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Abstract

Competition and Evolution in Economics and Ecology Compared

Compares and contrasts concepts of competition and evolution used in industrial economics and in biology. Particular consideration is given to the role of models involving optimisation by individuals (usually maximising their own benefits) in explaining the survival of individual entities and the evolution of economic and biological systems. The models considered include some based on game theory.

Ecologists usually distinguish between competition, mutualism, commensalism and parasitism as forms of interdependence between species. In economics, the first mentioned type of interdependence has been stressed but the other types have been largely ignored. Examples of their importance in industrial economics are provided. In addition, the importance of long-term mutualism for survival of economic entities rather than the pursuit of short-term advantage is highlighted especially when account is taken of market transaction costs.

The possibility that industrial evolution is more Lamarckian in character (involves the transmission of acquired characteristics) rather than Darwinian in nature is discussed. The non-biological nature of population of economic entities may well imply that application of Darwinian theory to industrial evolution is limited.

Biological evolution, in the absence of cataclysmic exogenous changes, is usually believed to result in speciation, that is increasing biodiversity, as species adapt more fully with the passage of time to available niches. However, it is possible that the evolution of economic systems tends to result in reduced diversity of business entities and reduced product variety. Thus industrial evolution may follow a very different path to natural biological evolution.

Competition and Evolution in Economics and Ecology Compared

1. Introduction

Both economics and ecology make considerable use of concepts of competition and of evolution. The purpose of this article is to compare these uses, and to consider the extent to which their application in ecology provides insights into economic phenomena and vice versa.

The concepts of competition and of evolution are first discussed in turn followed by consideration of links between competitive processes, optimisation and the evolution of systems. Then the nature of evolution of biological/ecological systems and links between optimisation, competition and evolution are compared and contrasted with that of economic systems. It is suggested that some areas of biological research into competitive processes, such as intra-species competition, could have a fertile research counterpart in economics, for instance in relation to the success or failure of firms in emerging industries.

2. Concepts of Competition

Economic thought appears to have had some significant influence on the development of ecological theory (Worster, 1985). Worster (1985) suggests that Darwin (1882) was influenced in his development of the theory of evolution of species by the views of T. R. Malthus (1798). Although, in the opposite direction, Alfred Marshall (1898) was convinced that economic thought would obtain more inspiration from biological analogy than from physics, physics probably exerted a greater influence in the 20^{th} century on economic thought than ecology or biology, notwithstanding increasing interest in evolutionary economics in the second half of that century.

Concepts of competition are fundamental to both economics and ecology. To various degrees, living things (including human beings) compete for the means (or at least some of the means) necessary for their sustenance and their survival. The populations of all living things are subject to some resource availability constraints and all eventually experience resource-scarcity and competition for scarce resources (cf. Grover, 1997). Nevertheless, not all resources needed for survival are in short supply in every situation. For instance, in most terrestrial situations the availability of ordinary air is not a constraint to populations of living things – other resource constraints prevent this constraint from becoming operative.

Economics tends to emphasize competition between individuals for scarce resources and the general processes involved in that competition, particularly via market mechanisms. Its focus is mainly on competition by individuals or individual entities. Thus, its focus is mainly atomistic and individualistic.

The nature of competition envisaged in ecology is more complex and based to a lesser extent on individual entities. While competition of individuals within species and between species is considered to be important, the importance of mutualism (and in some cases commensalism) within these processes is also recognized. In addition, ecology links biological competition closely to the evolution of species, and in many cases this involves competition for reproductive partners. Thus for sexually reproducing animals, competition is usually not entirely individualistic in nature but involves a degree of mutualism with partners and often offspring. Furthermore, members of a species sometimes cooperate in competing with other species, and mutualism sometimes occurs between species, and these in turn may be competing with other species. Consequently, it is clear that processes of competition and of mutualism or cooperation can be quite complex.

There are analogies to these ecological processes in economics but economists have given them comparatively little attention. Nevertheless, it is clear that mutualism can be important in the economic sphere. For example, family members are usually involved in mutualistic as well as competitive relationships. Mutualism or complementarity exists between some industries. Mutualism may also be present between some firms in the same industry e.g. Marks and Spencer and its suppliers (Tisdell, 1996, Ch.13; Tse, 1985) and between Japanese car manufacturers and their suppliers of parts in Japan. Several other business relationships exist where sharing of information may be mutually beneficial to those involved in this sharing. Comparatively little attention has been given by economists to such mutualism and the ways in which it evolves.

The traditional economic view of economic interdependence involves rivalry. This view of competition is summarised by Stigler (1987) who describes competition as "a rivalry between individuals (or groups or nations) and it arises whenever two or more parties strive for something that all cannot obtain". While there could be mutualism within a group or nation, this is not an aspect highlighted by Stigler.

The preoccupation of economists with competitive or rival economic relationships has been criticized by Kaldor (1977). He emphasizes the importance of complementarity rather than competition between industries and factors of production.

