chapter 2

The basic concepts involved in the ants model can be observed in many apparently disparate circumstances in the real world. My first two examples, from the restaurant trade and the film industry, may seem rather trivial, even though these areas of economic activity are becoming increasingly important. But they do illustrate important principles which have far-reaching consequences not just for economics but for the other social sciences. Short-term prediction and control of the overall outcome is either very difficult or impossible, although there may be regularities which appear over time in terms of the proportions of time which the system spends at different outcomes. Even periods of apparent stability are characterised by persistent small changes, which are punctuated from time to time by large and rapid movements.

Several restaurants are often located very close together in a street. There may be a clear differentiation of their products - such as the nature of the cuisine, price level and so on - or there may well be two or three offering very similar food, at comparable prices. The custom of these restaurants tends to fluctuate in a seemingly inexplicable way. One month, one will be bursting at the seams, while another will be half-empty, only for quite the opposite to be observed the following month.

Of course, such restaurants differ from the food sources of our ants in that the proprietors, far from trying to ensure that their sites are identical, will be constantly thinking about ways in which they can improve them and steal a march on their rivals. Yet the fluctuations in custom will often seem unconnected to their marketing efforts. For they are being driven by the same kind of dynamics which determines the outcome of the ants model. Potential customers hear a particular restaurant being praised or damned by their friends and neighbours, and may allow this to influence their choice when they next eat out. In other words, there is a probability that a deciding which food source to visit will be influenced by meeting someone else who has visited one of them recently. Further, an individual restaurant-goer, no matter how loyal he or she has been to a particular outlet, may, like our ants, experiment with a different one through his or her own volition.

A substantial degree of uncertainty is therefore inherent in the process of judging, say, how many people will visit a restaurant in the coming week. This creates the same qualitative difficulties for the policy-maker - in this case the restaurant owner - as it does at more elevated levels in the economy. Short-term prediction is hard. And it is difficult to judge the immediate impact of a marketing ploy, for, in the absence of such an initiative, the underlying dynamics of the situation might have been about to deliver a sharp up-turn or down-turn in the level of bookings. So there is a distinct risk that the wrong conclusions may be drawn about the effect of such policies.

When this chapter was first being written, the film *Anaconda* emerged as an enormous and completely unexpected box office hit in the United States. Described by one film critic as 'a movie about huge snakes devouring a B-grade cast', it nevertheless took $43 million in cinema receipts in the first three weeks of its release. But this is by no means untypical in the film industry. Indeed, during the process of revising the chapter, the low budget British film *The Full Monty*, featuring as its key characters redundant steel workers from a depressed, industrial part of Britain, also became a major American hit. Tremendous successes emerge from nowhere, and films made with huge budgets, replete with glittering names, can flop. *Primary Colours* is just the latest example of a major commercial failure, despite massive funding, leading stars and glowing reviews from the New York film critics.

The American economists Arthur De Vany and W. David Wallis published an article in the *Economic Journal* in November 1996, using a more complicated version of the ants model to account for success or failure in the American cinema and testing it by comparing its properties with those of the weekly data provided by *Variety*'s Top 50 films in America. The principle of positive feedback operates with devastating effect. During the nine months which they analysed, the top four films took over 20 per cent of all box office revenues, and the bottom four less than one hundredth of one per cent. The highest grossing film had revenue of $49 million, compared to the film exactly in the middle, defining this to be the position where the number taking more than its revenue is the same as the number taking less, which took only $300,000. And the worst performer had a total revenue of under $5,000, representing a ratio of 10,000 to 1 in favour of the most successful over the least.

The tremendous uncertainty surrounding the success or failure of a new release is reflected in the very brief tenure of studio heads. De Vany and Wallis attempted to contact nearly 400 film executives, but one third of their letters were simply returned with no forwarding address. A disaster with a major film can even be so strong as to bankrupt a studio, as happened, for example, with United Artists and *Heaven's Gate*.

The key to the whole process is interacting agents. Movie goers make or break films by telling their friends, an activity which is reinforced by the role of reviewers. The ants leave a trail for others to follow, but here the word is spread through conversation and reading newspapers. In the orthodox economic theory of consumer behaviour, the tastes and preferences of individuals are given, and the individual than acts so as to maximise his or her 'utility' with respect to these tastes. In the film industry, when a new release is issued, consumers do not know in advance whether they will like it or loathe it. In conventional theory, the actions of individuals are held to reveal their true preferences, but here they have to discover what their preferences really are. It is this which leads to the weight which is placed on the opinions of others in influencing individual behaviour.

