The Evolvability of Business and the Role of Antitrust

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Introduction

Complexity science is relevant to Antitrust Policy because the economy is a complex adaptive system (CAS) of economic and non-economic actors (Arthur et al. 1997). The study of complexity focuses our attention on the way complex behaviour in natural, biological, social or economic systems can and does result from the connections between the parts not from any inherent complexity of the parts.   In other words, the overall behaviour and evolution of a system is not a linear function of the behaviour of its parts. Both history and interactions matter. Simple rules of interaction can give rise to complex system behaviour over time. The study of complexity also directs our attention to the importance of feedback effects and evolutionary processes by which the rules of interaction and mix of players in a system changes over time. As Stuart Kauffman (2000) nicely expresses it – the winning games are the games the winners play.

My argument is to extend the main case for antitrust policy (in the sense described by Williamson 1996). To date, the main case focuses on economizing, including market power as a key filter for identifying suspect cases. Both production and transaction costs are considered as part of economizing and other factors are use to consider the benefits of different industry structures. CAS analysis focuses attention on dynamics, evolution and networks and I suggest "evolvability" as an additional main case consideration. Evolvability can be thought of in terms of various types of network impacts that go beyond the traditional focus on production and transaction costs. Network costs and benefits stem from the connections between transactions and relations over time and place, including how business arrangements at one time, limit or enable arrangements in the future. Such considerations, I argue, can and should be included in the rules of antitrust and in the processes of antitrust case analysis and decision making.

Much of what I say are not new ideas in economic and business analysis and theory. My ideas about complexity and business build on and parallel the theories of institutional evolution of Douglas North (e.g. North 1993), the pioneering work of Nelson and Winter (1982), the concerns of cutting edge economists (Colander et al 2004) and the work of researchers on economic and business systems associated with the Santa Fe Institute and Agent Based Computational Economics. But the time is ripe to try to bring these ideas together to see what they mean for public policy and in particular antitrust policy. Developments in the so called "complexity sciences" permit us to see more clearly and comprehensively the processes underlying the dynamics and evolution of business systems and offer a way forward, including methodologies for developing, analyzing and testing models of the way CAS develop and evolve over time and place.

A particular type of methodology associated with CAS analysis is agent based models. Such models allow the dynamics and evolution of CAS to be simulated and analysed under different conditions. Such methods are necessary because the inherent nonlinearity of CAS defy analytical

solutions and patterns of development can only be discovered by playing out a system's behaviour and interactions over time. It is from studies using agent based models, as well as other types of numerical simulations, that the hallmarks of CAS behaviour have been revealed; including: sensitivity of outcomes to starting conditions, path dependence, bifurcations or tipping points, basins of attraction and the stability of different system attractors. The term Artificial Life is sometimes used to characterize these types of models because they mimic the processes of living, reproducing and evolving. As Chris Langton (1996), one of the founding fathers, has observed, we are restricted to the study of what nature has left around for us to study and this results from one play of the tape of life – life as it is. Artificial Life methods allow us to consider alternative evolutionary conditions and pathways - to investigate life as it could be. This type of model I will argue offers a way forward for Antitrust case analysis and decisionmaking and parallels the development of these types of models in other domains, such as the agent-based computational laboratory for analysing wholesale electricity markets being developed for the US government by Leigh Tesfatsion and her research team (Koesrindartoto et al 2005).

Links to Antitrust

Anti-trust policy is about influencing the rules of interaction and evolution of business systems, with the aim of avoiding pathological evolutionary paths and the emergence, survival and reproduction of undesirable firms and business systems. I will be more specific about this later. From my reading of recent articles on issues confronting anti-trust authorities, the main problem seems to be that current policies focus on problems of static market efficiency and price competition and tend to ignore issues to do with dynamic market efficiency. Static market efficiency is reflected in rules to preserve price competitive markets and to limit market power, which is interpreted in terms of the distribution of market shares in a horizontally defined domestic market for substitutable and similar products or services.

Dynamic market efficiency has to do with the development and evolution of new types of markets, firms and industries that create and deliver value to consumers. While there are some links between static and dynamic market efficiency these are problematic. For example, larger, more powerful, firms may be able to devote more resources to innovation and thereby aid the evolutionary process. But they may also block or suppress undesirable (from their point of view) new competitors. In fact the process of innovation is more complex than this, as research has shown, and involves interactions within and between networks of firms and other types of organisation.

Michael Porter (2002) has argued strongly for an antitrust to focus on value, rather than just price and cost, and on dynamic rather than static efficiency and he advocates the use of his frameworks for analysing competition in industries and nations to assess antitrust cases. Also he has conducted research that suggests that variation in market shares rather than their mean distribution is a more effective indicator of dynamic efficiency (Sakakibara and Porter 2001). I see this as a step forward in our understanding and measurement of dynamic efficiency in business systems but no clear underlying theory of business system dynamics and evolution is articulated. Only a list of factors to consider in each case is presented, which hint at the underlying processes to which antitrust policy needs to direct its attention. I believe that including ideas from complexity theory and theories of cultural evolution, can help enrich and advance our understanding of the key processes driving the evolution of firms, markets and industries and provide a more coherent focus for antitrust policy.

The title of my paper is inspired by an article by Richard Dawkins, the eminent Neo-Darwinian biologist entitled "The evolution of evolvability," which was presented at the first Artificial Life

conference at the Santa Fe Institute in 1987 (Dawkins 1989). This topic goes to the heart of the problem confronting antitrust policymakers. They are concerned to influence, through regulation and enforcement, the process of evolution of business systems towards more desirable community outcomes, including efficiency and effectiveness. This is the essence of dynamic efficiency. Static efficiency is about tinkering with an existing business system to achieve improved outcomes, not with how this will affect the process of future evolution of the business system.

