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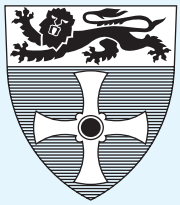

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WEAVING THE SEAMLESS WEB: A CONSIDERATION OF NETWORK ANALYSIS AND ITS POTENTIAL APPLICATION TO THE STUDY OF THE RURAL ECONOMY

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Abstract

The term network is proposed as a unifying concept allowing social scientists to investigate the social, the natural, the political, the economic, etc., concurrently. It allows us to examine how actors are enrolled into heterogeneous sets of relations. The term 'translation' is used to illustrate how actors are enrolled into networks and how their interest are thus modified. The rural economy can be considered to be the outcome of a multitude of such networks and the examples of pesticide usage and minerals planning are provided. The methodological approach that results from this perspective is 'follow the actors; as they construct networks and 'make' the rural.

1.Introduction.

In the first working paper in this series (Allanson *et al.*, 1994) we presented an evolutionary perspective on the rural economy and provided a series of case studies which demonstrated how this perspective might be applied. We characterised the rural economy as "a complex, open system" which encompasses a variety of socio-economic, technical and natural processes. Some of these processes may be local, others global but the rural economy can be considered as the expression of these processes in rural localities. The rural, then, is made and remade by a complex amalgam of the social, the economic, the natural, the technical, the local and the global. In the working paper we concerned ourselves with the rural economy at the level of the system and provided a few concepts, derived from an evolutionary perspective, which would allow the identification of system properties, such as self-organisation driven by microscopic diversity.

The adoption of an evolutionary approach was an explicit attempt to foster some amount of disciplinary integration, specifically between economics and sociology. Furthermore, the concern with sustainability highlights the need to consider how ecological concerns can be successfully integrated into the social sciences. Again the evolutionary perspective seemed to offer scope for a more unified perspective on the relationship between social and natural systems. By adopting the yardstick of sustainability we sought to focus attention on the possible pathways of deliberate intervention and change which might strengthen certain desirable elements in both social and natural systems.

The pressing need for social scientists to more fully address natural processes has recently been highlighted by Ted Benton (1991). He argues that a number of recent developments, associated with the 'new' social movements, necessitate a reconsideration of the traditional distinction between the 'social' and the 'natural'. These are: first, the recognition that key aspects of social being are associated with the 'natural' categories of sex and race; second, the politics of health have reminded us that embodied 'persons' interact with social-relational and biophysical environments; third, environmental movements have forced a recognition of "the causal importance of the *non-social* materials, objects and relations which fall within the spatial limits of human societies" (p.7); and fourth, the politics of

animal welfare has fostered a "non-anthropocentric ethical orientation" (p.8) which stresses the interdependence between species. Benton believes that these social movements mount a challenge to the constitutive dualisms of mind/body, biology/society, cause/meaning, nature/culture, behaviour/action, instinct/learning, nature/nurture, and animal/human, which underlie the dominant theoretical traditions in the social sciences (p.8). He argues that an appropriate strategy for social science might be to launch a critical examination of science itself.

Within the sociology of science a great deal of work in this vein has already been conducted in order to show how social science can make sense of natural science (although Benton makes no reference to this) and has begun to demonstrate the complex interactions between the 'social' and 'natural'. The most influential studies have been conducted under the heading 'sociology of scientific knowledge' (usually abbreviated to SSK) which "insisted that science was interestingly and constitutively social all the way to its technical core" (Pickering, 1991 p.1). The first studies in this genre attempted to establish a sociological 'hegemony' over science; that is, sociology attempted to 'explain' the production of scientific knowledge by recourse to relatively fixed sociological categories, i.e. scientists produce specific types of knowledge because it suits their interests (see for instance Barnes, 1977; Bloor, 1976). Thus these studies came to be accused of reducing the complexities of scientific knowledge and practice to a few simple sociological nostrums. As Michel Callon notes, the effect of this work "can be so devastating that the reader has the impression of attending a trial of natural science presided over by a privileged scientific knowledge (sociology) which has been judged to be indisputable and above criticism" (1986 p.198). An attempt has thus been made to establish a more symmetrical relationship between the disciplines. As one of the key proponents of this latter approach, Callon believes it is necessary to develop a single repertoire for analysing both the social and the natural, a repertoire which explains conflicting viewpoints and arguments in the same terms. Furthermore, he argues, the analyst must refrain from imposing a pre-established grid of analysis and should, in practice, 'follow the actors' in order to identify the manner in which "they build and explain their world, whether it be social or natural" (Callon, 1986 p.201). However, although a repertoire must be used which explains both the natural and the social in the same terms this does not mean that the sociologist simply repeats what s/he

is told by the scientist. A sociological understanding is still needed but one which allows us to question both nature and society simultaneously. We need to consider how both are 'made.'

Callon proposes the term 'network' as a unifying concept which provides a means of showing how the natural and social are bound together. In this paper I will adopt this term and explore the extent to which it allows a new understanding of the relationship between the 'natural', and the 'social', and other dualisms, such as 'action' and 'structure.' In particular, I want to focus on the concept of 'network' in order to understand how agents or actors become incorporated into stable relations with one another and how this facilitates the 'self-organisation' of the the larger system. As agents become enrolled into networks they may act to reproduce the sets of relations upon which the network is based. Likewise, as networks are extended they may allow the emergence of a system. In this sense I am seeking here to 'reverse the telescope' of the first working paper for I want to show how the system itself may be considered as an *outcome* of many network relations as they become interwoven with one another.

There is a long tradition of network analysis in the social sciences. The term network usually refers, within sociology at least, to relations between social actors (for instance, kin networks). These are social networks. In other social science disciplines the study of networks may be avowedly non-social, as when telecommunications, railways or sewerage networks are studied. Here chains of 'non-human' components link a few humans together. These are seen as primarily technical networks. Callon (and others such as Latour, 1987 and Law, 1986b) proposes a form of network analysis which is a 'hybrid' of these two more traditional forms. In this formulation networks are *composite*; that is, they are made from heterogeneous materials including humans, non-humans, texts, technical objects, money, etc. What appears to be social is partly technical and what appears to be technical is partly social. The word network is used in order to direct our attention to how resources are concentrated in a few places - the 'nodes' - which are connected to one another - the 'links'. The objective of network analysis is to follow the construction of these networks, to show how they are 'made', and the range of their effects.

