"Group selection vs individual selection and the evolution of cooperation in business networks"

Ian Wilkinson University of New South Wales, Louise Young, University of Technology Sydney and Dan Ladley University of Leeds
(IMP Conference, August 2007, Manchester, UK)

Abstract

This paper focuses on how and why things change – looking at the processes that drive evolution and the results of evolution. Focus traditionally has been on individual selection processes or "survival of the fittest" as the explanation for this. However recent theories of evolution have returned to the concept of group or multilevel selection processes as a complement to individual selection. Research shows that selfish strategies "beat" cooperative strategies (and hence facilitate survival) within groups but cooperative groups "beat" selfish groups to survive. This has led to a revolution in theories about the nature and evolution of cooperative strategies in human societies beyond that of kinship selection and reciprocity based explanations to theories of continuing interaction and on to group selection. We report the results of agent based models designed to explore the effects of group and individual selection in the evolution of strategies in Iterated Prisoner Dilemma games and compare these. Our analysis shows how group selection results in the evolution of productive strategy mixes in which both "fitter" individuals and groups emerge. We consider the implications of our results for the nature and development of interaction strategies in business networks and consider further research opportunities.

"Group Selection versus Individual Selection and the Evolution of Cooperation in Business Networks"

Introduction – Research in the Evolution of Business Relationships

"Philosophers have only interpreted the world in various ways; the point is to change it."
Karl Marx, Theses on Feuerbach, 1845

The role and importance of collaboration within and between firms in generating collaborative and competitive advantage is well known and well discussed. What is less understood is how and why relations and networks move from less to more collaborative forms and when this is desirable. Many models exist and have been empirically tested about the dimensions of business relations and how they are interrelated and what the characteristics of ones who perform better or worse are. In these models variance in one dimension, such as trust, cooperation, commitment, power and conflict, is "explained" in terms of variation in other dimensions, including characteristics of the focal relation, the actors involved and the context in which the relation operates. However, these models are inadequate because they have serious validity problems and do not really test causality and hence do not deal adequately with change and its drivers.

To expand on this, various types of causal links are assumed to underlie the structural equations linking variables in variance based models and the patterns of covariance observed, but variance based models of business relations and networks do not provide a direct test of the existence and importance of these causal mechanisms and how they work. All we know is that variation in one dimension is associated with variation in another and arguments can be made for causation operating in either or both directions, especially when cross sectional survey based data is used. For example, trust may be seen as a precursor of commitment or cooperation but commitment and cooperation can also serve to reinforce and enhance trust. The implicit assumption in these models is that if we "tweak" one variable, such as trust or commitment, this will affect other variables in the direction suggested by the path coefficients. But how is this tweaking done? Managers live in a world of actions and decisions not variables. Variables don't act, people do. The models are generally silent in terms of:

- "How," i.e. what <u>actions</u> managers or policy-makers can and should take to bring about change in the relevant variables,
- What the short term and long term outcomes will be,
- What causal mechanisms are in play, and
- How these causal mechanisms interact and play out over time.

In short, existing models are not dynamic and do not deal with the processes of change; instead they are comparative static models.

Other research addresses change more directly, however this work is largely descriptive. For example, much IMP research has described and characterized patterns of change and development in business relations and networks but there are not well developed theories to account for the changes observed. Four types of theories of change have been suggested: life cycle, teleological, dialectic and evolutionary (Van de Ven and Poole 1995), which have been used to offer some explanation of the development and evolution of business relations and networks. Evolutionary theories are the most comprehensive and encompassing type of theory as they subsume the other approaches as components (Aldrich 1999). They also form the basis of the research described here. But research in this area is still underdeveloped, even though interest appears to be growing (for reviews see Wilkinson 2001, 2006).

The problem for managers and policymakers is posed by the above quote from Karl Marx: to what extent and how managers and policymakers can change things, and, more generally, how and why do business relations and networks change and evolve. Models and theories of change and evolution that can address this are being given increased attention in the IMP literature as well as more broadly in the study of business (e.g. Huang and Wilkinson 2006, Buttriss and Wilkinson 2004).