The problem of course is that we cannot predict the future of business evolution, anymore than we can predict the future of natural evolution. The history and existing nature of business systems affect how they can and cannot evolve but in ways we cannot fathom in advance, because of the complex, nonlinear, self-organising, adaptive nature of the systems involved. Complexity and evolutionary theory teaches us how starting conditions and history matter and how micro interactions and adaptations lead to emergent macro patterns, and that systems gravitate towards different types of attractors depending on chance factors and tipping points that are only knowable from hindsight.
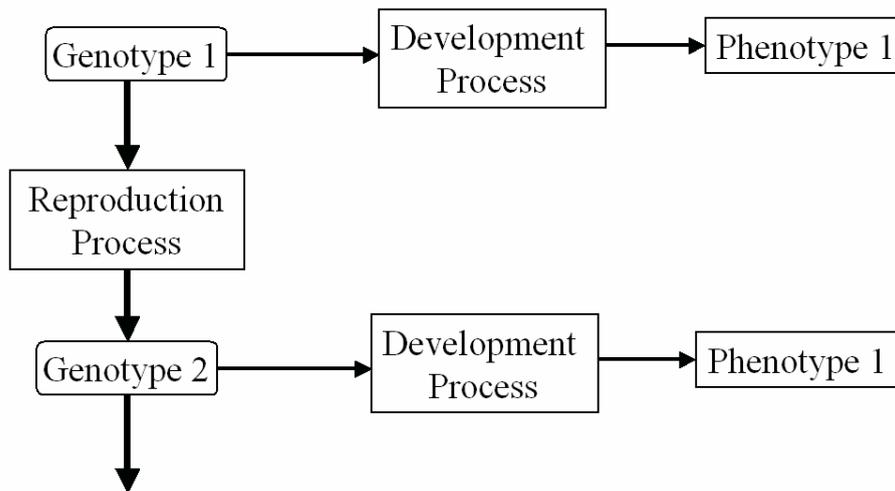
At first sight this seems to be an argument for anything goes and no antitrust policy because anyone's guess as to the future is as good as anyone else's. I disagree. The role of antitrust policy is to help encourage and select business systems for their evolvability, not to control or predict evolution. Business systems are living systems, business ecosystems (Moore 1996), and if they cannot evolve they will eventually stagnate and die because they will be unable to cope with and contribute to changing business contexts, including new types of ideas, technologies, demands, competitors and natural conditions. In order to understand this more clearly, and what it means for antitrust, we need to understand the nature of evolutionary processes, starting with biology and then moving on to cultural systems, which includes business systems.

The Nature of the Evolutionary Process

Figure 1 depicts the main elements of the evolution in terms of two key processes. First is the existence of entities that are capable of being reproduced over time. In biology the entities are the genes that are replicated as genotypes are passed from generation to generation. Genes are essentially subroutines that become expressed and used in some kind of order over time as a plant or animal develops into its phenotype (Dawkins 2003). In cultural evolution, including business culture, the entities that are replicated through time are called by different researchers cultural traits, routines or competencies (e.g. Nelson and Winter 1982). These are acquired or modified by social learning, including teaching, imitation and other forms of social transmission and which affect behaviour (Richerson and Boyd 2005). Dawkins calls to the basic entities of cultural evolution as memes that leap from mind to mind and are thereby reproduced, altered, reconfigured, and diffused through time and space (Blackmore 1999). They include ideas, knowledge, beliefs, values, skills, capacities, attitudes and orientations. But an individual idea is not really equivalent to a subroutine as genes are, unless we define memes to include a related set of ideas that constitute a way of doing something. These could be called meme complexes but to keep things simple I will use the term meme to refer to the subroutines expressed in cultural and business life.

Figure 1 The Evolutionary Process

(Adapted from Dawkins 1998 p 202)

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┌───────────┐      ┌──────────────┐      ┌─────────────┐
│ Genotype 1│─────▶│ Development  │─────▶│ Phenotype 1 │
└─────┬─────┘      │   Process    │      └─────────────┘
      │            └──────────────┘
      ▼
┌──────────────┐
│ Reproduction │
│   Process    │
└──────┬───────┘
       │
       ▼
┌───────────┐      ┌──────────────┐      ┌─────────────┐
│ Genotype 2│─────▶│ Development  │─────▶│ Phenotype 1 │
└─────┬─────┘      │   Process    │      └─────────────┘
      │            └──────────────┘
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Genes and memes do not exist in isolation but form genotypes or memotypes i.e. assortments of cultural traits that characterize a particular person, group or firm. These govern the way a phenotype develops and behaves. In biology, phenotypes are the myriad of types of flora and fauna that develop from the population of genotypes existing in a generation. The success of phenotypes affects whether or not the genes governing their behaviour will be passed on to the next generation. In cultural evolution, phenotypes refer to the characteristic patterns of behaviour and responses of people and organisations that are operating under the influence of different sets of memes or cultural traits. The term business model is sometimes used to refer to the mix of traits characterizing a particular type of firm's manner of operation and response and is a kind of business analogue to the concept of a genotype in biology. Just as in biology the success of the business model or memotype in its environment, including other phenotypes and memotypes, affects which memes or traits get reproduced over time and place. This comes about through various forms of social learning and transmission mechanisms as detailed by Boyd and Richerson (2005).

Genes and memes do two things (Dawkins 1989). They influence the development of the phenotype and they get themselves reproduced. The success of different phenotypes depends on the environment in which they develop and operate. The environment comprises the material world, the world of physics, chemistry and biochemistry, as well as other phenotypes that co-exist and with which a phenotype interacts. Natural selection refers to the struggle among phenotypes to develop and survive in a particular environment, independently or in cooperation. The same principle applies to biological and cultural evolution.

For genes to get themselves copied into the next generation, more than survival is required. Sexual selection, Darwins other theory as Dawkins (2003) refers to it, focuses on the struggle among males and females to find and secure mates with whom they can cooperate in passing on their genes to future generations. Genes that are useful for sexual selection may not be the same as and may even conflict with genes for natural selection, leading to some weird and wonderful sexual dynamics. Working with others I have recently suggested that an analog of sexual selection exists in cultural and business evolution which we term "business mating" (Wilkinson et al forthcoming).