At the system level sociologists of science and technology have also identified the same principles of heterogenity. Thomas Hughes, in his study of the electricity supply industry, sees such large systems as "seamless webs":

> "Builders of a technological system such as electric light and power interconnect components so diverse as physical artefacts, mines, manufacturing firms, utility companies, academic research-and-development laboratories and investment banks. These components make up a system because they fall under a central control and interact functionally to fulfill a system goal or contribute to a system output. Obviously, an electric light and power system would not function if all generators were removed; less obviously the system would also break down if an investment bank providing funds withdrew from the system" (1988, p.14).

In contrast to neoclassical economics, which often sees technological factors as exogeneous, and sociology, which often sees the development of technology as determined by the requirments of dominant social groups, Hughes believes the social, the technical and even further, the natural, the economic, the political, etc., are fully integrated components of the system. Similarly Clark and Lowe (1992 p.21), in examining the effect of agriculture upon the environment, believe that there are no neat distinctions between the social and the scientific. In the context of agricultural pollution regulation they say:

> "there are entities known as farmers, advisers, pollution inspectors, scientific researchers, technicans, civil servants, farms, laboratories, cows, wheat, slurry, effluent tanks, isoproturon, sillage, wild oats, BOD, oxygen meters, fines, grants, regulations, statutes, agricultural policy and so on, and their attributes are given by actors. Everything is all mixed up together and actors do not separate them according to whether they are social or scientific. Rather, what counts for any particular actor is whether the worlds they build work, whether their definitions... succeed, for what is at stake here is the very constituting of agriculture and environment".

The aim of the analyst therefore is to observe system or network builders as they use whatever materials are to hand to make the networks grow and achieve stability; or to put it slightly differently to follow actors as they weave seamless webs. The mode of analysis should thus seek to avoid using *a priori* distinctions, such as those between the social, the technical, and the natural in order to explain actors and their relations; rather these distinctions should be treated as outcomes once networks and systems have been stabilised.

Likewise, within social science it is common to distinguish between the social, the political and the economic or the market and regulation, as if in actuality these are sharply distinguished. However, once we turn to examine the formation of networks, again we see actors using whatever is at hand to stitch their worlds together. These divisions are the outcomes of network formation, whether the networks be academics resolutely studying Politics or sociologists studying The Social. Yet as any researcher knows, what actually goes to make up the Political or the Social are a lot of things which have to be sifted out in order to make these disciplines pure. Again, instead of starting with a neatly defined world, whose boundaries must be respected at all times we should seek to examine how these boundaries are established and maintained. But perhaps more importantly we should not be blinded to the ways in which actors building networks 'mix and match' elements from all.

The term 'network' is utilised here then as a unifying concept, one which underlies all manner of relations between actors, entities and artefacts. It enables us to examine how our world is made and re-made. In order to operationalise this mode of analysis, however, we need to look firstly at the ways in which relations are forged. We must then go on to consider, secondly, how these relations are extended and stabilised across time and space. Networks are the outcomes of these two simultaneous operations.

2.The problem of action.

I wish to begin by raising some of the conceptual and methodological issues associated with the relationship between 'action' and 'structure' in social science research, i.e. how should individual actors be integrated into wider social relations and structures? The problem of the relationship between structure and agency is raised here to show how network analysis may help

us to overcome the traditional dichotomy between the two. In so doing it reformulates how we think about 'size' i.e. the relationship between the micro and the macro, and proposes a new language for understanding how size is achieved.

Conceptualising the appropriate balance between the creative activities of knowledgeable actors and the demands imposed on such actors by their position within particular social structures (or societies) has been a key concern in social theory. Traditionally, there has been a fluctuation between individualist approaches, such as methodological individualism, which have tended to see that "all social phenomena - their structure and their change - are in principle explicable in ways that only involve individuals - their properties, their goals, their beliefs and their actions" (Elster, 1985, quoted in Bohman, 1991 p.148) and structural analyses which at their worst reduce the status of actors to that of 'cultural dopes'; that is, they simply function as bearers of the social system or structure. Moreover, these two approaches tend to have their own languages and modes of explanation; thus, large scale issues are discussed in terms of structure and system, while the small scale is analysed in terms of interactions, tasks, intention, etc. Recent attempts to span the structure/agency problematic have often used syntheses of the two - Giddens' structuration theory is a good example - taking some insights from structural functionalism or structuralist Marxism and ethnomethodology or phenomenology to derive a more balanced approach. This has often resulted in an uneasy alliance between perspectives concerned with actors and interaction and others pitched at the level of structure and system. The persistent failure to convincingly link the micro and the macro has, in the opinion of commentators such as Mouzelis (1993), caused sociological theorising to lose momentum and has widened the gap between conceptual development and empirical research.

When considering the role that network analysis can play in overcoming the action/structure dualism a useful starting point is methodological situationism. From this perspective it is proposed, after Goffman (1974), that the first object of social analysis is ordinary behaviour in actual social situations. Against methodological individualism, which tends to consider the individual to be a stable and unproblematic source of social action, we can observe that people seem to exhibit a multiplicity of personas which are "linked to social roles, to management of the self or simply to different

situations" (Knorr-Cetina, 1988 p.24). For Goffman the self "is not an entity half-concealed behind events, but a changeable formula for managing oneself during them" (1974 p.573). So the self, the person, exists through social interaction. Methodological situationism, therefore, takes the fundamental object of analysis to be 'action-in-context' rather than individual human actors.