The multiplicity of choices available to film goers leads to an even greater role for the opinions and actions of others in deciding the behaviour of any individual. In the world of the ants, there are just two food sources from which to choose. In the cinema, any single one of the Top 50 films is a potential source, as it were, to visit. As soon as differences begin to emerge between films, they compound with great speed, hence the enormous differences in revenues between the most and least successful.

The scale of the choice which is available is far, far greater than the simple difference between two and fifty possible destinations. Indeed, for all practical purposes, in the film context, the dimension is infinitely large. One person may be a film fanatic, and religiously view every film in the Top 50. At the other extreme, someone else may see none of them at all. But it is not just the number of films which an individual sees which counts, but the order in which they are visited. For it is the experience of seeing a film which spreads the news to others about its value. Seeing a film on the last day of its release does not have the same potential impact at all as seeing it on the first. The

possible permutations of both the number of films seen and the order in which they are seen is, even for an individual, gigantic. De Vany and Wallis point out that in a world of just 1,000 film goers and fifty cinemas, the number of possible outcomes is more than 10 followed by 210 zeros.

Enormous uncertainty and hence difficulty of prediction is therefore inherent in the film industry. Even the existence of major stars and a huge advertising budget is no guarantee of success. Indeed, the fact that such a film is released at a large number of cinemas compounds the risk. If the initial audiences do not take to it, this information will spread very rapidly, and the studio will be left with a major failure. The uncertainty of the industry is reflected in its structure. For example, contracts between studios and distributors are very flexible and adaptive, containing large numbers of contingency clauses to try to meet the wide range of possible outcomes.

An even more important application, given by Alan Kirman, of the principles of the ants model occurs in the financial markets. Anyone who follows the financial press even in a rather cursory manner is bound to come across sooner or later a very curious phenomenon. A currency such as the dollar may be widely described as being, for example, over-valued. In other words, there is a general perception that, in this instance, the dollar is in some sense too high against other major currencies. Yet, at the same time, foreign exchange traders will continue to buy the dollar in large amounts.

This example is not merely for illustration, for it actually happened on rather a grand scale. In the early 1980s, comments began to circulate that the dollar was over-valued, and the trickle turned into a tidal wave. For most of 1983, the whole of 1984, and into 1985, it was scarcely possible to pick up the *Wall Street Journal* or the *Financial Times* without reading about a stockbroker or dealer expressing this view. Yet, far from selling dollars, which seems the rational thing to do in these circumstances, dealers bought more and more of the currency. The dollar did, of course, eventually crash rather spectacularly in 1985, but for the best part of two years, dealers had exhibited clear signs of schizophrenia. They both knew and said that it was over-valued, yet still they continued to buy.

This kind of behaviour on financial markets is a severe embarrassment for orthodox economic theory. The theory of free markets ought to come closest to reality in exactly the world of exchange rates, shares and bonds. They operate in an almost completely unrestricted way, free of government intervention; information is widely and very rapidly available to all agents in the market; there are a large number of buyers and sellers; markets exist not just to buy and sell today, but contracts can be struck now to trade in a variety of complicated ways at dates in the future.

Movements in asset prices - to use the technical term which embraces currencies, equities, government bonds and so on - are explained by economists in terms of the efficient markets hypothesis. This exists in several different guises, each with its own nuance, but it is the general qualities of the theory which are of interest to us here. There are two basic ideas. First, that the price of an asset should reflect its 'fundamentals'. Ownership of a share in a company, for example, brings an entitlement to be paid dividends, and this future stream of dividends represents the underlying, fundamental value of the company. So the price of the share today is supposed to reflect the combined value of all dividends which are expected to be paid in the future. The second key concept is that all information which is available about fundamentals has to both be available to everyone and, through its widespread availability, be incorporated into prices. If it is not, those with the information can exploit it to make profits at the expense of everyone else. If it is the case, then the only reason why prices will change is when new information is made available. And this new information must not have been predictable in any way, because otherwise it would have been worth someone's while to predict it.