The business literature tends to focus on natural selection in descriptions of competition, as reflected in firms continuing struggle to survive in dynamic markets through creating and sustaining differential advantage (Alderson 1957). But in recent years there has been an explosion of interest in the nature, role and importance of business relations and networks in shaping business behaviour and performance (for a review see Wilkinson 2001). The ability to form successful business relations with suppliers, customers, complementors and even competitors and to join, and help co-produce mutually productive networks of such relations, requires competences that are different from but complementary to those involved in the struggle for competitive advantage. Firms cooperate to compete and compete to cooperate (Wilkinson and Young 2002). Firm's are selected for their mating abilities as well as their competitive abilities and this creates selection pressures and transmission biases for particular types of business subroutines or competencies that could not be explained by natural or competitive selection and a focus on the firm as an isolated economic actor. Just as in the animal kingdom, people and firms struggle to choose and get chosen by better business mates and who mates with whom in business is not random, as assumed in perfectly competitive markets, but is a form of assortative mating. However, to date their has been only limited research directly addressing the issue of who mates with whom in business (Wilkinson et al forthcoming).

Table 1 summarises the previous discussion and shows the terms used to describe key components of the evolutionary process in biology and business

Table1 Components of Evolution Processes in Biology and Business

Dimension	Biology	Business
Replication Unit	Genes	Memes
Transmission Unit	Geneotypes	Memotypes
Phenotype	Flora and Fauna	Firms, Households & Organisations
Transmission Process	Sex, Division	Social and Economic Learning and Copying
Adapting Unit	Extended Phenotype	Network
Variation	Mutation & Recombination	Innovation, Error & Recombination

I now focus on cultural evolution as this lies at the heart of our understanding of the development and spread of business systems and practices and the development of appropriate antitrust policies. The main processes that cause cultural change and evolution, that affect the number and mix of cultural variants in a focal population, have been summarised by Boyd and Richerson (2005). Inertial forces tend to reproduce the same cultural variants over time and result from unbiased sampling and faithful copying of memes. Forces for change comprise two types: *transmission biases* that make people and firms more likely to encounter and adopt some memes rather than others and adapt their behaviour accordingly; and *natural selection,* which affects what happens to people and firms that have different cultural variants or memotypes, such as whether they succeed or not and hence their memes are perpetuated or not and whether they become models to copy or

not. These processes represent generic types of targets for antitrust policy, as is explained in the next section.

Normative Implications of the Evolutionary Perspective

The evolutionary view has implications for firm strategy and for policy. For firms the strategic issues are how to effectively participate in the complex, self organizing, adaptive, evolving business systems of which they are necessarily a part. For antitrust policy the evolutionary challenge is to influence transmission biases and natural selection processes so as to improve the evolvability of a nation's business systems, including: (a) weakening inertial forces that tend to reproduce the same business systems over time when environmental variation calls for new business models; (b) shaping transmission biases to enhance productive entrepreneurial, innovation and imitation processes and (c) influencing natural selection processes, including the birth and death of firms, to ensure that the pool of cultural variants in the business population remains viable and varied, such that it opens up rather than narrows future development opportunities and evolutionary paths.

In order to understand the meaning of these type of policies we have to understand some of the main types of characteristics of CAS and the way they evolve that complexity theories have helped to identify. For further discussion of some the ideas see Wilkinson and Young (2002, 2005).

History Matters

History focuses attention on temporal and sequence effects, which are manifest in many ways. First, *starting conditions* affect the way a CAS behaves over time and the kinds of attractors that can emerge. This means that firms and business systems are restricted in what they can sense and the evolutionary pathways they can follow based on where they start from. Second, once we start down one evolutionary pathway it tends to block off some others, or what we refer to as *path dependence*. What is new about this? We always knew that firms could only act based on their resources, competences and orientations. Complexity teaches us a more profound lesson that the way we search forward in time and adapt is biased and may miss viable and better alternative evolutionary pathways and opportunities. We see this in research on innovation and the entrepreneurial process, which shows how prior knowledge affects our ability to recognize and discover new opportunities because it limits the kinds of links among existing and new ideas we are able to make (e.g. Kirzner 1997). Thus, collectively and individually we can only see and reach some futures. As the Irish joke goes, if you want to get to there I would not start from here! There is no guarantee that the assortments of knowledge that exist in the minds and memories of people and firms will allow us to recognize, let alone successfully exploit, all the opportunities available or even the best ones.

The third way history matters is in terms of the *temporal order*, or sequence of events, and the tempo or spacing of events. Simulations of complex systems show that order effects can change evolutionary paths and outcomes not just the mix of types of events or factors influencing a system. History plays out over time and key events or sequences of events and factors, such as the entry order of competitors, the sequences of technologies, or confronting particular types of problems or selective disadvantages early, rather than later, in a firm and industry's development can have major impacts on subsequent patterns of success and development (Porter 1990). Earlier events set the stage, alter the starting conditions, for sensing and responding to later events, which in turn affect the kinds of opportunities that can and are recognised and acted on by firms. A particular example is that of bifurcation or tipping points, in which small apparently insignificant events can entrain patterns of development and evolution far into the future – the preverbial butterfly affecting global weather or the postive feedbacks resulting from one technology getting a head start e.g. Beta vs

VCR (Arthur 1999). Order effects are reflected in the learning and knowledge development processes in firms and industries, which enable and constrain future developmental pathways, such as of the kind identified by Levinthal and March (1993), Simon (1993) and in Levitt's (1986) concept of marketing myopia.

The effects of history are hard to see when much empirical analysis in business, economics and social science is cross sectional and variance based (Abbott , Van der Ven and 2004). One of the lessons of research on complexity is to highlight the impact of historical processes and contingencies. Moreover, the increasing pace of change, speed of communication and far reaching inter-dependencies and interactions among businesses and economic systems across and within industries, technologies and nations makes their impact more difficult to ignore.