This approach sees social action as arising out of an *interlocking of intentionalities*: individual action is contingent upon the conduct of others in social situations. Furthermore, social situations constitute a reality of their own. They display a dynamic and level of organisation which cannot simply be reduced to some fundamental attributes of the participating actors: "to describe human behaviour, let alone *uncover its meaning*, we have to make reference to the *human and physical environment* in which it occurs" (Knorr-Cetina, 1988 p.28). We cannot reduce social situations to fundamental attributes of the participants. But neither are they the simple manifestations of some overarching social structure. The outcome of social episodes depends not just on how variables, such as rules and resources, 'structure' the situation but on how these are represented and interpreted by participants within the situation. Structural variables do not normally specify a unique and unambiguous course of action for they have to be interpreted against a background of situational features. They are implicated in the perceived requirements of the situation. However, the participants may use rules and structural variables to uncover the meaning of a situation: thus "the snake bites its tail; the relation between situation and structure (rule) is reflexive in that each is identified and elaborated in terms of the other, and the meaning of each becomes modified in the process of identification/elaboration" (Knorr-Cetina, 1988 p.31).

So there is an indeterminacy to situations and the constitution of structural variables. If structural variables were to determine the outcome of every situation then we could say nothing interesting about either actors or situations. But neither are situations simply governed by the interaction between individuals. As Hindess has made clear in his critique of methodological individualism and Marxist class analysis:"Actors make decisions and act accordingly, but they do so under conditions that are only partly under their control, and on the basis of techniques, ways of thinking and means of action available to them" (1988 p.97). We thus cannot account

for actors' decisions and actions by appealing to some internal rationality (nor for that matter the 'truth' of the knowledge involved - Giddens, 1984) because where actors have been 'irrational' (or 'mistaken') all we can say is that if they had known better and interpreted their situation differently they might have acted otherwise. Although the ways of thinking and techniques that actors use in making decisions and acting upon them will be differentially distributed amongst actors, again we must be clear that these do not specify unique courses of action; they must be used in relationships with others in particular contexts.

However, 'situations' are not necessarily discrete; they flow into one another and what happens in one will tend to have consequences for others. Often this is discussed in terms of the unintended consequences arising from one situation affecting others, but this tells us nothing about why the participants behave as they do. If we look at how actors assess and act within situations then the outcomes may well be unpredictable (even though actors strive for predictability) but we should not be surprised by this. If the outcomes of micro-situations are unpredictable then the 'global' outcome of many such situations may also be unpredictable or unintended.

Once we reach this point Knorr-Cetina (1988 p.39) argues that there are two strategies open to us: we can either adopt a "bird's eye" perspective and attempt to reconstruct the "network of relations" which emerge from interrelated micro-situations or we can "take a step back" and start from how the participants construe their interrelations. If we adopt the latter strategy, she suggests the use of the term "representation" to understand how the 'macro' comes to be actively constructed and pursued within micro-situations. Representations are understood as typifications at various degrees of abstraction that stand for the events or objects they typify. The macro then becomes a representation which is employed by actors in the course of their interrelations:

> "I am suggesting, then, that structural regularities are tied to participants' actual practices instantiated in networks of mutually related (via representations) micro-transactions which co-exist in parallel to each other. Hence, the existence of regularities which transcend micro-situations is not ruled out in the present perspective;

> but their grip is limited, so to speak, to the reasoning practices of interacting groups" (Knorr-Cetina, 1988 p.43).

If we take up Hindess's point that the techniques and ways of thinking which allow actors to formulate courses of action and read situations are differentially dispersed amongst actors, then is this unequal dispersion somehow 'structural' (in the traditional sense of the term) i.e. more than simply a representation? In order to answer this question we must attend to the first of Knorr-Cetina's strategies, i.e. the network of relations which emerge as actors in one situation attempt to tie other actors in other situation into stable sets of relations. The pursuit of this strategy inevitably leads to a consideration of 'power.'

3. The problem of power.

If a relative autonomy is granted to micro-situations then how might we account for power and domination? In addressing this issue we cannot resort to a conception of power (or structural domination) which exists outside of concrete situations and somehow reduces the complexity of these situations to the simple unfolding of structures of domination. If the structural is *made* within micro-situations then we cannot appeal to it as a *cause* of what happens in such situations. If actors derive power from their position in the social structure (membership of a particular class, ethnic group or gender) then this structure provides the explanation for everything else. We do not need to take very seriously actors-in-contexts. If structures are made within situations then they must be seen as *outcomes*. Power must also be seen as an outcome. We must look carefully at the processes which give rise to it as an *effect*.

According to Latour (1986) the problem of power may be encapsulated in the following paradox: "when you simply *have* power - in *potentia* - nothing happens and you are powerless; when you *exert* power - *in actu* - *others* are performing the action and not you... " (pp.264-265, emphasis in the original). The difference between power *in potentia* and power *in actu* is quite simple; it is the actions of others. Power is a 'composition' made by many people but *attributed* (via representations) to one of them. Thus the amount of power exercised is not related how much someone 'has' but to the number of actors involved in its composition. So power is an outcome of collective action and cannot, therefore, explain this collective action. To 'explain' power we must

examine how collective action comes about, or how actors come to work in unision.

To understand what binds actors together, again, we cannot privilege the structural. If actors are held together by social structures then we need explain little about action because it may be read from the structural context. If we adopt the perspective proposed here however, then the structural (or the social) "is not what holds us together, it is what is held together. Social scientists have mistaken the effect for the cause, the passive for the active, what is glued for the glue" (Latour, 1986 p.276). The study of the social, therefore, becomes the study of *associations*, in order to show how we are linked together and why "some orders are faithfully obeyed while others are not" (Latour, 1986 p.277).

Structure, society and power are the *outcomes* of collective action. To say simply that they are representations (summaries or typifications) does not explain how they are spread and how they tie actors in other situations into the chain. Using the example of the spread of scientific facts (and the establishment of scientific networks) Latour says:

> "In order to spread in space and to become long-lasting they all need (we all need) the actions of others. But what will these actions be? Many things, most of them unpredictable, which will transform the transported object or statement. So we are now in a quandry: either the others will not take up the statement or they will. If they don't, the statement will be limited to a point in time and space, myself, my dreams, my fantasies.... But if they do take it up, they might transform it beyond recognition" (1987 p.108).

In order to understand how relations *are* established, extended and maintained Latour proposes a linguistic metaphor, and uses the term *translation* to describe the enrollment of actors into networks .