While competitive and rival economic relationships are important, economics would be enriched by taking greater account of mutualistic economic relationships, as well as identifying situations of economic interdependence which are essentially parasitic in nature (usually involving some criminal activity such as protection rackets) and those entailing commensalism (cf. Svizzero and Tisdell, 2001)

3. Evolution

Evolutionary processes are central to a large body of ecological thought but on the whole have had less emphasis in economic theory, even though they are not entirely neglected as is evident from the publication of the specialized journal *Evolutionary Economics*. A contributor to the comparatively lower emphasis of economists on evolutionary processes may be the fact that there are significant limits to analogies between biological evolution and economics processes.

If, for example, a firm is considered by analogy to be the individual of a species and the industry the species, the replication of the firm corresponding to the reproduction of biological individuals does not appear to be a part of its agenda, although its survival usually is and in some cases its growth. Furthermore, today's firms (companies) do not have the same degree of finiteness of their lives as biological individuals. So it is difficult to argue that, like biological species, firms have a desire to reproduce themselves or in some way ensure the survival of their species or industry unless the latter confers some particular advantage on them for their own survival.

In addition, in biology genetic 'information' transferred to descendants plays a major role in selective evolutionary processes, along with mutations of such information. Again, it is difficult to find an exact analogy in economics. This is so despite the fact that Nelson (1987), in his theory of evolutionary economics, sees relevant fixed codes or customs of managerial behaviour within business as analogous to genes in biology. The degree of rigidity or inflexibility of such codes of conduct is likely to be much less than for genetic phenomena. Ecological and biological evolution by genetic mutation and selection takes place on a much longer time scale than the unfolding of economic processes.

Nevertheless, it should not be concluded from the above that no analogies are possible between economic and ecological processes, but undoubtedly caution is needed, and economic processes may evolve in the opposite direction to that suggested by ecological theory.

For example, given little change in external circumstances, many ecologists adopt the view that speciation tends to occur during a long passage of time. This means that the diversity and number of species tends to increase in the long term. However, the process of speciation is not necessarily a gradual process even if in the absence of major exogenous events and significant human interference, speciation is the rule over a very long time-period. The process of speciation appears to depend broadly on the variety of niches available and the extent to which mutation takes place. Suppose, for example, that a single species is utilizing two very similar niches. If evolution occurs which favours a new species in one of these niches, the pre-existing species in the end will be confined to the other niches since it is unable to compete effectively in the niche in which its use of resources in conflict with the new species (cf. Grover, 1997, p.1114).

It follows that the extent to which genetic mutation occurs and the degree of variety or niches available heavily influences the extent to which speciation occurs; that is the extent of biodiversity is achieved in the biological system. Thus, if human activity reduces the variety of niches available to living things (as seems likely), then it could be expected to reduce biodiversity (cf. Tisdell, 1999a, Ch.4).

While the concept of an ecological niche is widely used in ecology, in practice definitions of it are not hard and fast, and to some extent the identification of such niches is subjective. The concept of a niche in biology is made more difficult to define because some niches are not physically determined but depends on the array of living species. Nevertheless, niches play a major role in the ecological theory of competition and evolution (Arthur, 1987).

Ecological niche-related theory has a counterpart in economics. The theory of spatial competition as, for example, investigated by Hotelling (1929) has similarities, and this can be extended to competition between differentiated products (Hartley and Tisdell, 1981, pp.234-238). In such cases, high-cost producers can only survive and compete with low-cost producers if they are located in a market niche sufficiently different to that of lower cost producers.

If the situation happens to be relatively stable, this might lead to increasing variety of products with the passage of time. However, if the low-cost producers can reduce their costs of production at a sufficiently rapid rate, they may leave little or no room for specialist suppliers to survive. Consequently, no niches are left empty or exploitable other than by low-cost producers.

Whereas speciation may be the general pattern in biological systems not subject to exogenous forces (or massive human manipulation), it is not clear that economic processes evolve in the same manner. On a global scale, economic processes may result in reduced product variety, increased business concentration and reduced variety in business behaviour. Thus economic processes, mostly driven by market systems, may result in industrial systems evolving in the opposite direction to (largely) undisturbed ecological systems. Scitovsky (1976) has, for example, claimed that product variety has declined in the modern world. Authors such as Steindl (1965), Schumpeter (1942) and Marx (1954) foresee the possibility of increasing concentration of industry thereby indicating reductions in the variety of business structures. Tisdell (1999b) foresees the possibility that increasing globalisation will foster business concentration and result in less diversity of businesses and ultimately slow technological progress.