What can be done? At heart the task is to increase the ability to make productive links among ideas, both new and old, as well as facilitating the exploitation of the opportunities so recognized. There is a principle that seems relevant here that in marketing was espoused by Wroe Alderson (1957), one of the founders of modern marketing theory. He called it the power principle: to act so as to promote the ability to act.

Much research has focused on the way new ideas and innovations arise and diffuse in a social or business system. Much of it falls under the heading of entrepreneurship and it has become a hot topic and course offering in many business schools of late. The focus of research in this area used to be on the characteristics of the entrepreneur rather than the opportunity discovery process itself, but this has changed in recent years. The focus has shifted to examining the way different types of opportunities are discovered or discoverable. A critical role is played by the prior knowledge people and firms have and the way new ideas come from combining existing ideas in new ways (Shane 2000).

One way of priming the innovation process is to facilitate new types of potentially productive knowledge combinations. For example, I am part of a team trying to develop intelligent software agents to mine the internet for knowledge combinations that could prime the opportunity discovery process (http://research.it.uts.edu.au/emarkets/). Another development in Australia is the Bridge network concept base on the ideas (memes) of John Wolpert (2002). This initiative links firms in high tech industries in networks via trusted intermediaries who overcome some of the barriers to proprietary information sharing. In this way some of the potential opportunities from combining knowledge across firms in the network are identified that otherwise would not be seen. The potential opportunities are a function of the assortment of firms and knowledge that exist within the network and the potential productivity of new knowledge combinations from within that assortment.

Restrictions on the flow of information that limit the kinds of new knowledge combinations that can arise necessarily constrain the innovation and evolutionary process. Most of the great inventions of the past such as language, organisations, the printing press, intermediaries, the transistor, computers, high speed travel, communication and the internet have had their impact not so much from their direct impact but from the way they free up the flow of information and allow productive new knowledge combinations (opportunities) to be discovered and acted on. See for example David Bodanis's (2005) summary of the myriad consequences of the transistor. Each of these significant inventions represent a new platform for evolution to work on and are the cultural equivalent of the "invention" in nature of replicators, multi-cellular organisms, communication systems (e.g. eyes), mammals and minds (Dawkins 1989).

There are many forms such restrictions can take and antitrust law may wish to consider some of these. For example, one way new knowledge combinations arise is when people move between firms. But contractual clauses that limit disclosure and the types of firms an ex-employee can work for obviously limit the kinds of knowledge combinations that can occur. Against this is the issue of protecting the rights of those who have valuable knowledge to exploit it and the incentives to find and exploit new opportunities.

On a more general level, the ability of a population of organisations to evolve and adapt in superior ways to each other and to changing environmental conditions depends on the variety within and between the organisations. This idea goes back to Ross Ashby's (1952) original concept of Requisite Variety, which states that the ability of a system to deal with its environment depends on matching the variety of the environment within the responding system. In business systems the variety is reflected in the assortment of cultural variants or memotypes in the population of firms. Research on biological systems shows, the same or similar phenotypes may arise from different genotypes and co-exist in the population . When environmental conditions change, this variety in the underlying genotypes plays an important role in providing different pathways forward. Genotypes will vary in how they respond and survive in the changed conditions and hence explore a wider space of possibilities. But if all the genotypes were the same, for example optimised to the current conditions, this would limit the response alternatives to random mutations and local differences in context. Similar arguments apply to the evolvability of business systems and the range of generating memotypes underlying current firm behaviour. We know from studies of business evolution that radically new types of products and industries often come from outside the existing mainstream, in part because the mainstream tends to become myopic, blinkered and restricted in their ability and willingness to recognize and exploit new types of business models, especially those that undermine traditional ways of thinking and behaving, so called disruptive technologies (Christensen 2000)

Interaction and Feedbacks Matter

The second major contribution of complexity theory is to focus attention on the connections between the parts of a system as opposed to the properties of the individual parts. There are two aspects to this: the way micro interactions taking place among existing parts drives overall system behaviour and the way the pattern of interactions over time creates the parts themselves.

A complex adaptive system comprises a *network* of interconnected, interacting entities, actors or agents and overall system behaviour arises from the micro interactions taking place among them. This contrasts with much of business and economic theory, which focuses on the number and properties of individual economic actors, including their decision-making and management characteristics (e.g. Ball 2004). In economic and business systems interactions and feedback effects among activities, actors, resources and ideas or schemas all play a role in shaping behaviour and evolution (Hakansson and Snehota 1996, Welch and Wilkinson 2002). These interactions are the means by which resources are accessed and created, problems are confronted, innovations and adoptions occur, knowledge is shared and developed and value is created and developed.

The implication for antitrust policy is that the relevant units of adaptation and evolution are not individual firms competing in a focal horizontal market but networks of interconnected, interdependent, interacting firms and other organisations spanning various markets, industries and technologies. These networks together create and deliver value to intermediate and end consumers and develop and co-evolve over time through their internal and external actions, responses and interactions. This involves a continual process of configuring and reconfiguring the connections between actors in the network, changes in the actors included in the network and the role they play

and the creation and destruction of new types of actors and relations. This co-evolutionary process cannot be understood, the main forces that drive development and evolution cannot be identified, and the potential role and impact of antitrust policy cannot be fathomed without focusing on the structure and behaviour of relevant business networks.

The reason that business networks are the relevant focus of attention is because an individual firm, or set of competing firms in one market, are limited in their ability to sense, understand and respond to its environment compared to a network of firms spanning different markets and industries. The underlying principle is Ashby's Law of Requisite Variety. The variety of an individual firm's responses is limited by the capacity of its management to sense, understand and respond to its environment, a network of firms has a potentially far greater variety of responses, which is limited only by the alternative configurations of relations and interactions that can develop within and between them.