For translation to be effective, and thus escape the quandry described by Latour, it must do two things simultaneously: others must be enrolled so they participate in the network and their behaviour must be controlled in order to make their actions predictable. Yet this solution appears contradictory: "If others are enrolled they will transform the claims beyond

recognition. Thus the very action of involving them is likely to make control more difficult" (Ibid). The solution to this problem is provided by translation. The easiest route to creating a linkage between actors, explains Latour, is for both to recognise that they share explicit interests: "As the name 'inter-esse' indicates, 'interests' are what lie *in between* actors and their goals, thus creating a tension that will make actors select only what, in their eyes, helps them reach these goals amongst many possibilities" (1987 pp.108-109). If one actor believes that her interests will be furthered by helping another actor to achieve his interests then a rather simple case of 'piggy-backing' is apparent. However, this strategy has many drawbacks, not least that the first actor may end up following the second rather than *vice versa*. However, if the first actor can convince the second that they will reach their goal much more quickly if they follow the route proposed by the first actor then a type of enrollment may be accomplished. Again, however, this is a precarious strategy for the second actor still holds its own goals and will know how near or how far it is from them. Furthermore, its behaviour may be difficult to control and it may disrupt the network which the first actor is trying to build. Translation will be much more effective, argues Latour, if new goals can be defined by the first actor which will appeal to the second. Moreover, if the first actor can define a new goal, a means of achieving that goal, and is able to convince the second actor that its interest lies in reaching that goal, it will be in a strong position. However, the ability to define new goals will be limited if there are already clearly defined actors in existence: it would be much better to define new actors that could then be endowed with new goals, goals which can be reached only within the network being built by the first actor.

In order to illustrate how this might be achieved Latour provides the following example. In mid-nineteenth century Europe there were strong social groups - rich and poor, proletarian and capitalist. Health officers wishing to overhaul the public health system of cities were constantly thwarted by class hostility: "The simplest regulation for health was considered either to be too radical, or, on the contrary, to be one more stick for the rich to beat the poor with" (p.115). However, when Pasteur and the hygienists introduced the notion of the microbe they defined a rather different society, one made up of "sick contagious people, healthy but dangerous carriers of microbes, immunised people, vaccinated people and so on. Indeed, they added a lot of *non-human* actors to the definition of the

groups as well: mosquitos, parasites, rats, fleas, plus the million of ferments, bacteria, micrococci and other little bugs" (p.116). As a consequence a new form of solidarity was introduced as people came to see themselves in relation to these new entities:

> "As soon as newly formed groups were threatened by the newly invented enemy, common interest was created, and so was a craving for the biologist's solutions; hygienists allied with microbiologists were positioned at the centre of all regulations. Vaccines, filters, antiseptics, know-how that had until then been confined to a few laboratories spread to every household" (Ibid).

Thus translation has both a linguistic meaning - relating versions in one language to versions in another - but also a 'geometric' meaning - moving from one place to another.

Translating interests means "offering new interpretations of these interests and channelling people in different directions" (p.117). Callon (1986) summarises the process in four stages. First, an actor tries to make itself indispensable to others (this may occur as a problem is defined which only the first actor can solve) and tries to convince other actors to join the network. In the second stage the actor tries to come between the other actors and their alternative associations, thus removing discretion from their 'worlds'. Thirdly, roles are defined that stipulate the identity of each actor and how they should relate to one another. Fourthly, the initiating actor 'represents' the others, turns itself into their 'spokesperson' and speaks on their behalf. During this process a network comes into existence as disparate entities and actors are brought together on terms set by a strategically placed actor. Where there is a perfect translation the actors all speak in the same voices and their identities are stable within the network. The stronger the network the more tightly the various entities (human and non-human) are tied in; despite their heterogeneity they work in unision. The outcome will be a set of power relations.

However, network relationships are contestable. Other actors may attempt to recruit entities, which are already defined within particular networks, in order to build a new set of relations. In order to illustrate how this might take place we can cite the example here of the use of DDT in United States

agriculture. Dunlap (1981) discusses the background to the introduction of DDT into US agriculture. He shows how, during the latter part of the nineteenth century and early twentieth century, American farmers confronted a series of acute problems with such 'pests' as grasshoppers, chinch bugs, cotton worms, codling moths, Hessian flies, Colorado potato beetles, etc. This was characterised as an "insect emergency" (Dunlap, 1981 p.18) and resulted in a clamour from the agricultural sector for action. Specifically, action should come in the forms of chemicals. Dunlap explains that the focus on chemical control stemmed from the desire on the part of farmers for a "quick fix" (p.29). Other methods, cultural and biological, usually entailed changes in agricultural work habits and cropping patterns, changes that were resisted by many farmers. Thus the search for a chemical soltion arose not just from 'scientific' considerations but from 'economic' and 'social' constraints on the appropriate solutions. The task of developing an effective pest control fell to the Bureau of Entomology. The Bureau's personnel were well aware the diverse demands they had to satisfy, as Dunlap explains:

> "The failure of other methods to meet public demands for ways to stop insects without long, expensive research, changes in farming practices, or long-term planning paved the way for chemicals. The triumph of chemical insecticides was due not just to the visible results they gave, but to their acceptance by a public and a farming community that valued above all else, convenience, simplicity, and immediate applicability. That economic entomologists recognised this need and were prepared to meet it can be seen not only in the complaints that the entomologist was 'losing sight of the insect', but in positive exhortations to use pesticides" (p.35).