The question of product variety or diversity is, however, complex. In recent times although the variety of products globally may have declined at the same time those available locally may have increased. Much depends upon how we envisage the geographical range in considering diversity of commodities i.e. for example, whether it is locally or globally defined. Furthermore, if we consider the time-dimension and measure the flow of commodities subject to product cycles, this flow may have increased in modern times. Furthermore, just as it can be difficult to quantify biodiversity, so it can be difficult to quantify business diversity because of multidimensional considerations. Nevertheless, the upshot of the discussion is that economic systems may not generate more diversity in business and greater diversity of commodities with the passage of time whereas speciation seems to be the general rule in relatively undisturbed ecological systems. There seems to be strong tendencies towards standardisation in economic systems, and to the extent that evolution takes place, it may be in the opposite direction to that in ecology.

4. Optimisation, Competition and Evolution

Optimisation, competition, and evolution are closely linked in some expositions of economic and ecological theory. In ecology, this is partly a consequence of Charles Darwin's hypothesis that the fittest survive and reproduce (Darwin, 1882).

On the whole, individuals of all species are in competition to survive and reproduce. The most competitive are favoured to leave behind survivors and so pass on their genes. By means of competition, natural selection takes place. The genes of those individuals showing the best ability to reproduce are passed on whereas those with less ability to do that are lost to the biological system. In this way, evolution proceeds. Thus selected populations of species consist on the whole of individuals with the highest probability of reproducing and producing offspring also likely to reproduce effectively.

Note, however, that this process is the 'blind' result of past events and implicitly assumes that environments are relatively stationary. Consequently, the species and populations that evolve are not necessarily best suited to future environments if these differ substantially from those of the past. Thus the processes involved are not forward-looking and they do not seem purposeful or teleological in nature. Furthermore, as pointed out by Gould (1989, 1990), it is likely the evolutionary paths are not unique and the actual long-run paths pursued may be influenced to a considerable extent by chance or chaotic events. Consequently, the actual array of species which evolves may be less fit to survive than an alternative array which could have evolved had nature's dice been cast ever so slightly differently in the past.

The view has gained ground amongst some evolutionary economists that in economic competition the firms that survive are the most efficient available ones in providing economic benefits to society. The competitive process weeds out the less competitive firms and only the more competitive ones tend to remain. Thus a form of economic selection analogous to natural selection in biology takes place.

It should, however, be noted that the analogy is a very incomplete one. This is because in biology, evolution is closely linked to reproduction. As mentioned earlier, the analogy for reproduction of businesses is unclear, although it is likely that successful businesses will have would-be imitators and that such a business may grow in size. Furthermore, selection in the economics case may not result in the most efficient set of firms for current or emerging circumstances for similar reasons to those suggested by Gould (1989, 1990) in relation to biological evolution. Actually, the problem of optimal selection is even more acute in economics than in biology because economic environments appear to change much more rapidly than biological ones.

The concept of evolution by natural selection is closely linked to the ability of individuals (in heterosexual cases, pairs of individuals) to reproduce. The question has arisen in biology of whether some identifiable types of inherited behaviour are likely to result in successful reproduction. For instance, does optimisation of any sub-goals necessary for living increase the likelihood of individuals surviving and successfully reproducing? Is the latter, the ultimate goal in much ecological thought, fostered by optimising some sub-goal or sub-goals? Dawkins (1986, p.21) refers to the "reproductive success of an animal over its entire life compared to rivals" as a measure of the long-term optimality of its behaviour. Pursuance of sub-goals appears to be concerned in her view with short-term optimality. For example, with whether an animal appears to optimise some function in its day-to-day life, "such as the amount of energy it is collecting in a certain amount of time" (Dawkins, 1986, p.21).

As Dawkins (1986, p.2) points out, "emphasis on animals as 'optimisers' has led to an extraordinary degree of confusion about what 'optimal' really means" in its application to adaptation and selection. Similar confusion also seems to exist in economics. This is not surprising since to a large extent economists have encouraged the emphasis of ecology on optimality, either indirectly, or directly, such as by Tullock (1971).

A major problem, as envisaged by Dawkins (1986) is that optimising a particular sub-goal can be inconsistent with individuals maximising their chances of survival and passing their genes on in the evolutionary process. In other words, the fittest in the evolutionary sense are likely to be those not maximising any particular sub-goal (or short-term goal) but those maintaining an appropriate balance between sub-goals necessary for the maintenance of life.

For instance, obtaining food is necessary for life but minimizing the net amount of energy expended in a certain amount of time, optimal foraging, does not maximise the chance of individuals leaving offspring. "An animal that gathers food optimally might actually leave fewer offspring in its lifetime than an animal which gathers it less than optimally because it is so intent on feeding that it gets eaten by a predator. In other words, the long-term reproductive success kind of optimality and the short-tern efficiency kind of optimality should be kept distinct" (Dawkins, 1986, p.21).

This idea has some implications for the hypothesis of some evolutionary economists that the survivors in business competition are those firms, which maximise profit, and that these are most efficient or fittest. It is probable that business survival does not depend, in an uncertain and changing world, purely on the pursuit of a single goal such as profit maximization. Furthermore, there is greater difficulty in knowing the nature of profit maximization. For example, is short-term profit maximization suggested or rather long-term profit maximization in the Hicksian sense (Hicks, 1939) of maximizing the capitalised value of the business meant? If it is the latter, what is the time-horizon for optimisation and how are the considerable uncertainties about future economic and technological variables allowed for? Is, in fact, the hypothesis of profit-maximization extraordinarily vague in practice, so vague as to be hardly operational?