The *purpose of this paper* is to describe and test a new type of theory that we believe is of particular relevance and importance in understanding and accounting for the development and evolution of cooperation in business relations and networks - the evolution of cooperation, based on group selection mechanisms. First, we briefly introduce group selection and then review existing theories of the development of cooperation in biological and social systems and show how group selection mechanisms offer a way of explaining the emergence of cooperation in contexts that other theories cannot. This applies in particular to large scale cooperation amongst strangers, which is directly related to business relation and network contexts. We then develop agent based models of the evolution of strategies in iterated Prisoner Dilemma and other types of interaction games that are designed to capture some of the essential features of the tension between cooperation and competition in business relations and networks. The models are built on those used by Axelrod (1984, 1987) in his famous work examining the dynamics and evolution of cooperation. However, Axelrod only considered individual selection mechanism, whereas we compare the results for individual versus group selection mechanisms on the development of cooperative strategies and how this impacts individual and group performance. We show how group-selection mechanisms produce not only superior group performance but also individual strategies that are superior to those produced by individual selection. Finally, the implications of our results for understanding the dynamics of business relations and networks and the role management and policy-makers can and cannot play in developing collaborative advantage is discussed.

Group Selection

Group selection is best illustrated by an example of the difference between group and individual selection. An illustration of the operation of group selection mechanisms is the breeding of hens to lay more and larger eggs. Breeding from the fittest (most prolific laying) individual hens has been used for years to improve output in poultry farms and has evolved hens that lay more and bigger eggs. But the process also produces what might be described as “psychopathic chickens” - hens that are very aggressive, who fight, kill and even eat each other. The result is high mortality rates that undermines the gains in laying ability. However, research by Muir (1996) showed that group selection overcame this problem. By breeding from groups of hens, specifically <u>all</u> those that lived together in the cages with the highest average egg mass irrespective of their individual performance, he was able to evolve hens that overall produced greater egg mass than those who were individually selected or bred randomly. These hens were ‘kind and friendly’ toward each other and lived normal life spans, which in turn results in greater overall efficiency and improved animal welfare. Subsequently Muir (2005) has shown that the same results occur in other types of animal and plant communities.

Group selection mechanisms explain the emergence of cooperative groups. This is because they account for the co-evolution of both fitter individual strategies and groups of interacting strategies in groups. This is in contrast to individual selection theories that explain change in terms of the survival of individuals that are fitter than others and ignore the contexts of those individuals in terms of the strategies of others that an actor interacts with. In other words it ignores the significance of the social world in which business operates. Most business action is group or collective action. Within firms, people interact in groups of various sizes, from small teams to departments, to units and the firm as a whole. Business relations and networks are groups of firms that interact more with each other, and regional and national communities of people and firms are still other types of groups.

Group selection has been ignored until recently because it was considered incorrect by biologists and social-biologists. Yet the evolutionary equations underlying it and how it relates to individual selection were derived by two researchers Griffing (1967) and Price (1970), apparently working separately, in the 1960s. Based on the evolutionary equations developed by Price (1970), Henrich (2004) shows how the expected change in frequency of a cooperative strategy per period is a function of within-group and between-group selection processes, i.e. the effect of a cooperative strategy on an actor's performance, holding its local group composition constant, and the effect of the group on performance, holding the cooperative strategy fixed.

Theories of the Emergence of Cooperation

Theories of group selection are outside the mainstream of theories of the emergence of cooperation. There are three main types of theories of cooperation: kinship ties, signaling and repeated interaction or reciprocity.

Kinship theories are based on the regard and caring people have for others they are related to, such as children, parents and siblings. Research shows that the degree of altruistic, self sacrificing or cooperative behaviour shown to others is proportional to how closely related they are. Social insects, such as ants and bees for example, are all half sisters, which means they have half their genes in common. This accounts for their extraordinary degree of collaboration and self sacrifice for the good of the colony that emerges. Similarly, parents make extraordinary sacrifices for their children that they would not do for strangers.

Signaling theories are based on cooperators being able to identify each other by signaling their cooperativeness, what Richard Dawkins has referred to as "green beard theory." If all cooperators had green beards they could recognise each other and cooperate. Unfortunately this is a not a stable solution, as it would create opportunities for non-cooperators to evolve who had green beards, who could then exploit the cooperating greenies! (See review by Henrich and Henrich 2006.)