DDT was introduced in this milieu in 1942 and appeared to the Bureau as "a gift from heaven". It was described by one Bureau scientist as "a miraculous insecticide" (quoted in Dunlap, 1981 p.37). It solved the problems of all parties: it was effective on a wide range of different insects, though apparently low in mammalian toxicity; it was light; and it was cheap. DDT allowed the Bureau to provide the solution to the problem blighting most farmers. It boosted the status of the Bureau and tied together a huge network extending from the laboratories to vast numbers of farms. It furthermore, defined the pest problem squarely in terms of chemical control. A leading

entomologist was moved by the success of DDT to declare that all pests might subsequently be eliminated: "The time has now arrived for the eradication of the house fly and with it the horn fly... This is not a fantastic dream but something that is almost certain to happen" (quoted in Dunlap, 1981 pp.37-38). This network was maintained for almost two decades until Rachel Carson in *Silent Spring* described it as a "chain of evil" (1991 p.23). No longer was DDT ascribed the status of a "miracle"; now the chemical was presented as an "elixir of death" (p.31). In order to change the status of the chemical (its 'identity') Carson needed to build a new network in which the representation of DDT was seen as a destructive force. Carson attempted to do this by connecting a number of seemingly disparate entities such as "major river systems", "the soil", the "bodies of fish, birds, reptiles, and domestic and wild animals", "earthworms", the "eggs of birds", and, perhaps most evocatively "man himself [sic]" (see p.31). All these entities were tied together by a newly-represented DDT:

> "One of the most sinister features of DDT and related chemicals is the way they are passed on from one organism to another through all links in the food chain. For example, fields of alfalfa are dusted with DDT; meal is later prepared from alfalfa and fed to hens; the hens lay eggs which contain DDT. Or the hay, containing residues of up to 7 or 8 parts per million, may be fed to cows. The DDT will turn up in the milk in the amount of about 3 parts per million, but in butter made from this milk the concentration may run to 65 parts per million (p.37).

Thus a new chain is held together by DDT. But this is disturbing to the earlier network in which DDT played the key role for "DDT is definitely toxic" and could lead "chronic poising and degenerative changes of the liver and other organs" (p.36). Thus DDT is re-represented by Carson and this allowed a new network to come into existence. The struggle around the identity of DDT pitted the first network, consisting of entomologists/chemical companies/pests/farmers, against a second, which came into existence around Carson's representation. The latter consisted of biologists (such as Carson)/suburbanites (whose gardens were adversely affected by the chemical)/birds (dying from DDT poisoning)/ecologists (enrolled to adjudicate over DDT in the environment) and legislators (enrolled to regulate the chemical).

This example illustrates how network relationships can be contested and re-established in new ways, as entities are re-defined and re-ordered. And the above examples are not trivial; public health systems have done much to define both citizenship and urban living, while agricultural pesticides have profoundly shaped food production and the rural environment. Thus from the constitution of such networks come our everyday conceptions of society and space.

4. Network analysis.

Society, structure and power are outcomes as actors are associated. These associations can be termed networks. Those who are powerful are not those who 'hold' power but those who are able to enrol, convince and enlist others into networks on terms which allow these initial actors to 'represent' all the others: "they speak for the others that have been deprived of a voice, that have been transformed from objects that spoke for themselves into mere shadows of their former selves" (Law and Whittaker, 1988 p.179). Thus the controlling actor 'grows'; by borrowing the force of others it can inflate to a larger size (becoming what we might term a 'macro-actor' - Callon and Latour, 1981). Power, therefore, is "the composition of a set of actors who are temporarily enrolled in the schemes of the powerful and who accordingly lend their efforts to his/her project" (Law, 1986a).

If power 'lies' anywhere it is in the resources used to strenghten the bonds (Latour, 1986a p.276) and these resources may include a long list of non-social elements, such as technologies, texts, and money to name but three. To understand networks we must identify how the associations are made and stabilised, how power "is recursively woven into the intricate dance that unites the social and the technical" (Law, 1991 p.18). We need to study the 'worlds' built by actors, the elements that compose them, how these elements are defined and linked together and how actors impose definitions and linkages upon others. The notion of translation attempts to get at how some actors gain the right to speak for others and at how they impose particular definitions and roles upon these others. To be successful an actor must 'colonise' the worlds of others. Thus actor worlds (or situations) are not independent but are tied together in associations which may result in domination. And, these associations are held together by a variety of entities, some social, some technical, some natural, etc.

The type of network analysis being proposed here directs our attention to the ways in which key actors come to exercise power over others by drawing them into sets of relations on terms which favour the former. The issue becomes, therefore, how key actors, or using an organisational term, *centres* of translation (decision making nodes), act on others in other situations; in short, how they 'act at a distance'. If we turn to what we might call the geography of actor-networks, then it becomes apparent that when we speak of 'global' or 'local' networks we are really raising the issue of the *reach* of the network in question i.e. how others in distant places (and times) find themselves 'fixed' by the strategic centres. The scale of these processes refers to distance, to the attempt by external actors to enrol local actors within particular networks of control. The question of scale (global, local) can, therefore, be posed in the following terms: what links local actors to non-local actors (i.e. actors in another locale) and how do these non-local actors effect change and control from a distance? Latour (1987) believes that the answer is rather simple; "how to act on unfamiliar events, places and people? Answer; by somehow bringing home these events places and people". This can usually be achieved by three means:

> "(a) render them mobile so they can be brought back; (b) keep them stable so that they can be moved back and forth without additional distortion corruption and decay; and (c) [make them] combinable so that whatever stuff they are made out of, they can be accumulated, aggregated or shuffled like a pack of cards" (p.223).

Latour cites the example of the census to show how this process is commonly undertaken. The census forms are distributed and collected. They allow all the surveyed households to be 'brought back' to the centre of calculation where they can be acted upon. However, the number of forms and the volume of information they hold is unmanageable. They have to be reduced to tables, graphs and summaries. Eventually all the households will be translated into manageable statistical categories; they will have been through several 'moments' of translation and have been combined through common forms of calculation that allow elements to be stabilised and brought back to the centre. The forms of calculation 'stand for' and represent the many diverse households. Here the calculating centre produces a legitimate representation. This legitimacy derives from the incorporation of

the participating households within a common form of calculation and the stabilisation of certain elements of the households as they move through the processes of translation. Likewise social surveys reduce varied actors to questionaires which are then brought back to the research centre and translated into tables, texts, etc.