In any case, pursuit of maximum capitalised value or long-term profit is in reality likely to be constrained by liquidity considerations. While traditional microeconomics assumes perfect knowledge (Hicks, 1939) and a perfect capital market, this is far from the case in practice. While the owners or managers of a business may wish to pursue a strategy, which in their view will maximise the capitalised value of their firm, to do so may require loans and credits. Lenders, however, may not be confident of the success of such a strategy and may fail to finance it. Or if a company goes into the red in the short-term but has good prospects in fact for long-term profitability, its creditors may nevertheless be excessively influenced in their expectations about the profitability of the company but its short-term results, and the company may fail due to a shortage of credit. Thus, in reality the survival of a firm does not depend solely on the maximisation of its profit, however that is defined. Indeed, attempts to maximise the capitalised value of a firm can be inconsistent with its survival.

While economic argument about the appropriate concept of profit maximization is an 'old chestnut', the concept is central to the contention that business competition favours the survival of firms which maximise profit. While business competition can be expected to result in the elimination of firms that make persistent losses and have little prospect of future profit, it does not follow either that profit-maximisers are survivors. Business survival depends on complex phenomena and both design and chance play a part in it.

Furthermore, just as species and individuals selected for survival are not necessarily the fittest of the future, for example because there is exogenous environmental change or because chance factors of the type suggested by Gould (1998, 1990) apply, so the array of surviving firms in a competitive system is not necessarily the optimal set for the future. Furthermore, if industrial evolution reduces diversity of business organizations, the capacity for future beneficial evolution of the economic system may be reduced (cf. Tisdell, 1999b). In other words, the evolutionary dynamics of the system becomes impoverished.

5. Economic Hypotheses Suggested by the Study of Intra-specific Competition

Both competition between firms within industries and between industries is a key subject of microeconomic enquiry. Similarly, according to Fujii and Toquenaga (1998, p.178), "competition (both intra- and inter-specific) has been one of the most studied subjects in ecological research". Arguably, despite the similar focus of economic and ecology, ecological research has paid much more attention to the processes involved in competition than has been so in economics research.

Ecological studies of intra-specific competition usually concentrate on resource competition and the extent to which members of an initial population survive. In studying the survival of initial populations of a species, ecologists have given particular attention to the processes of contest competition and 'scramble' competition.

Scramble competition involves simultaneous common exploitation of a limiting resource by the initial population of a species. In economics, it corresponds to open-access to natural resources. If scramble competition prevails ecologists believe that no significant limit to the survival of the initial population of a species is reached until the limiting resource is used to its carrying capacity. Once the carrying capacity of the limiting resource is exceeded, the level of the surviving population crashes, in the extreme case to zero because no individual obtains enough of the limiting resource to survive. Where x_1 is the population carrying capacity of limiting resource, the relationship between the initial level of population and the surviving population level is like that shown in Figure 1 by OBCD. Or the probability of any number of the initial population surviving P, is

$$P(x) = 1 \qquad \text{for } x \leq x_1$$
$$= 0 \qquad \text{for } x > x_1$$

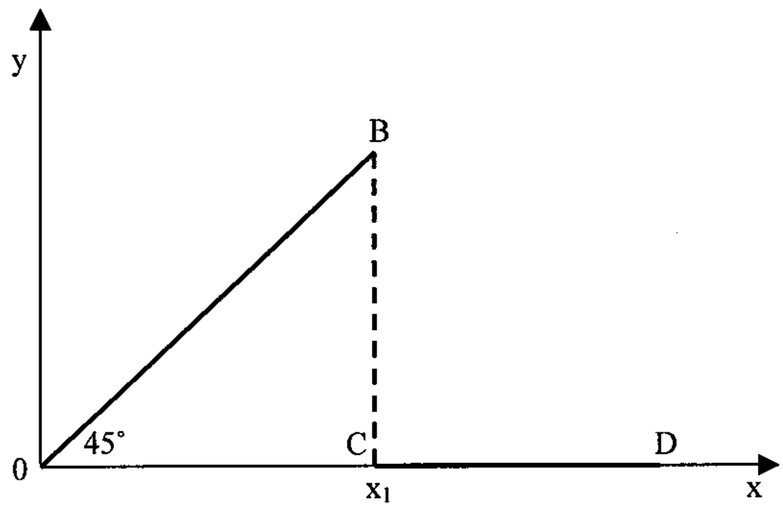

Figure 1. Population survival consequences of 'scramble' competition.