Lastly, repeated interactions among individuals can produce cooperation because of the shadow of the past and the future that affects individual interactions. This has been demonstrated most famously in research by Robert Axelrod, who examined the development of cooperative strategies in iterated prisoner's dilemma games (Axelrod 1984). He showed, for example, how Tit-for-Tat, a cooperative strategy that cooperates in the first round of any interaction and then does whatever the other player did on the previous round, emerged as the winner of tournaments in which different strategies were made to play each other over several rounds. Also demonstrated was how the same type of strategy emerged as the winner over time in an evolutionary simulation. Subsequent research has refined his results in various ways but the central point - that repeated interaction, as well as the ability to choose and refuse partners, shapes the nature of the strategies that emerge and survive - still stands, as does the finding that cooperative, but not naïve, strategies that induce cooperation in others eventually do well and can win out. (See review by Henrich and Henrich 2006.)

Such theories help account for many forms of cooperation and the development of cooperative business relations and networks can be explained in part by signaling theories and reciprocity. But they are not able to account for the emergence of large scale cooperation among people who are strangers, which is the kind that characterizes much business collaboration. However, such cooperation can and does emerge, as has been demonstrated in IMP case research and in other studies of business relations and, more generally, is evident in a major set of human behaviour experiments recently conducted by ethnographers and economists around the world (Henrich et al 2001, 2005).

Group selection mechanisms offer a new way of explaining such results and, in business, it offers further insight into the way cooperation can and does develop and the factors affecting its emergence. Henrich (2004, p 5) has shown that group level factors of one form or another underlie all theories of the emergence of cooperation, or altruistic or "pro social" behaviour, as it is sometimes referred to: "[A]ll solutions to the evolution of altruism – whether they are based on kinship, reciprocity or group selection …. – are successful according to the degree in which 'being an altruist' predicts that one's partners or group members are also altruistic."

Thus being in a group of other cooperators is as important as being a cooperative individual. But how do groups of cooperators emerge? Research in biological and social communities shows that, as already mentioned, competitive behaviour "wins" (i.e. produces behaviour that is selected for) against cooperative behaviour within groups, but cooperative groups outperform competitive groups. A tension therefore arises between the evolution of competitive behaviour within groups and the evolution of cooperative groups. Do the same results apply to business? In order to investigate this we redid some of the experiments of Robert Axelrod and compared the results of individual selection versus group selection.

Methodology: Agent Based Models of Iterated Prisoner Dilemma Games

We follow the procedures used by others to simulate the evolution of strategies in interacted Prisoners Dilemma (PD) games (e.g. Axelrod 1987, Lindgren and Nordahl 1996). A simulation model was developed based around the PD payoff matrix game shown in Figure 1, where C is cooperate and D is defect. In this game the dominant strategy in a one-shot interaction is defection as both stand to lose more by cooperating if the other defects. This is known as a Nash equilibrium, as there is no incentive for either party to change. When actors repeatedly interact different types of strategies can emerge, as actors can respond to each other's behaviour over time, remember past behaviour and outcomes (the shadow of the past) and anticipate future gains (the shadow of the future). As noted, cooperative forms of behaviour can emerge in these conditions, as has been shown in the classic simulation tournaments of Robert Axelrod (1987).

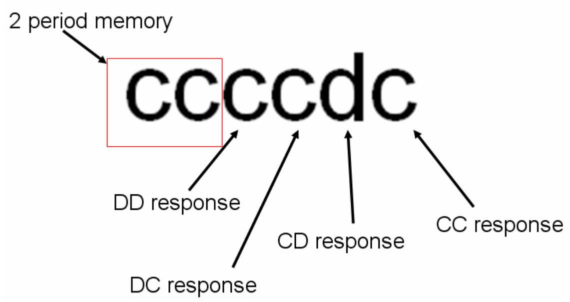
The PD game captures the mixture of cooperation and competition confronting firms in exchange relations. If both cooperate they can gain (the reward for cooperation, R, which is 4 in this example) but, if one cooperates by, say, investing in relationship specific assets, they are vulnerable to opportunistic behaviour by the other (a form of defection) who can take advantage of the other party's investment due to its increased power. In this case the defector receives the temptation payoff, T, and the cooperator receives the suckers payoff, S. Hence there is an incentive for both to not invest in relationship specific assets, without some guarantees or trust in the other. If both defect, do not invest in relation specific assets for example, they each receive the defection or non-cooperation payoff, P. The general condition for a PD game is that $T > R > P > S$ and that $(T + R)/2 < R$. Research devoted to the analysis of PD games and other forms of interaction games has a long history (e.g. Shubik 1964) and transaction cost theory and agency theory, which deal with these types of issues in business, have been used extensively by researchers to analyse business interactions and relationship formation.