In many ways, the efficient markets theory is a reasonable description of how prices on financial markets actually move. The assumption, for example, that prices can only change when new, unpredictable information becomes available, implies that asset prices will move completely randomly over time. If the factor which changes prices is unpredictable, then the changes in prices themselves will be unpredictable, in the same way that the outcome of a random process such as the toss of a fair coin cannot be forecast. An immense literature exists on the question as to whether asset prices are truly

random. Certainly, it appears to be extremely difficult to devise trading rules from past information which will make systematic profits in the future.

But the most important empirical difficulty for the efficient markets hypothesis is the fact that movements in asset prices are far too volatile. The range of fluctuations of the share price of a company is typically much greater than that of the stream of dividends which the company actually pays over time. Prices fluctuate much more than do fundamentals. Nobel economics prizewinner Kenneth Arrow, who first placed free market theory onto a modern and rigorous mathematical basis, has described this as an 'empirical falsification' of orthodox theory. Or, in plain English, the theory is wrong.

Of course, the efficient markets theory relates to the expectations about future dividends, for example, rather than to dividends themselves. So it could be, and is, argued that the theory is correct because the relationship between fundamentals is highly non-linear, so small changes in expectations feed through to large changes in prices. But this is not much more than high class sophistry. Expectations cannot be measured, and so the relationship between them and prices can never be tested in a way which leads to the hypothesis being falsified.

The pathbreaking work on the relative volatility of share prices and dividends was carried out in a series of papers in the 1980s by the American economist Robert Shiller. He used American data over more than a century, from 1871 to 1979, to chart the actual value of share prices against the 'true' value which a perfectly rational market ought to have assigned to them given how dividends actually turned out. The line on the chart representing dividends is very stable, but the share price line shows tremendous volatility, remaining at extremes of over- or under-valuation for long periods of time.

In any event, as Alan Kirman has remarked, 'it is difficult to believe that there could be a sudden change in the fundamentals which would lead agents simultaneously within half a day to the view that returns in the future had gone down by over 20 per cent. Yet this is what would have to be argued for the October 1987 episode on world stockmarkets'. In recent years, the Nikkei index of Japanese shares has seen spectacular falls, and it now stands at barely one-third of its peak level.

Further, we often see large and sudden changes in the values of major currencies, as in the example of the US dollar discussed above. After long periods of relative stability, in which agents declare that the currency is over-valued but still buy it, the currency then collapses rapidly. For most of the 1990s, for example, the yen was very strong against the dollar, but then fell in value by some 50 per cent in the space of a year. The East Asian economies were eulogised for years as the strongest in the world, the wave of the future. Yet towards the end of 1997, their currencies collapsed against the US dollar, in some cases losing over 80 per cent of their value in a matter of days.

The difficulties caused for conventional efficient markets theory by actual behaviour in financial asset markets can be summarised as follows. First, if sharp changes in price are solely due to changes in fundamentals, as the theory requires, why do we not observe equally large fluctuations over time in those actual fundamentals? Second, if prices change without any obvious change in fundamentals, some operators in the market must be acting irrationally, which is quite contrary to the basic precepts of the theory.

The theoretical framework provided by the ants model enables us both to account for the apparently excessive volatility of asset prices, and to understand why dealers continue to buy an asset despite believing that it is over-valued compared to the price indicated by the fundamentals. There is, of course, the risk that readers might become too excited at this point and anticipate that the secret of making risk-free profits is about to be revealed.

For those of a nervous disposition, the words of Miss Prism to her young charge Cecily Cardew in Oscar Wilde's play *The Importance of Being Earnest* must be recalled: 'Cecily, you will read your Political Economy in my absence. The chapter on the Fall of the Rupee you may omit. It is somewhat too sensational'. But, on a more mundane note of reassurance, although the model of interacting agents gives a much deeper understanding of past behaviour in asset markets than does conventional economic theory, one of its strong conclusions is that future changes in prices are essentially unpredictable.