There are many examples from business research and management practice that bear witness to the increasing attention being given to the role and importance of business relations and networks, i.e. the connections between economic actors, as opposed to the characteristics of the individual actors, as forces underlying performance, competitiveness, innovation and adaptability. The paper by Hakansson in this special issue includes an account of some of the research and thinking of the IMP group about the nature and importance of relations and networks and I will not repeat them here. Two examples will suffice. One is the increasing recognition that innovation takes place more between firms and other organisations, rather than within them (e.g. Chesborough 2003, Hagel and Brown 2005, Subroto et al 2000). The relevant interactions are not limited to those associated with a particular market but cut across markets both horizontally and vertically and across technologies, regions and nations. They also include interaction and feedback effects with the natural environment, which are becoming an increasing focus of attention these days and set ultimate limits to the long terms evolution and sustainability of an economic or business system (e.g. Diamond 2004). The second example is the concept of the extended phenotype or extended enterprise view of the firm and soft assembled strategies (Wilkinson and Young 2005). Genes, as Dawkins (1987), has pointed out are not limited in their expression to the body and behaviour of the phenotype it happens to be embedded in. They are also capable of affecting the development and behaviour of other animals and plants and this has implications for survival and reproduction and hence affects the evolutionary process. He refers to the effects of genes from one animal or plant on linked plants and animals as the extended phenotype. In the same way firms and people make use of the resources and innate characteristics of their local environment as an extension of their senses, memory, resources and mind in various ways, such that the boundary of the self or firm is negotiable and flexible (e.g. Lane and Maxfield 1996).

Unfortunately most business disciplines make their primary and often only focus of attention the management of the individual firm and what drives its efficiency, competitiveness and performance over time. This is understandable as firms employ most of the graduates from our business programs, help fund these programs and managers are the main buyers of consulting services. But the types of environment in which firms now operate tend to generate problems and opportunities that are beyond the ability of firms to sense, comprehend or respond to independently. Such environments are variously described as turbulent, complex or hypercompetitive (e.g. Emery and Trist 1965, D'Aveni 1994, Wilkinson and Young 2005). In such conditions the relevant units of analysis are networks of interrelated and interdependent firms and organisations spanning industries, markets, technologies and nations. This creates major strategic problems and opportunities for firms and policy makers. I should mention that relations and networks are also

relevant in other types of environments but we need not go into that here (for a more extended discussion see Wilkinson and Young 2005).

Complexity theory suggests that antitrust policy needs to focus attention on the nature and role of these different types of interaction and feedback mechanisms if it is to intervene meaningfully in business system development and evolution. But not all such interactions are under the control or influence of government policy and governments have to learn how to recognise qualitatively different types of evolutionary pathways and tipping points, so as to help steer business away from pathological attractors. This, of course, is easy to say but research in complexity shows that this is no easy task.

Hakansson, in his paper in this special issue, explains how a focus on interactions and networks changes our view of the way firms and markets behave. Markets are seen as networks of exchange relations developed between firms in and across markets, in which economic actors are directly and indirectly connected. These networks of connected exchange relations shape the way a particular market behaves and evolves and in turn the interactions actions and their outcomes serve to reproduce, strengthen weaken or alter the underlying pattern of exchange relations. I will not repeat the discussion here. Suffice it to say that a network and interaction view is central to complexity research.

Interactions and feedback effects are not characteristic of other types of market analysis. Porter's industry analysis framework includes interactions in the form of rivalry among players in a market including existing competitors, potential entrants, potential substitutes, as well as with suppliers and buyers. But a business network focus leads to a consideration of other types of direct and indirect relations and interactions taking place among firms and other organisations, including collaborative and competitive forms, that cut across traditional market, industry and technology boundaries. But the network and interaction perspective goes further, it also emphasizes how the ongoing patterns of action and interaction creates organisations and networks. This is considered in the next section.

Dissipative Structures

So far I have taken the existence of economic actors, usually firms, as given and focused on the role and importance of the connections between them as driving performance and adaptation. But complexity research directs our attention to the very nature and existence of the actors in complex adaptive systems. It makes the process primary, the continual flow of action and interaction, and actors are derived from this, as reproduced patterns of action and interaction reinforced over time or undermined and eroded.

To illustrate we may use the analogy of a river. The continuous flow of water downstream in a river results in the formation of local patterns of repeated behaviour, such as eddies or whirlpools. These are local structures that are reproduced over time through an ever changing stream of water molecules following the same patterns of behaviour. The eddies and whirlpools are macro structures that arise, in a self organizing manner, from the ongoing local interactions taking place among an everchanging stream of water molecules. Over time, as conditions change, due to increased or decreased water flow and local environmental impacts, the pattern and location of eddies and whirlpools changes. Eddies, whirlpools and business firms and networks are examples of what are called dissipative structures, a concept developed by Ilya Prigogene, which won him a Nobel Prize. Dissipative structures are what complexity is about.

In this view *non-change* rather than change becomes problematic (Abbott 2001). Why do firms and networks which embody particular characteristic patterns of behaviour persist? How are these

patterns reproduced over time amidst the constant flux of actions and interactions taking place? This approach offers, I believe, additional fruitful perspectives for formulating antitrust policies.

Antitrust policy focuses on the structure and conduct of firms in markets as a means of improving overall economic performance. The underlying assumption is that firms organize the activities taking place in markets and the number of firms in a market and the way they individually behave matters. After all, isn't it firms who make decisions about how and when to act and interact? An alternative perspective focuses attention on the ongoing processes taking place, the actions and interactions, and how these create firms rather than the way firms create the patterns of actions and interactions (Wilkinson 1990). The business of antitrust is to help shape the kinds of interaction and feedbacks that lead to the right kinds of firms and networks evolving, rather than controlling the firms and networks that exist in order to produce the right kinds of interaction and feedbacks.