Figure 1 Prisoners' Dilemma Payoff Matrix

	C	D
C	4,4	1,5
D	5,1	2,2

Figure 2 shows how individual strategies are represented in the simulation as 6-bit strings of letters, indicating how a strategy will respond to particular patterns of behaviour of another player (the opponent). In this case we assume only a two round memory, i.e. that each player remembers only the last two plays of their opponent. The final 4 letters of a strategy represent what a strategy would do in response to each combination of plays in the last two rounds. This memory can be extended to include what the focal player has played as well as what the opponent has played in the last n periods. But, for simplicity, we focus here on a "simple" two-round memory. To begin interactions players have no knowledge of each other and a two round starting memory is included in the strategy that affects what the player will do in the first two plays of the game. If this is CC, as in Figure 2, it means that the player will cooperate in the first round as indicated by the last letter in the strategy. In the second round their response depends on the second memory letter, which is what the opponent is assumed to have done in the last but one period and what the opponent actually did in the previous round. After two rounds the actual plays of the opponent in the previous two rounds makes up the memory.

Figure 2 Representation of Strategies as 6-Bit strings



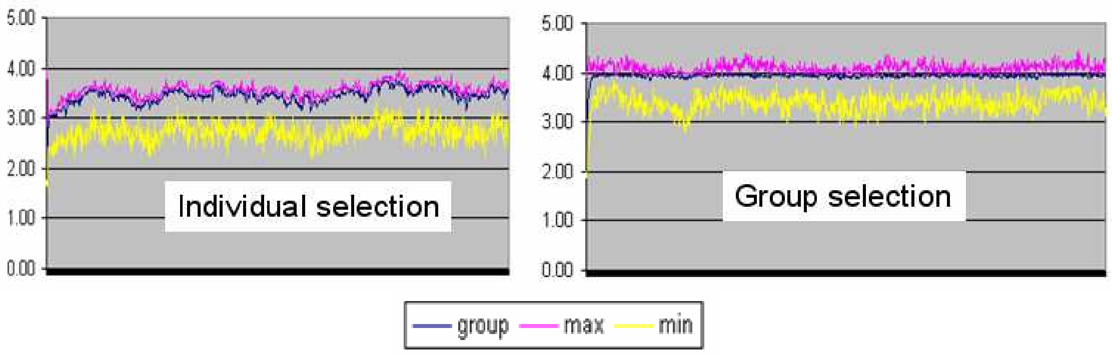
The actors in the simulation are divided into 8 groups and strategies in each group are randomly generated in the first generation of the simulation. Each strategy set (player) plays an iterated PD game over 200 rounds with each other member of its group, excluding itself, in a round-robin fashion. There are no carryover effects from plays with one opponent to another. After each player in a group has played every other, scores are totaled and the performance of individuals and groups are calculated. Strategies are then evolved for the next generation using either (a) the fittest individuals in each group or (b) from all individuals in the group that is fittest on average. Genetic algorithms with cross-over are used to produce new strategies by "mating" from the pairs of individuals selected. Thus two selected strategies having a sequence of 6 letters are "mated" by taking an arbitrary cut point on a strategy and joining one part of one strategy to the other part of the other. For example, if a strategy CCCDC is mated with a strategy DDCDD with a cut point of 2 on the strategy, they produce two child strategies CCCDD and DDCDC which replace the two parents in the population. A mutation rate, *m,* is also included, which is the chance of a given response on a strategy flipping from one state to another at the beginning of a generation. Lastly, there is a small chance, *p*, of a strategy moving from one group to another at the beginning of a generation.

The same procedure is used for 1000 generations for individual and group selection separately and the whole simulation is repeated 10 times. The mutation and group switching parameters were not varied throughout the simulations.