The idea that the behaviour of others can influence an individual's decision in financial markets is by no means new. From time to time throughout history, examples emerge of schemes which draw in more and more people in spectacular fashion, until the whole edifice collapses. The pyramid selling scheme which led to the virtual disintegration of Albania as a country in early 1997 is but the latest illustration. Historical classics of this genre include the Dutch tulip mania of the seventeenth century, when the price of tulip bulbs was bid up to astronomical levels, and the notorious South Sea bubble in Britain in the early eighteenth century. The only rationale for these events is that people became influenced very powerfully by the behaviour of others. As prices rose ever more steeply, contrary to the precepts of conventional economic theory, more and more people became desperate to buy.

A more mundane illustration of the principle was given by Keynes. In the politically incorrect Britain of the 1930s, beauty competitions were frequently held in the popular press. But the task was not to choose the most beautiful entrant, but to guess which of the entrants most people who cast a vote would choose. Keynes likened behaviour in the financial markets to this same principle. But he was unable to provide a formal rationale for it, and so descriptions of such behaviour remained purely anecdotal.

Kirman gives a model where, instead of two types of food source, we can postulate the existence of two types of operator in the financial markets, who look at different kinds of evidence to judge whether to buy or to sell. He provides completely realistic descriptions of these two types of agent. First, fundamentalists, so called not because of the fervour of their beliefs, but simply because they hold that prices are essentially determined by their underlying, fundamental values.

Second, chartists, who bear no relation to the great working class reform movement of that name in England in the 1840s. Chartists in this context believe that inspection of charts of the previous movements of the price of a currency or share over time provides evidence about its future behaviour. The techniques they use vary, from almost mystical mutterings about 'head and shoulders' or the rarely observed (but frequently gesticulated) 'Left Hand Extended V' patterns on a plot of data, to the most

advanced rocket science mathematics. But they form views on future prices by extrapolating from past movements.

These two methods of thinking about prices will often give quite different opinions about what the price of any given asset ought to be. In 1984, a fundamentalist thought that a sharp fall in the dollar ought to take place. But a chartist expected it to stay high, simply because it had been high in the recent past.

The essence of Kirman's model is that in any given period, an agent can continue to behave in the same way as before; he or she can change behaviour independently in reaction to news; or, finally, the agent can be persuaded to switch by the behaviour of others, by the trails which they leave when their buy or sell decisions appear on the dealing screens. In other words, in a completely different setting, we have the identical analytical framework to that of the ants model.

As with the ants model, the division of the total number of dealers in any given asset who are either fundamentalists or chartists will change continuously. Sometimes, almost everyone will be a chartist, but a switch back to the complete opposite at some point is absolutely inevitable. The very nature of the dynamics of the process dictates that some of these large changes will be very rapid. And, at these times, we will almost inevitably see a large change in the price of the relevant asset, as it switches from being determined by fundamentals, say, to being generated by extrapolation of its own past behaviour as chartists come to dominate this particular market. In short, asset prices will be volatile because of the underlying volatility in the proportion of the different types of agent operating in the market.

This latter volatility is reinforced by the speed with which information is made available and exchanged in financial markets, so there is a very large number of 'meetings' with other agents. It is not a matter of lurking outside the nest waiting for the signal which a returning ant will give. Information on the activities of others bombards the dealer continuously.

So, in the unexpected setting of the world of Wall Street and Masters of the Universe, our model of ant behaviour provides a better explanation of events than does conventional economic theory. Both imply that changes in asset prices are essentially unpredictable, which appears to be true. But orthodox economics cannot account for the sheer volatility of asset markets, and the paradoxes which arise such as traders continuing to buy assets which they say are over-valued.

An even more difficult issue for conventional theory arises in the choice and selection of products in areas of new technology. In orthodox economic theory, the consumer is sovereign. He or she has access to all the relevant information, processes it efficiently, and chooses accordingly. But there are many examples of products which are technologically inferior not just surviving, but driving out of existence competitors with distinctly superior qualities. The free market chooses not the best, but the worst.

An example from the early 1980s is the struggle over the VCR market between Betamax and VHS. Betamax machines were easier to operate and had a number of features which even now are not embodied in the standard model of VCR. After diligently reading the relevant consumer magazines to discover this information, and behaving exactly in the way free market theory prescribed, for old habits die hard, I bought one. The purchase was very satisfactory, except for one thing. Within a matter of a couple of years, Betamax had been driven out of business by its technologically inferior rival. It became impossible even to buy new Betamax video tapes, although, at least initially, I had some success in obtaining second hand ones at auctions of the contents of grand country houses enforced by the sharp British recession of the early 1990s. Finally, I had no choice but to bow to majority opinion and purchase a VHS machine.