On the other hand, contest competition gives rise to a survival pattern of a different kind. Contest competition involves the exclusion of rivals by cannibalism or effective aggression, which may be combined with the staking out of exclusive territories. In fact, there are a variety of means in nature by which some members of a population obtain exclusive territories that provide them with enough resources to survive. Those members of a population in such cases unable to obtain territories usually perish. Exclusive territoriality in nature is akin to private property rights in economics.

Once again assuming that the carrying capacity of the resource-base is a population of x_1, the population survival relationship for this case is theoretically of the type shown in Figure 2 by OBE. It differs from the scramble case because exclusion of competitors in this case enables the surviving population to survive up to the level corresponding to the carrying capacity of the environment.

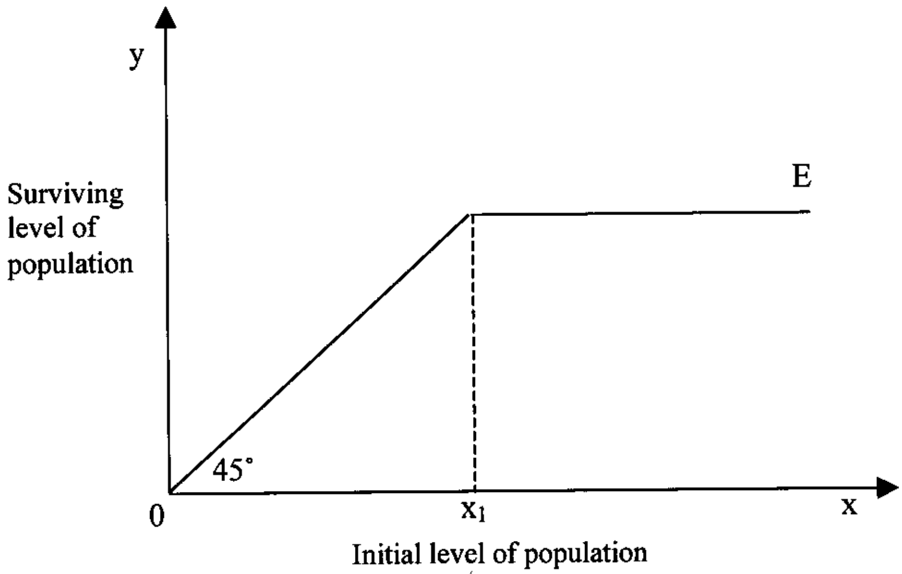

Figure 2. Theoretical relationships for survival of a population given contest competition.

However, these relationships do not allow for the deaths of members of the initial population that arise independently of intra-species competition. If such deaths occur naturally, the threshold initial population is in excess of x_1. For instance, if the mortality rate is m, the initial population of the species only reaches the threshold for survival if it is equal to

$$x_2 = x_1/(1-m).$$

This is illustrated in Figure 3. There $x_1 = y_1$ corresponds to the population carrying capacity of the resources available to support the population, but natural survival of the population even in the absence of resource limitations, is less than unity so line OBB' has a slope of less than 45°. Resource-constraints on population survival in this case are not encountered until $x > x_2$. Therefore, the scramble survival relationship is as shown by OB'C'D' and that for contest competition OB'E'.

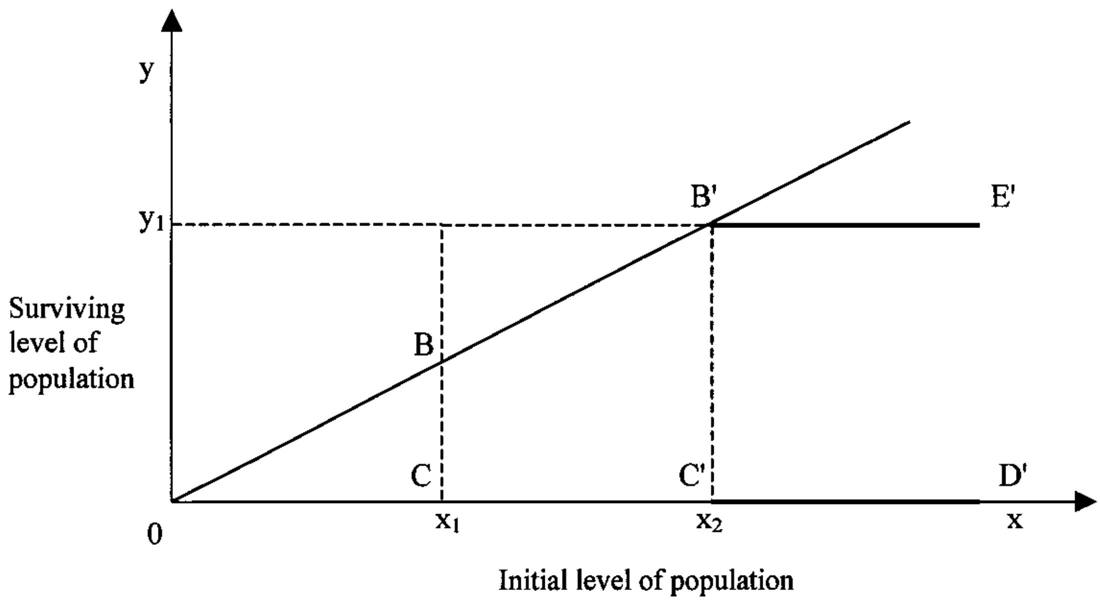

Figure 3. Adjustment of scramble and contest competition relationships to allow for mortality other than that due to competition for resources