Through translation processes it is possible to do things in one place (the centre) that fix the identity of another place (the periphery?) within the network. The construction of networks and the ability they give certain actors to 'act at a distance' is what ties the micro to the macro or the 'local' to the 'global'. By examining the connections in this way we are able to specify the exact means by which the local is represented within the network. What elements are combined, how they are mobilised, and what forms of calculation are used to carry the local to the centre are the issues of concern. We are not now dealing with the simple unfolding of social structures through space and time but the means whereby structures are (re)produced by actors as they make their associations and attempt to stabilise them.

In the rural domain an example of the way networks attempt to tie diverse localities into common forms of calculation, allowing certain actors the ability to 'act at a distance', can be found in British minerals planning. Within the land use planning system decision making is taken at the local level. Often particular developments are assessed in terms of local considerations. However, minerals planning is distinguished by the disruptive and destructive nature of extraction activity. Moreover, this disruption is to produce a resource which may have no local benefits but is deemed necessary 'nationally'. Thus in the words of the UK Government "for the economic well-being of the country it is essential that the construction industry is provided with an adequate and regular supply of the minerals it needs" (Department of the Environment, 1989). In order to allow extraction to take place, and to curtail local autonomy, a sophisticated regulatory framework has been established. This framework allows 'action at a distance' in both time and space, for it seeks to impose a spatially uniform policy and to develop 'the long term view'.

At the apex of the framework for minerals planning are the forecasts of aggregates demand made every four years. Until recently, they were drawn up by the Department of the Environment (DoE) and the National

Coordinating Group (a body which oversees the planning framework consisting of representatives from the local authorities, minerals companies, DoE and other government ministries), but are now compiled by a firm of consultants. Essentially the forecasts are a 'trend projection' of aggregates demand moderated by predictions about economic growth. The national forecast is then translated into regional forecasts by ten Regional Aggregates Working Parties (made of representatives from the same bodies as the National Coordinating Group) who then distribute quotas to the County planning authorities. Thus local authority planners are bound into a system which requires them to ensure the production of so-many million tonnes of aggregates from within their territory. Local decisions are thus enrolled into a form of calculation, determined by the minerals forecasts, produced within the planning network. The network has been established by minerals companies concerned to ensure continuing planning permissions and national Government bodies concerned to provide for the "economic well-being" of the country. These two sets of actors have come together and merged their interests, and have then sought to establish a network which to some extent captures local authority decision making. Thus diverse localities are enmeshed in a uniform system of representation which reduces them to 'quotas' (for fuller details see Lowe *et al.*, 1993; for an example of how this network has been successfully resisted see Murdoch and Marsden, 1994)

This example shows how 'rural' space comes to be redefined within a particular network. What is also interesting about this case is the way that 'regulation' and the 'market' are recast within the network. The market for minerals, at one level, can be seen as an outcome of the demand calculations made at the apex of the plannng framework. These are then translated into a series of local markets as the local authorities adopt their quotas. Regulation is defined as the ability to deliver the required amount of minerals.

This case is by no means unique and we can consider rural localities as cross-cut by various network relations which give rise to different and competing representations of rural space. This is not to say that there are no commonalities, no coherent views and uses, for actors borrow and steal one anothers resources, they draw upon existing identities and interests as they seek to establish new networks or consolidate existing ones. The outcome will be types of rurality which are spatially dispersed (minerals planning

spreads its net over many locales) but which will share many common features (see Marsden *et al.*, 1993).

5. Some methodological considerations.

The type of network analysis being proposed here has implications not just for how we conceptualise the elements that make up the rural, but also how we empirically analyse these. However, the relationship between our conceptual understanding of networks and their identification is extremely close, for network analysis proposes a rather simple set of rules to guide empirical analysis. In order to understand what these are we first need to clarify one or two core concepts.

Firstly, in the work of Callon, Latour and others the status of the term 'actor' is unclear. For instance, Callon, in his early work (e.g. 1986), uses the term to describe any entity that could act otherwise (including natural entities). In a later paper he describes an actor as "any entity able to associate texts, humans, non-humans and money. Accordingly, it is any entity that more or less successfully defines and builds a world filled by other entities with histories, identities and interrelationships of their own" (1991 p.140). However, this still includes texts, technical objects and natural entities. Furthermore, he points out that human beings are often placed in the position of being intermediaries, while non-humans are elevated to the status of actors (as when legal rights are accorded to the latter)[1]. However, while sympathizing with Callon and Latour's radical symmetry I would contend that only human actors can construct actor worlds and believe that more useful is Hindess's definition of an actor as "a locus of decision and action, where the action is in some sense a consequence of the actor's decisions..." (1986b p.115). This does not confine the notion of actor to the individual but to any entity able to reach decisions and act upon them: "capitalist enteprises, state agencies, trade unions and community associations are

[1] Collins and Yearley (1991) believe this shift to a 'radical symmetry' between humans and non-humans removes the "special authority" (p.310) of sociological accounts of science and thus allows the scientist to once again claim privileged access to the nonhuman realm. Callon and Latour (1991) respond by positively celebrating the end of the 'Great Divide' between the human and the nonhuman domains. "Who provided them [Collins and Yearly] with this real distribution between social and natural worlds? The scientists whose hegemony in defining the world [Collins and Yearly] so bravely fight" (p.348). Callon and Latour argue that we must follow actors (through their networks) to show how they divide up the world, not simply respect the existing divisions (see Pickering, 1991 for this debate in full).

examples of actors... they all possess means of taking decisions and of acting on at least some of them" (Hindess, 1988 p.105). Classes and societies, however, cannot be included because they have no means of taking decisions and acting upon them (although there are many actors who claim to represent these categories). This is not to say that humans are the only entities that do things - clearly natural and technical entities are key intermediaries in holding social (human) worlds together and may play key roles in the decision making practices of 'institutional' actors (i.e. those decision making bodies which are made of individuals). Further these intermediaries do not always stick to the roles alloted to them by human actors and may act to disrupt human relations in irreversible ways (Callon (1991) provides the examples of the Chernobyl nuclear reactor and the AIDS virus). However, these entities are only knowable (by us - humans) through our social worlds. Thus the term actor denotes the status of sociability and knowing.