Networks Matter

The foregoing discussion highlights the role and importance of networks in business systems. Antitrust theory can draw on research on the nature and evolution of networks to inform its understanding of business networks and how government policy could play a productive role in business evolution. Our understanding of network structures and their effects has improved significantly in recent years as a result of the study of complexity and progress made in the mapping, analysis and simulation of networks (e.g. Barabarasi 2002, Ball 2005). Neo-classical economic theory of perfect markets assumes a random mixing of suppliers and customers resulting in a random network pattern of trades. If extended to other vertically linked or complementary markets a larger random network configuration would be the result. Business networks would comprise fleeting interactions among a set of equal sized small suppliers and customers. This seems to be the basis of much theory underlying antitrust policies around the world. Distortions or failures of perfect markets in the form of monopolies and imperfect competition, whether they arise for natural or contrived reasons, are a central focus of antitrust cases. It is generally assumed that such failures are not in the consumers' or societies' interests and need to be controlled or reconfigured. Unfortunately research shows that networks of people and firms (as well as other entities) do not develop into such random network structures.

Depending on the patterns of interaction taking place and the way they are interconnected over time and place, different types of trading networks and associated patterns of exchange relations can emerge which have characteristic properties. These properties are a source of opportunities and threats. The focus for antitrust theory and policy is to understand the processes of network development and evolution and to identify ways of intervening that influence these processes in productive ways, rather than simply regulating firms occupying particular network positions that are the outcomes of these processes. The outcomes in a sense are inevitable, it is the processes of business development and evolution that require more attention than the structure it produces. The structure reflects the processes at work and only temporary reconfigurations are possible if the underlying processes remain unchanged.

What are the types of networks that can arise? Which ones should we be more concerned about? And what types of processes produce different kinds? These are all big questions and I do not believe we have firm answers yet but lots of intriguing work is going on. As Barabarasi, one of the leaders in this field, has commented, there are a "zoo of network types out there" (cited in Ball 2005). For our purposes three non-random types deserve our attention - structured, clustered or small world, and hub or scale free networks. Structured networks are those following a fixed

regular pattern of connection, such as a lattice or grid, and usually reflect a network deliberately designed for some purpose. Such networks generally do not grow naturally as there usually is no designer or network controller. Instead network structures emerge in a self organizing way from the patterns of interactions taking place in complex adaptive systems and the way they develop over time.

Small world networks have received much attention of late owing much to the name Kevin Bacon and to the research of Strogatz and Watts (Watts 1999). Small world networks are those in which each node is only a few steps or links away from any other node, even though the network is not richly interconnected. Most links are clustered together around those nearby in some way e.g. space, behaviour, beliefs, and that these local networks are highly interlinked or clustered. People who know you well probably know each other, firms compete and trade more with those serving the same customers or using similar suppliers and inputs. But some links are with other nodes that are not part of the local network and which may be "far away" in some sense. These long reach links, which are simulated in terms a few random connections in the network, have the effect of reducing the average distance in links between nodes in the network significantly. The importance of these links in business and markets is reflected in research by Ronald Burt (1992) work on the importance of structural holes and Mark Granovetter's (1973) research concerning the strength of weak ties. They show how these long reach links tend to be weak links but are an important source of new information and ideas. This is because strongly interlinked people or firms are more likely to know what each other knows. Long reach links bridge structural holes in networks, acting as bridges between otherwise non connected parts of a network. Similar concepts have been used to explain the nature and role of entrepreneurs and the way they are able to recognise and discover new types of opportunities (or threats) because of the new knowledge combinations that have access to that others do not. Unfortunately it is not yet possible to identify all structural holes that might be fruitfully occupied or to estimate how many of them have been occupied – but the internet and the death of distance is having an effect I am sure.

The third form of network structure is the hub or scale free network, which can be confused with a small world network because it does have small world properties – nodes are on average not far from each other in terms of number of links. But scale free networks have a distinctive distribution of links per node called a power law, which is quite different to the normal or Gaussian distribution we are familiar with from courses in statistics. If the frequency distribution of links per node followed a normal distribution, we would expect most nodes to be around the middle of the distribution with a tail on either side. The central tendency or mean reflects the scale of the distribution or where it is located on a scale of number of links per node. A power law has no central tendency or characteristic scale, instead most nodes have very few links and the frequency of nodes with x links falls off rapidly as x increases. On a log log scale, showing the cumulative frequency of nodes by number of links, the curve is a straight line. This means that some links have a very large number of links, while most do not. These are the hubs in the network. Such network patterns have been found in many situations including earthquakes, ecological systems, cities, friendship networks, sexual partners, movie actors, co-authorships, patent links and trading networks.

Iansiti and Levien (2004) in their analysis of business ecologies refer to hubs in this type of network structure as keystones, with Microsoft being portrayed as such a hub or keystone. This has led to some controversy over whether hubs are a good or bad thing in economic terms, especially with the recent Antitrust Case concerning Microsoft. Such a network position seems obviously good for Microsoft but is it good for the US and the world economy to have such hubs? Can and should Microsoft's behaviour and the structure of the networks in which it is involved be changed or

controlled in some way and who and how should this be done? See for example Foer's 2005 discussion of this.

What does research on these types of structures tell us? First, such scale free networks seem to be characteristic of any living system and reflect the way networks grow naturally. The underlying rule for development may be summarised in terms of the "the rich get richer." As a network grows new nodes are more likely to form links with, be attracted to, or find, nodes that are themselves already well connected. The probability of a new node linking with another node depends on how many links the other node already has. Thus people and firms are more likely to form links with people and firms who already have more links with other people and firms. Various psychological, social and economic mechanisms lead to this type of behaviour, which represent forms of positive feedback effects. In the case of Microsoft, the network economies involved in using a computer operating system that many already use is the main positive feedback mechanism. .

Trading or exchange networks are likely to form scale free networks because they grow by similar processes to those described. In markets the pattern of market shares among brands and firms follows a power law type distribution, reflecting the frequency of purchase and amount bought by customers over a period. The trading relations firms have with their suppliers and customers is usually characterized in terms of the 80:20 rule whereby 20% say of its customers account for 80% of its business. The number of trading relations firms have with others firms might also follow some kind of power law distribution. In economic theory the development of scale-free networks is reflected in models of markets with strong network externalities, which is a special type of rich get richer development rule. These markets result in outcomes in which the winner takes most of the market, which is a scale free network with hubs (e.g. Economides 2001).