In reality, population survival curves will not, usually, accord exactly with the stark forms indicated above. They may, for example, show some degree of continuity and be curvilinear. For example, the relationship shown by curve OFG in Figure 4 may reflect essentially contest competition and that shown by curve OHJ in this figure scramble competition (cf. Fujii and Toquenaga, 1993). Furthermore, more complicated models can be constructed allowing, for example, for migration possibilities if they exist, and for reproduction.

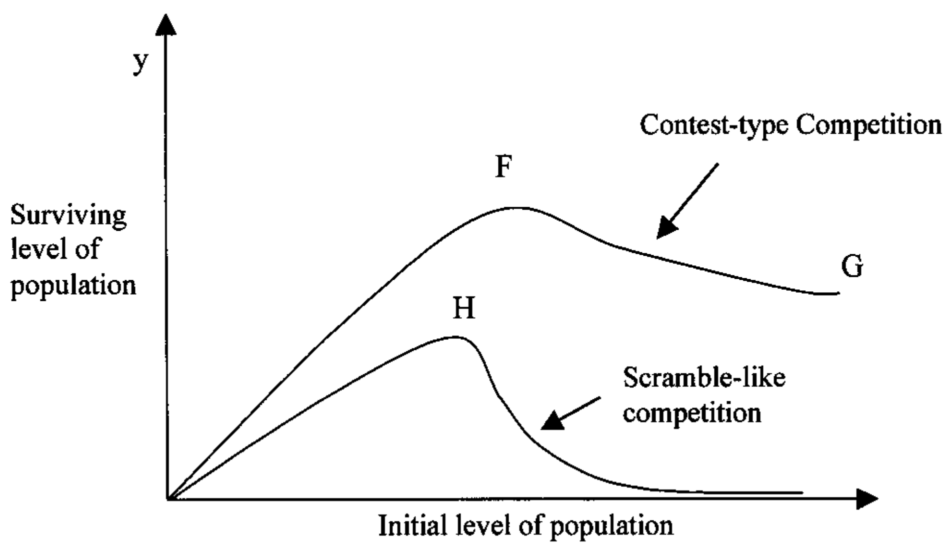

Figure 4. Modified population and survival curves to allow for other than extreme cases.

While some of these models may be applied to human competition for use of natural or environmental resources, my interest here in this aspect of ecological thought is in relation to the emergence of new industries or products (Tisdell, 2001), especially the processes involved in the marketing of new products.

Whereas ecological population-survival models seem mostly to suggest either neutral or competitive survival relationships in relation to initial populations, such assumptions seem not appropriate in economic modelling of the introduction of new products.

The theory of the processes involved in the introduction of new products is complex and as yet little explored in economics. The likelihood of survival of initial entrants supplying new products varies with a wide range of circumstances. Only a few of these circumstances can be allowed for and I shall expound some of the possible relationships involved by considering the probability of survival (in supplying the new product) of firms initially supplying the new products.

For novel products, the curve for probability of survival of an initial entrant (assuming that all entrants in aggregate are basically similar) might be as shown by relationship 0ABC in Figure 5. A minimum threshold exists in this case for survivability. Unless the initial population of entrants (or scale of entry) exceeds x_0, an initial entrant has no hope of survival. Because of favourable external economies (mutualism), the probability of survival of an initial entrant rises for initial scales between x_0 and x_1. Subsequently contest-like competition becomes dominant and the probability of survival of an initial entrant begins to fall. Situations in which such relationships are likely to arise are outlined in Tisdell (2001). Note that in the case shown that there is no circumstance under which all initial firms survive because some are assumed to always disappear for reasons other than competition *per se*.