However, what clearly emerges from the sociology of translation is that the identity of actors is not fixed, for it is constituted within networks; again, identity is constructed within varied sets of power relations. Therefore, while actors can be defined as decision making 'bodies', they cannot be ascribed, in advance, any fundamental, essential, unchanging characteristics. These emerge within networks. Thus, it is important to note that identity and interest are not pre-given in this perspective. Rather the aim is to understand how networks of interest are actually constituted and reproduced by actors themselves using various strategies and sets of resources. Interests or identities are only pre-given to the extent that they are the "temporarily stabilised outcomes of previous processes of enrollment" (Callon and Law, 1982 p.622), that is, of previous rounds of network construction.

Hindess (1986a) argues that interests have explanatory significance only in so far as they offer actors reasons to undertake particular courses of action as they become part of the ways of thinking that actors use in social situations. But if these ways of thinking are 'structured' by others, through processes of translation, then we can begin to see more clearly how the abilities of actors to formulate interests and act upon them come to be unequally dispersed. Furthermore, the activities of these networks can lead to unequal resource distributions, extending the scope for certain actors to enrol others.

According to Callon *et al.* (1985 p.10) the role of analysis is to study the creation of "categories and linkages, and the way in which some are successfully imposed while others are not". This entails describing "without fear or favour, what it is that actors do" (p.5). Explaining the operation of power in these terms requires sensitivity to the kinds of explanations offered by both the actors under observation but also by the observer. To fulfil the obligation of describing what it is that actors do, Callon suggests three methodological principles. The first is "agnosticism", which entails impartiality between the actors engaged in a particular social conflict. The analyst "refrains from judging the way in which the actors analyse the society which surrounds them. No point of view is privileged and no interpretation is censored. The observer does not fix the identity of the implicated actors if this identity is still being negotiated" (Callon, 1986 p.200). The second principle is "generalised symmetry" which stipulates that all the conflicting viewpoints must be explained in the same terms. The third principle is that the observer "must follow the actors in order to identify the manner in which they define and associate the different elements by which they build and explain their world..." (p.201). We must, therefore, follow the process of network building in ways which allow us to see how all the actors "co-evolve" (Latour, 1991 p.117); we allow the actors to *teach us* the causes of the success or failure of the network. We do not fix the causes - such as efficiency, power, structure - in advance; these come at the end of the story, they are *outcomes*.

This type of approach attempts to close the gaps between concepts, methods and the objects of analysis; it seeks, as Dreyfus and Rabinow describe Foucault's methodology, "to stay as much as possible on the surface of things, to avoid recourse to ideal significations, general types or essences" (1982 p.132). In this way *explanation* is proposed in terms which bear a close resemblance to *description.* It is from within the social processes of network building that our accounts must be constructed. These will necessarily be 'hybrids' (Latour, 1988) made up of the language of the social scientist and of those we study (just as the networks are hybrids, made from heterogeneous materials). We are now striving for equality with those whom we choose to study; this method proposes "equal status for those who explain and those who are explained" (Latour, 1988 p.175). This does not mean simply repeating what we are told by our respondents nor does it mean

assuming that we (as 'objective' social science analysts) know more than they do. It is possible that each can learn from the other.

This analysis points to the need for a methodological approach that allows access to the dynamics of the social context and the processes of network building. The most applicable method is the case study, in which a particular event or sequence of events can be explored in depth. If we wish to follow the actors, how they reach decisions and act upon them, then the case study approach is particularly appropriate as it provides an opportunity "to highlight and analyse the processes by which social actors actually manage their everyday social worlds and attempt to resolve certain problematic situations" (Long, 1989 p.248). More broadly, Clyde Mitchell (1983) defines the case study as the documentation of some particular phenomenon or set of events that has been assembled with the explicit aim of drawing theoretical conclusions. These conclusions, however, will be drawn from *within* the case study as we follow the actors. However, it may be practically impossible to follow actors everywhere and, more often than not, the account of network building may have to be gained retrospectively.

While we might subscribe to the view that situations have a dynamic of their own which prevents the foreclosure of outcomes, we can also attempt to control for certain features of these situations. The research context can be assessed according to criteria thought to be relevant to the behaviour in question. Controlling for selected background variables may allow a comparative assessment to be made across case studies. We must watch carefully, however, as these background variables come into play in different ways. Again they do not specify single courses of action. Case study work can be systematic as well as reflexive and sensitive to a range of real life situations.

We have called this method elsewhere quite simply "action in context" (Marsden *et al.*, 1993) and we have operationalised it in a series of localities chosen for their differing and comparable 'background features' (e.g. Murdoch and Marsden, 1994). This necessitated the adoption of a conception of social space which stresses the multiple uses to which a single space can be put and points to the localised effects of social actors operating over a variety of distances. This allows us to focus upon the methods adopted by actors as they formulate and seek to achieve their objectives. It

allows us to analyse the means by which interests and objectives are constructed, represented and come into effect, and what the social and material consequences are likely to be.

6. Conclusion.

I began by considering the relationship between action and structure and adopted a perspective which sees the latter as resulting from the structuring practices of the participants in social situations. Such an approach raises the question of whether we can see situated outcomes as somehow providing the 'pre-conditions' for (or, as Giddens puts it, enabling or constraining) action in other social situations. However, if structures are nothing more than the structuring practices of actors then how do we account for power and domination? From what source do actors derive power and how do they 'store' it? I adopted the view that power is an outcome as actors attempt to enrol others to their representations, interests, stategies, aims etc., via processes of translation. These processes allow the establishment of networks. Importantly, these networks are not simply social *or* technical but are made up of heterogeneous materials as actors use whatever is at hand in the struggle to dominate or enrol others. The 'glue' that binds actors together is made up of technologies, texts, techniques, natural entities and other humans.

The methodological approach that results from this perspective is quite simple: 'follow the actors' as they attempt to impose their worlds on others. We let them show us where to look, what materials they use in the course of network construction, and how they come to be related to others. In short, we get them to do as much work as possible for us. The repertoire of translation gives us a flexible mode of analysis which allows us to 'follow' but at the same time it directs our attention to the means whereby associations are made and sustained. And while our own accounts will be hybrids (partially derived from the actors we study) this should not affect our confidence in the ability of the social scientific discourse to interpret the world. On the contrary. We have methods and aims which are our own. Our perspective on the world is unique but it is drawn from the experience of those others that we have studied. By concentrating on the means whereby some actors come to impose their worlds on others, we can trace patterns of domination and their distributive effects in a way which both highlights the

contribution of our respondents and the capability of social science to describe/explain.