Results

Figure 3 shows the pattern of change in performance over time for group selection and individual selection simulations average over all the simulation runs. Average group performance across the eight groups in each generation is shown, as are the maximum and minimum scores for an individual in any group. We can immediately see that group selection produces superior overall performance. Average scores are higher and the highest and lowest scores in each generation are greater for group compared to individual selection.

Figure 3 Performance Over time: Individual vs Group Selection



The mix of strategies resulting in the final round of one simulation run is shown in Figure 4. This shows the predominance of cooperative strategies in the case of group selection. The first two letters of a strategy reflect what might be thought of as the "predispositions" of the actors, in terms of what they assume has been the past history of interaction when actors first interact. In this simulation run these do not differ between group and individual selection; they all "assume" their opponent has cooperated in the previous two rounds. Here, they all think nice things about their opponent before interaction begins. Interactions among those in the groups developed through individual selection cooperate all the time; each begins by cooperating and this confirms their "predispositions" and so they continue to cooperate. But any perturbation of these strategies could move them away from a cycle of cooperation. In contrast, for groups developed through group selection mechanisms, there is a major difference is the frequency of cooperative responses, no matter what the opponent did in the previous two interactions. Of particular note is cooperation in the third position of each strategy, which is the response to DD. This means that the strategies in group selection will cooperate after two defections but this never happens with individual selection. As a result the mixes of strategies are less vulnerable to becoming locked into a cycle of defections.

Figure 4: Mix of Strategies in the final round of one simulation (Rows Equal Groups)

Group Selection

ccccdc	ccccdc	ccccdc	cccddc	ccccdc	ccccdc	ccccdc	ccccdc
ccccdc	ccccdc	dcccdc	dcccdc	cccddc	dcccdc	dcccdc	ccccdc
ccccdc	dcccdc	cccddc	ccccdc	dcccdc	ccccdc	ccccdc	dcccdc
ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	cccccc
ccccdc	dcccdc	ccccdc	ccccdc	ccccdc	dcccdc	dcccdc	ccccdc
ccccdc	ccdccc	ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	ccccdc
ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	ccdccc	ccccdc	ccdcdc
cccddc	ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	ccccdc	cdccdc

Individual Selection

ccddcc	ccddcc	ccddcc	ccdccc	ccddcc	ccddcc	ccddcc	ccddcc
ccdddc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc
ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc
ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccdccc
ccdddc	ccdccc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc
ccdccc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc
ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc
ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc	ccddcc

When the results of individual strategies playing each other in each group are examined, different patterns of behaviour are apparent and the group outcome is the sum of all these pair-wise interactions. For this run of the simulation the players in each of the groups produced by individual selection always cooperate with each other over, as noted already. For group selection more interesting patterns of behaviour occur, as shown in Figure 5.

Figure 5 Interactions Among Selected Strategies Evolved by Group Selection

Play sequences

dd dc cd cc　　　dd dc cd cc

CC CCDC vs CC CCDC-> CC,CC,CC......
CC CCDC vs DC CCDC-> CC,CC,CC.....
DC CCDC vs DC CCDC-> CC,CC,CC....
CC CCDC vs CC CDDC-> CC,CC,CC....
DC CCDC vs CC CDDC-> CC,CC,CC....
CC CDDC vs CC CDDC-> CC,CC,CC....
CC CCDC vs CD CCDC-> CD,DC,CD,DC, CD...
DC CCDC vs CD CCDC-> CD,DC,CD, DC ...
CC CDDC vs CD CCDC-> CD,DC,DD,DC,DC,CC,CC...

In other results, not reported here, we have examined how the mix of strategies varies when different length memories are introduced, when games other than Iterated Prisoners Dilemma (IPD) are played and for different types of payoff structures. Of particular interest are situations in which the **combined total payoff** is greater when one player cooperates and the other defects. For example, in the IPD game simulated here, the total payoff is greatest when both cooperate, i.e. 4 + 4 = 8. If one cooperates and the other defects the total payoff is 5 + 1 =6. In games in which cooperate-defect (CD) produces a greater combined total payoff there is a tension between the group (dyad) payoff and the individual payoff. This results in some additional complexities that are beyond the scope of this paper.