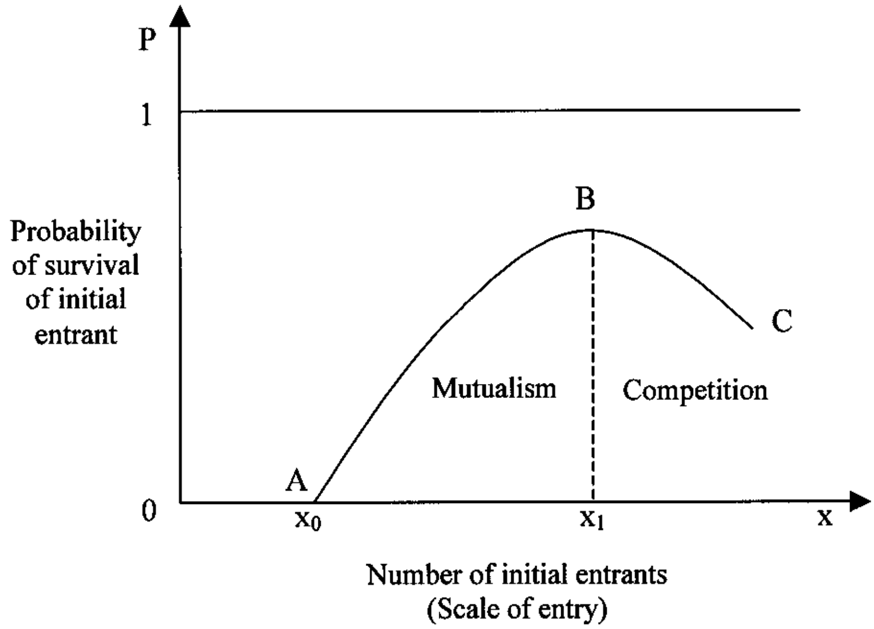

Figure 5. A survival curve for some types of new products and entrants supplying these.

Given the relationship shown in Figure 5 mutualism is dominant for the initial number of entrants up to x_1 and after that competition becomes dominant. Furthermore, unless entry is on a scale of more than x_0, the whole industry or the new product will fail to become established.

However, the relationship shown in Figure 5 applies to the introduction of some but not all new products. In some cases, the threshold OA may not exist and the mutualistic phase may not be marked. This may approximately so say where an aquacultured product (the 'new' product) is being introduced to a market where the wild caught product provides the initial competition. In such a case, the probability of survival of an initial entrant in marketing the product might take the form indicated by the curve identified in Figure 6. No initial threshold of entrants is present for survivability.

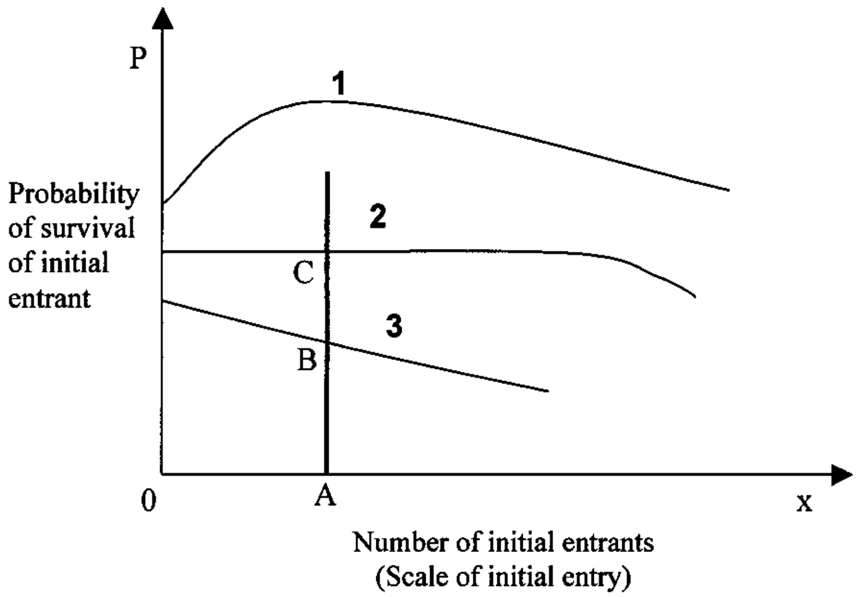

Figure 6. Some alternative possible probability of survival curves as a function of the scale of initial entry to a new market

In Figure 6, the curves marked **2** and **3** indicate the form of a couple of other survivability relationships as a function of the scale of initial entry to a new market. Case **2** has similarities to both the contest and scramble cases because competition does not occur until the initial population reaches a sufficiently high level. In the economics case, this may be because initial entrants are selling in spatially separated markets. In case **3**, competition is present if there is more than one member of the initial population. It is also conceivable in some economic circumstances that only portions of curves **2** and **3** apply because a minimum positive scale of entry is needed to ensure any prospect of establishing the market. In a very simple case, this might be imagined to be the scale OA, and so curve **3** is only applicable to the right of B and curve **2** to the right of C.

Note that the above is not a complete theory of the survival of groups of firms supplying new products or products to new markets. However, it provides some suggestions about this topic in the light of ecological theory. It also seems likely that the survival of many species depends on some minimum initial population (threshold), and the survival of some is a mutualistic function of their level of initial population up to a particular positive level of that population.

6. Conclusion

Given the major concern of both ecology and economics with competition and the growing interest of economists in evolutionary processes, or in processes generally rather than comparative statics, considerable scope continues to exist for fruitful interaction between ecological and economic thought. However, economic phenomena and ecological phenomena are not identical. Hence, considerable care must be taken in drawing analogies between ecology and economics. As mentioned, it is difficult to draw a direct link between biological reproduction, natural selection and evolutionary paths in ecology and similar possible paths in economics. This is because biological reproduction does not have a close analogue for business firms, even though most wish to survive as do most creatures. Ecology yields some interesting insights into the nature of survivors and the probability of survival of population. For instance, modern ecology makes it clear that the survivors in a population are not necessarily the fittest for the future, and they may not even be the best selection for the present. This lesson has yet to be learnt by some economists.