References.

Allanson, P., Murdoch, J., Lowe,P. and Garrod,G. (1994) The Rural Economy: an evolutionary perspective. University of Newcastle upon Tyne: Centre for Rural Economy. Working Paper 1.

Barnes, B. (1974) Interests and the Growth of Knowledge London: Routledge and Kegan Paul.

Benton, T. (1991) 'Biology and social science: why the return of the repressed should be given a (cautious) welcome' Sociology **25**(1) pp.1-29.

Bloor, D. (1976) Knowledge and Social Imagery London: Routledge and Kegan Paul.

Bohman, J. (1991) New Philosophy of Social Science: Problems of indeterminacy Cambridge: Polity.

Callon, M. (1986) 'Some elements of a sociology of translation: domestication of scallops and the fishermen of St Brieuc Bay' in Law, J. (ed) pp 196-233.

Callon, M (1991) "Techno-economic networks and irreversibility' in Law, J. (ed), pp 132-164.

Callon, M. and Latour, B. (1981) 'Unscrewing the big leviathan: how actors macrostructure reality and how sociologists help them do so' in Knorr-Cetina, K. and Cicourel, A. (eds) Advances in Social Theory and Methodology: Towards an integration of micro- and macro-sociologies London: Routledge.

Callon, M. and Latour, B. (1991) Don't throw out the baby with the Bath School! A reply to Collins and Yearly' in Pickering, A. (ed) Science as Practice and Culture Chicago: University of Chicago Press pp. 343-368.

Callon, M. and Law, J. (1982) 'On interests and their transformation' Social Studies of Science **1** pp. 615-625.

Callon, M., Law, J. and Rip, A. (1985) Mapping the Dynamics of Science and Technology London: MacMillan.

Carson, R. (1991) Silent Spring [5th Edition] London: Penguin

Clark, J . and Lowe, P. (1992) 'Cleaning up agriculture: environment, technology and social science' Sociologia Ruralis **32** pp.11-29.

Clyde Mitchell, J. (1983) 'Case and situation analysis' Sociological Review **31** pp.187-211.

Collins, H. and Yearley, S. (1991) 'Epistemological chicken' in Pickering, A. (ed) Science as Practice and Culture Chicago: University of Chicago Press, Chicago pp.301-326.

Department of the Environment (1989) Guidelines for Aggregates Provision in England and Wales Minerals Policy Guidance Note 6, DoE London.

Dreyfus, H. and Rabinow, P. (1982) Michel Foucault: beyond structuralism and hermeneutics Brighton: Harvester.

Dunlap,T. (1981) DDT: Scientists, Citizens, and Public Policy Princeton: Princeton University Press.

Elster, J. (1985) Making Sense of Marx Cambridge: Polity.

Giddens, A. (1984) The Constitution of Society London: Polity.

Goffman, E. (1974) Frame Analysis: an essay on the organisation of experience New York: Harper and Row.

Hindess, B. (1986a) 'Interests in political analysis' in Law, J. (ed) pp. 112-31.

Hindess, B. (1986b) 'Actors and social relations' in Wardell, M. and Turner, S. (eds) Sociological Theory in Transition London: Allen and Unwin.

Hindess, B. (1988) Choice, Rationality and Social Theory London: Unwin Hyman.

Hughes, T. (1988) 'The seamless web: technology, science, et cetera, et cetera' in Elliot, B. (ed) Technology and Social Process Edinburgh: Edinburgh University Press pp.9-19.

Knorr-Cetina, K. (1988) 'The micro-social order: towards a reconception' in Fielding, N. (ed) Action and Structure London: Sage pp.21-53.

Latour, B. (1986) 'The powers of association' in Law, J . (ed) pp. 264-280.

Latour, B. (1987) Science in Action Milton Keynes: Open University Press.

Latour, B. (1988) 'The politics of explanation: an alternative' in Woolgar, S (ed) Knowledge and Reflexivity: new frontiers in the sociology of knowledge London: Sage pp.155-177.

Latour, B. (1991) 'Technology is society made durable' in Law, J (ed) pp.103-131.

Law, J. (1986a) 'Introduction' in Law, J (ed). pp.1-19.

Law, J. (1986b) 'On the methods of long-distance control: vessels, navigation and the Portuguese route to India' in Law, J (ed) pp.234-263.

Law, J. (1991) 'Monsters, machines and socio-technical relations' in Law (ed) pp.1-25.

Law, J. (ed) (1986) Power, Action, Belief: A new sociology of knowledge? London: Routledge.

Law, J. (ed) (1991) A Sociology of Monsters: Essays on power, technology and domination London: Routledge.

Law, J. and Whittaker, J. (1988) 'On the art of representation: some notes on the politics of visualisation' in Fyfe, G and Law, J (eds) Picturing Power London: Routledge pp.160-184.

Lowe,P., Murdoch, J., Marsden,T., Munton, R. and Flynn,A (1993) 'Regulating the New Rural Spaces' Journal of Rural Studies 9(3) pp. 205-222.

Long, N. (1989) 'Theoretical reflections on actor, structure, and interface' in Long, N. (ed) Encounters at the Interface: A perspective on social discontinuities in rural development, University of Wageningen: Sociological Studies **27** pp.221-244.

Marsden, T., Murdoch, J., Lowe, P., Munton, R., and Flynn, A. (1993) Constructing the Countryside London: UCL Press.

Mouzelis, N. (1993) 'The poverty of sociological theory' Sociology **27**(4) pp.675-695.

Murdoch, J. and Marsden, T. (1994) Reconstituting Rurality London: UCL Press.

Pickering, A. (1991) 'From science as knowledge to science as practice' in Pickering, A. (ed) Science as Practice and Culture Chicago: University of Chicago Press pp.1-26.