Thus we should expect power law distributions and hubs to arise. It is not the property of the firm or person occupying the hub position that causes it to become a hub, it is an outcome of the way networks grow and evolve. How should we deal with them and what are the benefits and dangers? Are they another form of natural monopoly that require government regulation? If they do require some form of government regulation and control, which government should be responsible? In an increasingly globalised economic system the relevant networks are not confined to one country, so should the US government regulate and control hubs like Microsoft or does it require a network of governments to (effectively) regulate ecomomic networks?

Research by Barabarasi shows that there are various types of natural constraints affecting the power law character of scale free networks, particularly the size distribution of hubs. For example, there are limits to how many movies one actor can be in, how many friends an individual can have. Firm size, technology and geographic constraints affect how many customers or suppliers a firm can handle. In addition firms and people are heterogeneous and there are forces of repulsion as well as attraction in networks, such that at times the rich may get poorer, at least for some in the network. For example. Some people have strong negative feelings about using Microsoft and are committed to other operating systems such as Apple or Unix. Research by Granovetter and Sung (1986) show the impacts of positive and negative bandwagon effects on the adoption of products. People differ in their attraction to a product depending on how many others are buying it in terms of two thresholds: a lower threshold in terms of the percent of (relevant) people buying it before they will buy it and an upper threshold indicating the percent of people buying it that will trigger a person to try something else. People differ in both these thresholds and this underlies the dynamics of the system.

Are their natural constraints that limit the power and reach of economic hubs or keystones like Microsoft or can hubs become too powerful and control and direct the future evolution of the

network in their own interests? If a power law type distribution is a natural result of interactions does it mean, for example, that if we break up Microsoft we will just end up with another operating system assuming the same powerful position? If this was an open source system like Linux would this be better, as some would argue? But we also have to consider the incentives underlying the emergence of hubs in the first place. If the hubs that emerge naturally in any living business or economic system are subject to government takeover, and as a result their core technology is made freely available, would this damage the process of evolution of networks in the first place. Firms that were on their way to becoming hubs would have incentives to limit their growth and to encourage competing hubs to grow, as well as to disguise their "hubness." Would this result in the evolution of better functioning networks over time or would it lead us into inferior evolutionary pathways?

A metaphor that occurred to me in contemplating these questions was to compare Microsoft and its operating system to the English language. Microsoft's role is similar to some organisation being in control of the development and evolution of the English language. You don't have to use English but many people are using it because so many people already use it in business, science and social life around the world. Well we might argue whether we all speak the same English but let's not get into that. Languages evolve as new words are added their meaning changes and the rules of grammar alter. All of us are free to use the word to say and write and think what we want in English but there are some things that are more easily said and thought in other languages, so I believe. No one controls the English language and regulates the core rules of grammar, spelling and meaning of words, although dictionaries and rules of good English are produced. Indeed its living nature comes from the way these standards change over time and how innovations in language arise and spread. Is Microsoft the equivalent to a controller of the core of the English language? Is it like the French government organisation that tries to control the evolution of the French language? Despite the attempts to control it the French language has evolved and in ways not necessarily desired by the French government. Hence we can expect Microsoft to be unable to control the evolution of operating systems and the way they are used. From my limited understanding of the technicalities involved Microsoft seems potentially more powerful than the French government controlling French. This comes from the core of its operating system which is only made available to developers in machine code form such that it cannot be altered by anyone other than Microsoft. If this is so evolvability is constrained. How serious this is and how difficult it is to work around this constraint is hard to say. Is it an inevitable natural constraint similar to the laws of physics and chemistry are in biological evolution? No, the core operating system is itself a unit of evolution.

This is enough of a metaphorical digression. Now let us return to what we know about the behaviour and evolution of business networks and what this means for antitrust.

Nature, Role and Regulation of Scale Free Business Networks

There is no simple answer to all these questions and problems but complexity theory and its associated methodologies help us address them more clearly. In the remainder of this paper I will consider the potentially good and bad characteristics of a scale free business networks, their evolution and evolvability and the role antitrust policy could play.

Scale free networks are resilient because random failures of parts of the network do not affect its connectivity and functioning very much. However, if hubs can be identified such networks are vulnerable to attack. So perhaps we need to be worried about the failure of a Microsoft, as this will lead to a rapid contagion of others directly and indirectly linked to it. While Microsoft could be a keystone enabling many others it could equally be a way of rapidly spreading damage. This ability to spread damage in terms of inhibiting the actions and performance of others lies at the heart of

discussions about regulating Microsoft. Microsoft is a type of monopolist because of its power to do good or evil and most economic theory assumes monopolists will use their power in their own interests and this will be against the interests of the many.

At the risk of repeating myself, we need to distinguish between the effects of regulating the behaviour of or breaking up an existing hub on the performance and behaviour of others in the network and the effects they may have on the evolution and evolvability of the network. For example, will regulating a hub tend to ensure its continuation as a hub, preventing other forms of network evolution? Will breaking it up lead to the emergence of another hub with similar characteristics, which then has to prosecuted all over again, or will it lead to some process of network evolution that will be better or worse? In order to answer these questions we need some idea of how networks evolve over time. After all, there used to be business networks before Microsoft. Is Microsoft somehow the result of the internet and computers rewriting economic laws? I doubt it.

Business networks evolve through a process of reconfiguring the links between and among actors, activities, resources and schemas. Incremental changes are taking place all the time as interactions take place over time. Radical changes involve significant and novel types of reconfiguration. As discussed above, entrepreneurship, including opportunity recognition and exploitation, lie at the heart of the process. How does a scale free network play a role in the evolutionary process? Innovations involve generating new ideas and these come from recombining existing ideas – they are not endogenously determined manna from heaven (Nelson and Romer 1996). Ideas get recombined through the research effort of individual actors and through the communication and interaction-taking place among actors.