A longer lasting illustration, so deeply embedded in our culture that it is scarcely ever noticed, is the design of the QWERTY keyboard. A controversy exists as to whether, in the final decades of the nineteenth century, it was deliberately designed to be inefficient. But, certainly, at various times during the last century, more efficient designs have been invented and marketed, but all have failed. The inferior technology prevails.

The North American economists Robin Cowan and Philip Gunby provide a detailed illustration of pest control strategies, in the *Economic Journal* of May 1996. In the United States, the use of chemical pesticides remains by far the dominant method of control, even though scientists have warned of its dangers for over thirty years. The alternative which has been developed is integrated pest management, or IPM, which relies upon understanding and enhancing natural controls on species which cause damage. There is a high fixed cost in setting this technology up, but thereafter it is extremely cheap, for it relies on knowledge. And once produced, knowledge is easy to replicate. There have been many studies of the economics of IPM and, at worst, farmers using this strategy rather than chemical control obtain similar profits and rates of return on their investment. At best, they can gain, with one study finding an increase of average returns of $15,000 a year for those farmers using IPM. Cowan and Gunby discuss at length the citrus fruit industry in Israel and cotton in Texas, concluding that IPM is unequivocally superior. Nevertheless, pesticides prevail.

But the phenomenon of one particular offer driving another out of the market, regardless of its initial merits, is not confined to products, whether aimed at consumers or at the industrial market. The location of industry itself often exhibits these features. There may be some objective reasons why Silicon Valley became a favoured location for computer companies, but they can hardly be so strong as to account for the position of dominance which it has achieved. Success often breeds success, and once firms started to locate in Silicon Valley, it became more attractive to others who needed access to the highly skilled labour force being built up in the area. But, in advance of this process getting underway, the region was simply one of a number of potential locations where the computer industry might have started to expand.

Conventional thought on the location of industry places much emphasis on factors such as transport infrastructure to facilitate ease of access. But whilst many parts of old industrial Britain are closely connected to the motorway network, it is South East Wales and the North East of England which show by far the most signs of industrial regeneration, attracting Japanese and other foreign companies in increasing numbers. Indeed, areas such as Merseyside, which by objective criteria might appear to be more favourably placed, continue their spiral of decline. This is emphatically not to say that

rational reasons can never be given for the concentration of industries in certain locations, or, indeed, that all industries exhibit the same degree of concentration. But geographical clusters of firms do frequently form in a much denser way than would appear merited on conventional criteria.

The key to understanding these phenomena was provided by a deep article published in 1983 by the British polymath Brian Arthur, written jointly with two Russian mathematicians[1]. The title, 'A Generalized Urn Problem and Its Applications', gives no clue as to the connection between its contents and the problems discussed above, but in many ways it is the seminal article on the concept of interacting agents in economic and social theory. Despite its forbidding title, we will soon see that it essentially sets out a view of behaviour which is similar to that of our ants model. There are some important differences, but in one sense we can think of Arthur's approach as a simplified version of the ants.

Arthur and his colleagues produced elegant solutions to some difficult issues in probability theory. The questions themselves can be stated quite simply. An urn contains a mixture of white and black balls. A random sample of balls is removed from the urn, and various rules exist about the collection of balls which is put back in. For example, if more than half[2] the balls removed turn out to be white, the whole sample is returned to the urn, along with an additional white ball. If more than half are black, the sample plus an extra black ball are put back. What, if anything, can we say about the proportion of white to black balls which will emerge in the urn in the long-run?

Arthur and his colleagues said a great deal about this, and about other rules for replacement which might be used instead. And Arthur realised that his theorems had direct implications for the choice between competing new technologies for both consumers and firms. A new product is invented, the video recorder, for example, and two competing versions are marketed. Initially, consumers have very little information to guide them about the rival offers. They did not realise previously that such products existed, so their tastes are quite unformed. Indeed, as with our movie example, people

[1] Ermoliev and Kaniovski, in *Kibernetica*, Jan-Feb 1983

[2] In this example of a rule, the random sample is always of an odd rather than an even number of balls

have to learn what their preferences are. Suppose, for there is no reason to do any other, that the population of potential adopters is divided equally in its preferences between the two. One group is more likely to choose one technology, and the other group its competitor.

