readily co-exist with a notion of space as fixed and absolute in its coordinates" (ibid, p.357). Building on this, ANT

> sees spaces and times as emerging from processes and relations, and concerns itself with the topographical textures which arise as relations configure spaces and times. What ANT adds to the more commonplace understandings of relational spaces is a concern with networks (ibid, p.359).

Murdoch goes on to highlight three aspects of these 'translated spaces', emphasising that (1) networks are always a means of acting *upon* space, and "it is the sets of associations which define and constitute spatial qualities"; (2) spaces are arranged so that certain types of action can be conducted, and thus "the action in actor-networks configure space"; and (3) these actions, and the relations through which they are conducted, are 'grounded' within these networks which transcend spatial scales (ibid, p.361). This supports Latour's view that researchers should following networks, wherever they may lead (Latour 1993, p.117).

Following on from this, Murdoch suggests that, "the extent to which a particular place can be demarcated and localised will depend, therefore, upon the ability of the network to actively mobilise elements which can frame or mark-off discreet spatial units" (Murdoch, 1997, p.362). Spaces are enrolled into networks and ordered and arranged in line with the terms of enrolment, allowing actors to 'act at a distance' using heterogeneous materials. In this way the 'centre' (network builder) is able to dominate its 'periphery' (other actors or material things which are being enrolled). He adds that, "(i)n understanding the construction of network spaces we need to investigate the various forms of 'remote control' which allows actors (or centres) to dominate peripheries" (ibid, p.362).

In undertaking the necessary translation work to enrol actors and spaces, two types of network are likely: those where translations are perfectly established and those where stabilisation is imperfect and contingent. Murdoch suggests that these constitute 'spaces of prescription' and 'spaces of negotiation', echoing the frontier between order and chaos which characterise dissipative social systems. He continues the similarities with ANNs by quickly dissolving the dualism, pointing out that both types are likely to be present in all networks, and quite probably at the same time. They are two sides of a single process of inscription and resistance to inscription; appearing, disappearing and flowing into one another across time and space. In these ways, actors (and places) have varying levels of autonomy to influence network dynamics, to instigate perturbations that can destabilise the network, possibly leading to network transformation or destruction, a la Prigogine and Nicolis (1989).

In these ways, ANT provides important perspectives and insights on network dynamics. It helps us to understand networks as heterogeneous collectivities of people and things, relationally tied to each other over time and space. These ensembles have their own trajectories, negotiated and inscribed into the practices of their actants, which 'perform' the work of the network and respond to the performances of other networks as they oscillate between chaos and order.

6. Conclusions

The world is a complex place, so it is befitting that any conceptualisation of it should take this complexity into account. The world is also increasingly structured by networked relations, be it in the (global) economy, through political processes or in terms of cultural semiotics. Theories that embed themselves in this network paradigm are progressively being drawn upon to help us understand the diverse relations and, more importantly, *inter*-relation-ships that structure the practices of actors (and things). We have examined the existing theories of the property development process and agreed with other critics that they are found wanting and limited. We regarded Guy and Henneberry's call for a 'cultural institutionalist' approach as a promising way forward.

Guy and Henneberry called for frameworks that could link-up and integrate the economic and the social to provide the necessary 'zoom-lens' to focus (and re-focus) on the complexities implicated in these networks of production and consumption. They seek perspectives that are able to:
- handle the dynamic processes involved;
- examine contextually situated and contingent sets of actor inter-relationships;
- recursively link agency and structure;
- map such processes across spatial scales, from the local to the global and back again; and
- take into account the cultural frames through which these processes are negotiated and put into practice.

The framework we have presented seeks to address these points and build a holistic (rather than 'totalising') appreciation of the inter-play between actor negotiations of network processes and the structural properties of network inscriptions. This is set within a broader paradigm of network complexity in which dissipative systems inter-relate with each other at the frontiers of order and chaos. This allows us to 'follow the networks' as they are constructed, stabilised and transformed, inscribing their relational discourses and practices onto actors, places and through time.

With any attempt to tweak the conceptual landscape there are bound to be difficulties. We are aware that our framework is not without problems. The conjoining of ANNs and ANT requires a little more conceptual glue to clearly show the symbiosis of the two complementary frameworks and there is important work to be done on consolidating the recursive structure-agency duality that we claim for the approach. Furthermore, it still remains at a level of abstraction that requires methodological detailing in order for it to be applied to the particular sub-network(s) involved in land re-use. However, our initial ideas on this are worth outlining here to indicate the potentialities of the network ideas developed above.

Based on Wasserman & Faust (1994) and Langton (1994), we expect that the next methodological steps of our research should focus on:

a) *the structure and form of the network:* we should clearly identify who the inter-dependent actors/actants are and how they are linked with each other (i.e. find the 'connectors' and 'intermediaries'), we are interested in lasting regularities in relationships between actors and the materials that bind them together (e.g. contracts, reports, money deals). An interesting path to follow would be a quantitative examination of 'one mode' networks (i.e. between investors) in order to discover whether 'power laws' apply and whether we have scale free networks where preferential attachment would exist. Which networks are weighed and directed and how are their 'constituents' mapped?

b) *the dynamics of the network:* it is also important to know how strong the relationships are between the actors in terms of flows of "material or non-material resources" between them, and the rules, norms and routines (SOPs) that underpin those connections and frame individual action.

c) *the 'learning processes' involved:* how the rules, norms and routines underpinning the connections are changing as a result both of internal fluctuations and because of the interactions of the network with its environment. Also important here is to explore the 'inscription' processes involved (e.g. discourses and other 'power effects') and how 'spaces of negotiation' are opened-up, closed-down or left as 'trace-elements' in the network memory (Law, 2004).

By exploring these elements we hope to un-cover the rich tapestry of socio-economic dynamics and web-relations that go to make up the investment sub-network currently shaping 'the brownfield development process'.

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