Scale free networks help preserve ideas, both good and bad, because they are hard to eliminate completely. This is shown by research on the spread of viruses in human and internet environments. Although programs targeted at hubs can significantly reduce their presence and spread in the network, they remain in parts of the network ready to spring into action when network conditions permit. Scale free networks also facilitate the recombining of ideas because of their small world character. This helps ideas to be found and for ideas to find productive homes through communication networks. No matter where ideas are located, they are not very far from others in the network. This recombining is limited by the extent to which ideas are easily found, communicated and used by others and by the way knowledge is distributed throughout the network. Some ideas are locked away by firms, protected by patents or not easily communicated or understood because they are tacit, sticky and embedded in relations and routines (Badaraco 1990).

Hubs play an important part in facilitating the spread of ideas and therefore influence innovation through impacts on the opportunity discovery and exploitation process. As this is central to evolution and the evolvability of the network it seems this subject should play an important role in Antitrust policy deliberations. This suggests that potential targets for antitrust policy are the various types of actual and potential transmission biases that could adversely effect evolvability. Some of these already form part of antitrust policy because they are related to issues of static efficiency and price competition. For example, misleading and deceptive practices result in biased transmission and affect the numbers and types of competitors which in turn limits the cultural variants for the evolutionary processes to work on.

Other ways in which potentially productive recombination of ideas can be inhibited include: entry barriers to new types of firms; obstacles to new types of relations and interactions forming among firms in and among different markets, industries and nations; the ability of workers to set up or move to new firms or nations in order to exploit innovations that their existing firms or nations are

unwilling or unable to exploit; the limited exposure of some industries and parts of networks to international cooperative and competitive interactions; and the inability and unwillingness of firms to share information and ideas with other firms for fear of losing control of the ideas and/or damaging their own prospects compared to counterparts. These are perennial problems that shape the kinds of business networks that arise, which firms eventually become hubs, how these change over time and how efficient a given network is at any given time.

The central issue it seems to me is not to freeze business networks in terms of a particular structure, pattern of conduct and/or regulation, but to ensure many natural experiments can and do take place among and within firms in order to give evolution more to work with. In this way the requisite variety of the network and economic system is preserved and many potential evolutionary pathways are opened up rather than closed off. Freezing a network or part of it is like killing off part of the living system, reducing it to be part of the environment rather than part of the living system and evolutionary process.

Agent Based Models of Markets Matter

Tools to help us map the structure and evolution of business networks over time and place now exist and are beginning to be used in more sophisticated ways (e.g. Powell et al 2005). Tools also exist to help us examine the impact of different types of regulatory systems on the behaviour and evolution of business networks. In particular, agent based models of economic systems offer ways of developing and testing our theories of business structure, conduct and evolution including the impact of various types of Antitrust policies.

We cannot conduct experiments about the impact of different types of antitrust policies in actual economic systems. It would be politically and managerially impossible to implement, extremely costly, be likely to damage whole industries and economic sectors, and take a long time. Instead, we need to construct some generic agent based models of business interactions and network evolution and performance which can be used to conduct such experiments and to focus debate and actual antitrust case analysis. I am not saying we need to have a special model for each industry, network and antitrust case. We need to reach agreement on some models and processes that allow for and require a more focused, clear, transparent and logical analysis of the theories, arguments and implications of different antitrust policies and decisions. Our models will not be perfect and will need to be modified over time as we learn more about the processes at work. But all models are imperfect and are only helpful representations of key processes to aid thinking and prediction. Macro economic models are used to guide economic policy, why not micro models to guide antitrust and trade policy? An example of the kind of model that needs to be developed is the agent based model of the wholesale electricity markets in the US being developed by Leigh Tesfatsion and her colleagues that is designed to test the economic reliability of the Wholesale Market Power Platform proposed by the US Federal Energy Regulatory Commission in 2003 ((Koesrindartoto et al 2005). Agent based models have also been developed for the purposes of studying transport systems, ecological systems, economies and distribution systems.

Conclusions

In this paper I argue for an extended main case for antitrust policy, in the sense described by Williamson (1996). To date the main case focuses on economizing, including market power as a key filter for identifying suspect cases. Both production and transaction costs are considered as part of economizing and other factors are use to consider the benefits of different industry structures. CAS analysis focuses attention on dynamics, evolution and networks. I suggest "evolvability" as an additional main case consideration and that this can in part be related to network costs in

addition to production and transaction costs. Transaction costs (and benefits) focus on individual transactions and relations in isolation. Network costs (and benefits) focus attention on the *connections between transactions and relations over time and place*, including how business arrangements at one time limit or enable arrangements in the future. Such considerations can be included in the rules of antitrust and be included in the process of antitrust case analysis and decision making.

Incorporating such ideas into antitrust policy is not without its difficulties. In particular it requires that they are administratively and politically feasible. This of course has to do with the evolvability of the law, policymakers and lawyers as well as business and law schools that are involved in the reproduction and diffusion of relevant business memes! Antitrust policy, business schools and law schools do not stand outside of business systems but are relevant actors in the CAS that is the business ecosystem. They affect and are being affected by business practice and ideas about business practice. Furthermore, in an increasingly globalised world business system, issues of evolvability and economizing are not confined to one nation but to interrelated networks of nations and their antitrust policies. US antitrust policy and decisions impact other countries business systems and vice versa, which leads us into a much larger evolutionary arena.

I suggest that a way of facilitating policy development and case analysis is through the use of agent based models of relevant business networks. These are capable of extending our understanding, analysis and theory in the area of business networks and their evolution. They are more than a technique, they are a modeling philosophy and a way of developing and comparing theories not possible in other ways (Tesfatsion 2005 Fioretti 2005).

By introducing an evolutionary perspective, we are able to see antitrust policies in a new and potentially helpful way and to direct our attention to potential policy targets that may not otherwise be considered. In order to do this we need to make use of methods and theories of business and economics drawn from complexity and network research. We are at an exciting stage of development of these ideas, theories and methods and need to draw from them and contribute to them.

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