The key assumption now is that the more people choose one rather than the other, the more and more likely it becomes that others will subsequently choose the successful version of the product. The choice of version by any agent alters the probability that all subsequent agents will choose this rather than its rival, so that positive feedback takes place.

In other words, we have a version of the ants model in which the behaviour of individuals directly alters the behaviour of others.

It is easy to think of reasons why people should behave in this way. For example, lacking information, it makes sense to observe what others do and follow their example. If a friend or neighbour buys a VHS machine and is satisfied, you are more likely to do the same. Once this process gets underway, the lead in market share which VHS obtains encourages retailers, for example, to stock tapes for these machines rather than for its rival Betamax, which in turn gives an incentive for new purchasers to choose a VHS machine, so that a virtuous circle comes into existence for VHS, which becomes a vicious one for Betamax.

In terms of Brian Arthur's urn, we can think of a random sample of just one ball being drawn. Supose it is white, and we put it back in along with another white, according to our rule. After this is done, the proportion of white balls relative to black has risen, if only by a tiny amount. So the probability of drawing a white in the next random sample of one has increased. In terms of two rival new products, the choice of one of them by a consumer shifts the chances, ever so slightly, in favour of the next person making the same choice.

Arthur and his co-authors proved as a theorem that in such circumstances, no matter how small the change in the probabilities following each individual adoption, one

technology will eventually gain 100 per cent market share and its rival will be eliminated. By changing the rules on replacement, results are obtained which predict the dominance of one product over the other, but do not require its complete elimination. But this simply-stated theory shows why, once we allow for interaction between agents and positive feedback, inferior technologies can drive better ones out of existence, in complete contradiction to the predictions of orthodox consumer theory.

There are two main differences between this model and the one we use to describe the behaviour of our ants[3]. The first is that the total number of ants in the colony is assumed to be fixed. Of course, in practice there will be births and deaths and the population will change. But it will do so only slowly, if at all, and so analytically it simplifies matters if we think of the population as being constant. In contrast, the Arthur model relies upon an unlimited supply, or at least a very large number, of new balls being made available.

But it is the second difference which is the reason why we might think of the Arthur model, for all its profundity, as a simplification of our ants. Once a ball has been drawn, the consequences for the split between colours - and its impact on the subsequent behaviour of others - is fixed. It is as if, once an ant had decided which site to visit, for whatever reason, it never changed its mind again, but was condemned in perpetuity to re-visit the same site.

In our ants model, of course, any individual ant can in theory change its mind time after time. Why, then, bother with Arthur's more simplified version of ant behaviour? The reason is that, in certain circumstances, the assumption that once a decision is taken it cannot then be altered, is a good approximation to reality. The simplified version offers a better description of the real world.

Once a firm has a built a plant in Silicon Valley, the Ile de France, the Thames Valley, Bavaria or wherever, the decision is very difficult to reverse. It is hardly likely

[3] There is a third, more subtle one regarding how many agents influence the choice of any individual. In the ants model, only the small number the ant meets on emerging from the nest matter, whilst in the urn, the *total* split is the factor which alters behaviour. It is as if each ant could observe the overall behaviour of the colony.

that the buildings will be dismantled brick by brick and shipped across the world.[4] Similarly, individual consumers who buy an expensive item - and videos were very expensive in their early years - will be very reluctant to change their minds and buy a competing version as well. Eventually, of course, as the old product wears out, or as they cannot buy supporting equipment such as video tapes, they will be forced to do so. But in the short-term, we can think of their choice as being effectively fixed.

A nice property of Arthur's model, in keeping with the general theme which interacting agents often introduce into our understanding of the world, is that it is not possible to predict in advance which technology will succeed. For by construction the outcome is a matter of the random process of initial adoption. Whoever gains an early lead will set up the process of self-reinforcement, and will probably obtain control of the entire market.