Discussion and Conclusions

We believe that group selection theories have important implications for understanding and modeling the evolution of business relations and networks and for examining when, why and how cooperative strategies emerge. Our results show that group selection has important affects on the behaviour and performance of those involved. Group behaviour is what business is all about, and business relations and networks are types of groups whose importance is already emphasized and demonstrated in research by IMPers and others. Group selection mechanisms must be, therefore, an important part of explaining for the development and evolution of business. But, as already noted, existing theories of business relations and networks are largely static, not dynamic or evolutionary. Ways forward exist, as the research described here highlights, including theories and tools for modeling and testing dynamic and evolutionary theories of business relations and networks.

What do our results mean for managers and policy makers? Instead of focusing on and rewarding individual performance, be that individual workers or departments within firms or individual firms in relations, networks and industries, our results suggest that the relevant groups within which individual actors operate must be recognized and rewarded. It is no good championing an individual worker for their productivity if that productivity is largely the result of the group they operate in. To do so invites the weakening of the group and its replacement by individuals who create a very different group dynamic and performance levels for all – just as occurred when individual hens were selected for their egg laying capabilities without reference to the group context in which they laid their eggs (Muir 1996)! In a similar way the productivity of a firm depends on the actions of others and how they are interconnected, and to champion winning firms may be to neglect the engines of their success, which lie outside the firm itself. Value and performance is co-produced by the actors involved and through their interactions over time and the actors themselves are the product of these interactions. Research we and others have been involved in clearly shows this in various contexts (e.g. Denize and Young 2007, Morlacchi et al 2005, Roy et al 2004, Welch et al 1998, 2000, Wilkinson et al 2000)

Much work still needs to be done. We have begun to explore the implications of group selection for other types of iterated games but we need to move beyond such stylized models and simulations to the systematic study and modeling of actual relationship and network histories. We also need to combine models of group selection with models of the way groups form and evolve, in the form of business relations and networks. The evolutionary model described here group selection is based on a set of groups that already exist but, as we have argued, business involves group behaviour of various kinds that are not pre-given. Group section hence operates at various levels simultaneously and the formation and reformation of groups is part of the process. This involves other types of processes that may be described as forms of business mating, including the way people form teams, join and leave firms and the way firms choose and are chosen as business relationship partners and form networks of interconnected, interdependent firms (Wilkinson et al 2005).

The tools to develop models of this type are now available and are being used in various disciplines to develop models of biological, social and economic systems. These new methods are linked to the fast growing field of complexity science and to the study of complex adaptive systems, of which firms, relations and networks are examples. Large scale or macro order and change in such systems emerges from the on-going local or micro-interactions taking place among system elements over time. Structures, such as business firms, relations and networks emerge and are reproduced or not over time in a bottom up, self-organising manner, rather than being the result of the command and control exerted by some type of central actor, leader or manager. Complex adaptive systems like this are beyond the reach of traditional analytical methods to study; they are highly non-linear and dynamic. Instead we must capture the mechanisms underlying their behaviour in simulation models and understand behaviour and outcomes by computing them out over time, by comparing them to what has happened in real business systems and by conducting experiments using the models developed. These types of models are called agent based models, artificial life or, in the case of economic systems, the whole field of study is known as agent based computational economics. Agent based modeling arose out of the growth of computing power and the development of new forms of distributed programming techniques. They represent a new way of doing science, that may be described as generative social science (Epstein 2006), which has only just begun (for an overview see Tesfatsion and Judd 2006). Explanation here is not in terms of variance based models and the more compact summarizing of co-variance matrices in various types of path models. Instead it involves explanation in the sense Herbert Simon described: "to 'explain' an empirical regularity is to discover a set of simple mechanisms that would produce the former in any system governed by the later" (Augier and Simon, 2004 p5). This is the type of explanation we need in order to understand how and why change occurs and to know when, where and how managers and policy makers can make a difference or not; because it is about actors acting, not about variables wiggling!