Notes

1. For example, parallels have been drawn between the concept of 'punctuated' equilibrium in biological evolution (Grant, 1991, pp.340-341; Gould and Eldridge, 1977) and periodic innovatory cycles in economics involving widespread creative destruction of existing industries and so on. While that might be a reasonable parallel, the cause of the economic phenomenon may be endogenous rather than exogenous. The latter may be assumed in some models of biological evolution, but not necessarily in all.

2. Several global environmental catastrophe theories due to human over exploitation of natural resources to which there is open-access (e.g. the atmosphere and greenhouse gas emissions) have parallels with 'scramble' competition.

References

Arthur, W. (1987) *The Niche in Competition and Evolution*, John Wiley, Chichester, UK.

Darwin, C. (1882) *The Origin of Species by Means of Natural Selection*, Murray, London.

Dawkins, M. S. (1986) *Unravelling Animal Behaviour*, Longman, London.

Fujii, K. and Toquenaga, Y. (1993) "Mode of Competition and Interspecific Competition Outcomes". Pp.178-198 in H. Kawanabe, J. E. Cohen and K. Iwasaki (1993) *Mutualism and Community Organization: Behavioural, Theoretical and Food-Web Approaches*, Oxford University Press, Oxford.

Gould, S. J. (1989) *Wonderful Life: The Burgess Shale and the Nature of History*, Norton, New York.

Gould, S. J. (1990) *The Individuals in Darwin's World*, Edinburgh University Press, Edinburgh.

Gould, S. J. and Eldridge, N. (1977) "Punctuated Equilibrium: The Temper or the Mode of Evolution Reconsidered", *Palaeobiology*, **3**, 114-151.

Grant, V. (1991) *The Evolutionary Process A Critical Study of Evolutionary Theory*, 2nd edition, Columbia University Press, New York.

Grover, J. P. (1997) *Resource Competition*, Chapman and Hall, London.

Hartley, K. and Tisdell, C. (1981) *Micro-Economic Policy*, John Wiley, Chichester, UK.

Hicks, J. (1939) *Value and Capital*, 2nd edition, Clarendon Press, Oxford.

Hotelling, H. (1929) "Stability in Competition", *Economic Journal*, **39**, 41-57.

Kaldor, N. (1977) " Equilibrium Theory and Growth Theory". Pp.273-291 in M. J. Boskin (ed.) *Economics and Human Welfare*, Academic Press, New York.

Malthus, T. R. (1798) *An Essay on the Principle of Population as it Effects the Future Improvement of Mankind*, J. Johnson, London.

Marshall, A. (1898) *Principles of Economics*, 4th edition, Macmillan, London.

Marx, K. (1954) *Capital*, Foreign Languages Publishing House, Moscow. Translation of the 3rd German edition.

Nelson, R. (1987) *Understanding Technical Change as an Evolutionary Process*, North-Holland, Amsterdam.

Schumpeter, J. (1942) *Capitalism, Socialism and Democracy*, 2nd edition, Harper Brothers, New York.

Scitovsky, T. (1976) *The Joyless Economy*, Oxford University Press, Oxford.

Steindl, J. (1965) *Random Processes and the Growth of Firms: A Study of the Pareto Law*, Griffin, London.

Stigler, G. J. (1987) "Competition". In J. Eatwell, M. Milgate and P. Newman (eds.) *The New Palgrave*, Macmillan, London.

Svizzero, S. And Tisdell, C. (2001) "Concepts of Competition in Theory and Practice". *Revista Internazionale di Scienze Economiche e Commerciali*, June (in press).

Tisdell, C. A. (1996) *Bounded Rationality and Economic Evolution*, Edward Elgar, Cheltenham, UK.

Tisdell, C. A. (1999a) *Biodiversity, Conservation and Sustainable Development*, Edward Elgar, Cheltenham, UK.

Tisdell, C. A. (1999b) "Diversity and Economic Evolution", *Contemporary Economic Policy*, 17, 156-165.

Tisdell, C. A. (2001) "Externalities, Thresholds and the Marketing of New Aquacultural Products: Theory and Examples" *Economic Theory, Applications and Issues*, Working Paper No.1, Department of Economics, University of Queensland, Brisbane 4072.

Tse, K. (1985) *Marks & Spencer: Anatomy of Britain's Most Efficiently Managed Company*, Pergamon Press, Oxford.

Tullock, G. (1971) "The Coal Tit as a Careful Shopper", *American Naturalist*, **105**, 77-79.

Worster, D. (1985) *Nature's Economy: A History of Ecological Ideas*, Cambridge University Press, Cambridge, UK.

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