Brian Arthur's theory has come to be known as the theory of QWERTY. It has sparked an important policy debate between economists such as Paul Krugman and policy entrepreneurs like Lester Thurow and Robert Reich. The immediate point at issue between Krugman and his fellow Americans is whether this theory gives a new and powerful justification for state intervention in the economy both in general, and in particular through industrial policy. Admittedly, Reich and Thurow show little awareness of the existence of such theory, especially the mathematical aspects of it - a fact which Krugman is often keen to highlight. But this is merely a debating point. Reich and Thurow - the 'strategic traders' as Krugman calls them - advocate interventionist industrial policy, and whether they can follow the mathematics which in theory offers support for such a stance is irrelevant.

Krugman is very cautious about making policy pronouncements based on this new theory. This is for two reasons. First, he regards acknowledgement of the power and effectiveness of markets as a central part of the identity of professional economists, who should be reluctant to 'come out too brashly against markets having their own way,

[4]Though this this did once happen to the old London Bridge, allegedly purchased by Texans who believed they were buying the world famous Tower Bridge rather than its nondescript downriver counterpart

especially when it comes to the almost sacred principle of free trade'. Second, and more important, he fears that the theory might simply be used to rationalise bad policies.

On the first point, Krugman might have reflected upon the economic history of his own country, particularly during the second half of the nineteenth century when the foundations of its world dominance were being established. Undoubtedly, the sheer resourcefulness and unbounded optimism of many Americans, which have continued to the present day, were important factors. But central government played an absolutely essential role in the whole process. For example, beginning with the Morrill tariff of 1861, a series of acts through to 1897 increased sharply the degree of protection which domestic producers in the United States enjoyed. As the Western territories expanded, America became by far the largest domestic market in the world, sheltered behind tariff barriers. Aware of the potential shortage of labour which might arise as the West was opened up, the federal government defended the interests of Northern industry by maintaining open doors to immigrants. Further, enormous grants were made from the public purse to the private railway companies.

In short, in common with virtually every country which has ever industrialized successfully, America did so with policies which were in direct contradiction of the theorems of competitive markets and of pure free trade. The Far Eastern economies are but the latest additions to this list.

It can, of course, be argued that such examples merely show that, *ex post*, certain forms of intervention and restrictions on trade appear to have been successful. Their existence does not imply that any such policies will necessarily succeed. Logically, this argument is correct. But the theory of QWERTY enables us to set down a few guidelines for the conduct of interventionist industrial strategy, albeit of a different kind to the traditional ones.

For example, support for companies to get new technologies or new products to market as rapidly as possible seems to be a sensible strategy in those industries where early success might secure a decisive advantage. It is a necessary and not sufficient condition for industrial success, but the traditional British Treasury attitude, reflected in

finance ministries around the world, of opposing such support as a matter of principle is simply wrong.

A second policy guideline is the encouragement of strategic alliances at, say, the national or European level. An explicit aim of such a framework is to increase the effective degree of monopoly to allow the profit share in national income to rise. The current obsession with consumerism - and preventing companies making high profits through such behaviour - is highly damaging to European industries. Of course, such alliances do need monitoring, to make sure that the profits are being used positively and not simply handed out in dividends. But they are essential in a number of industries to gain the full advantages of increasing returns to scale.

But, as a final point, the theory suggests very strongly that it is not at all sensible to support industries where other countries already have a lead. They will already be benefiting from increasing returns in such industries. So, for example, it is misguided to continue to give large subsidies to Air France, Alitalia or Iberian Airways (in the guise of 'restructuring funds' to satisfy European Commission guidelines) in the belief that the companies will be able to establish themselves on the same scale as British Airways, their chief rival.

It is possible, with care and thought, to interfere with market mechanisms in a positive way, and QWERTY provides a rigorous theoretical basis for this intervention. But as Krugman rightly warns, the approach does not give carte blanche justification for any form of intervention which happens to take the political fancy.

The ability to develop models in which the behaviour of individuals is directly affected by the behaviour of others, exemplified by our ants, represents a very important intellectual advance for the social sciences, and offers a more powerful account of a very wide range of phenomena than does conventional thinking. The message of this approach is by no means easy for policy makers to digest. Short-term prediction and control, on which so much of public policy is based, is inherently extremely difficult and sometimes literally impossible. A more studied, less frenzied approach is needed,

looking at the longer-term properties of the system as a whole, if any real and consistent success is to be achieved.