References

Aldrich, H. (1999) *Organizations Evolving* Sage

Augier, M. and J.G. March, 2004, *Models of a Man: Essays in Memory of Herbert A. Simon*, Cambridge, Massachusetts: The MIT Press

Axelrod, R. (1984) *The Evolution of Cooperation*, New York, Basic Books

Axelrod, R. (1987) "The Evolution of Strategies in Iterated Prisoner's Dilemma" in Davis, L. ed. *Genetic Algorithms and Simulated Annealing* Los Altos, CA: Morgan Kauffman, 32-42

Buttriss, G. and Wilkinson, Ian F. (2004) "From 'snap-shots' to 'moving pictures': Tracing Processes Using Narrative Sequence Analysis in the Evolution of an E-Business" IMP Conference Copenhagen Sept 2004

Denize, S. and L. Young (2007) "Networks of Suppliers, Suppliers of Networks" IMP Conference Manchester.

Epstein, J. M. (2006) *Generative Social Science*, Princeton University Press, Princeton

Griffing, B. (1967) "Selection in reference to biological groups. I. Individual and group selection applied to populations of un-ordered groups" *Aust. J. Biol. Sci.* 10: 127–139

Henrich, J. (2004) "Cultural group selection, coevolutionary processes and large-scale cooperation" *Journal of Economic Behaviour and Organisation* 53 (2004) 3–35

Henrich, J., Boyd, R., Bowles, S., Gintis, H., Camerer, C., Fehr, E., McElreath, R. (2001) "In search of Homo economicus: experiments in 15 small-scale societies" *American Economic Review* 91, 73–78.

Henrich, J., Boyd, R., Bowles, S., Gintis, H., Fehr, E., Camerer, C. eds. (2005) *Cooperation, Punishment and Self Interest: Experimental and Ethnographic Evidence from 15 Small Scale Societies*. Oxford University Press, New York, and University of Michigan.

Huang, Yimin, and Wilkinson, Ian F. (2006) "Understanding Power and Trust in Interfirm Relationships: A Dynamic Perspective" IMP Conference, University of Bocconi, Milan, Sept 6-9, 2006

Lindgren, K. and Nordahl, M. G. (1996) "Cooperation and Community Structure in Artificial Ecosystems" in C. G. Langton ed. *Artificial Life: An Overview*, Cambridge Mass; MIT Press, 15-38

Morlacchi, P. Wilkinson, I.F. and Young, L. (2205) "Social Networks of Researchers in B2B Marketing: A Case Study of the IMP Group 1984-1999" *Journal of Business to Business Marketing* 12 (1) 3-34

Muir, W. M. (1996) “Group selection for adaptation to multiple-hen cages: selection program and direct responses” *Poultry Science* **75:** 447–458.

Muir, W. M. (2005) “Incorporation of Competitive Effects in Forest Tree or Animal Breeding Programs” *Genetics* 1247-1259

Price, G. (1970) Selection and covariance. *Nature* 227, 520–521

Roy, S. Sivakumar, K. and Wilkinson, I. F. (2004) “Innovation Generation in Supply Chain Relationships – A Conceptual Model and Research Propositions,” *Journal of the Academy of Marketing Science* 32 (1) 61-79

Shubik, Martin ed. (1964) *Game Theory and Related Approaches to Social Behavior* Wiley: New York

Tesfatsion, L. and Judd, K. eds. (2006) *Handbook of Computational Economics,* Vol. 2, *Agent-Based Modeling*, North-Holland, Amsterdam

Van de Ven, A. and M. S. Poole (1995) “Explaining Development and Change in Organizations” *Academy of Management Review* 20 (3) 510-540

Welch, D., Welch, L. Wilkinson, I.F. and L. Young (1998) "The Importance of Networks in Export Promotion: Policy Issues" *Journal of International Marketing*, 6 (4), 1998 pp.66-82

Welch, D., Welch, L. Wilkinson, I.F. and L. Young (2000) “Market Focus or Group Functioning? Analysis of an Export Grouping Scheme” *Journal of Euromarketing* 9(2) 59-84

Wilkinson I.F., Mattsson, L-G and Easton, G (2000) "International Competitiveness and Trade Promotion Policy from a Network Perspective" *Journal of World Business* 35 (3) 275-299

Wilkinson I.F. (2001), “A History of Channels and Network Thinking in Marketing in the 20th Century” *Australasian Marketing Journal* 9 (2), 23-53

Wilkinson I. F. (2006) “The Evolution of an Evolutionary Perspective on B2B Business” *Journal of Business and Industrial Marketing* 21 (7) 458-465