Industrial Dynamics: Why Connections Matter

Brian J. Loasby

DRUID ACADEMY Winter Conference

Klarskovgaard, 18-20 January 2001

5 January 2001

Department of Economics
University of Stirling
Stirling FK9 4LA

Tel. +44 1786 467470
Fax +44 1786 467469

e-mail b.j.loasby@stir.ac.uk

Modelling time

In *Value and Capital*, Hicks (1948, p. 115) defined 'Economic dynamics [as] those parts [of theory] where every quantity must be dated'. Subsequent theoretical development has shown that this is not a sufficient criterion. In the Arrow-Debreu system not only must every quantity be dated, it must also be indexed by location and state of the world; yet in a model that conforms to these specifications there is no room for dynamics, but a single equilibrium which extends over all dates, locations and contingencies. There is no arrow of time: later dates influence earlier allocations in precisely the same way as earlier dates influence later allocations; there is no sense in which one thing can lead into another. Indeed, within such a model there is no scope for decisions: an equilibrium allocation is deduced directly from the basic data, which includes a complete set of preferences but requires no algorithms of choice. The individual is of measure zero, not only because the effects of a single person's preferences and endowments has no perceptible effect but because no individual is allowed to take any initiative. Everything that could possibly happen must be incorporated in the specification of one or more states of the world, either as an exogenous event or as a possible consequence of human action; the occurrence of any novelty, either endogenous or exogenous, violates this requirement and demonstrates that the apparent equilibrium had been derived from false premises.

It is as well that all differences between dates are incorporated in a single equilibrium, because no resources are available to cope with change, having already been optimally allocated in that equilibrium. There are not even any resources available to cope with equilibration. Walras eventually realised that his suggested process of disequilibrium production, in which producers converged on equilibrium output by trial and error, was not compatible with the prior derivation of equilibrium; error implies waste, and there is no margin for waste. Achieving the deduced equilibrium, whether it be the original allocation or a revised allocation appropriate to a new configuration of data, cannot happen within a functioning Arrow-Debreu economy. The markets – strictly a single market – in which this equilibrium allocation is attained as a complete set of contracts open once only, and close before the economy starts operating. It is not surprising that this looks less like a model of a market system than a model of a command economy.

Since all transactions are arranged outside the economy, within the model there are no transaction costs. Now as Coase (1988, p. 15) pointed out, if there are no transaction costs there can be no problems with externalities; impacts on third parties, whether beneficial or harmful, should simply be added to the list of goods and to the preference systems of those affected by these impacts. Where transactions are costless, there can be no unexploited gains from trade – indeed there are no third parties. If, however, it is thought appropriate for particular theoretical purposes to incorporate costs of transacting, then it is illegitimate to compute equilibria separately from the analysis of the transacting process. Not only does this process generate costs; these costs depend on the way in which transactions are organised and the sequence in which agents search for the best attainable set. Moreover, it is a natural consequence of transaction costs that some transactions, especially those for dates at which there are many possible states of the world, are likely to be postponed, and it may seem attractive to commit some resources to

the development of systems for making and implementing later decisions. This, of course, is the basis of Coase's explanation for the firm; it is also the basis for an explanation of markets as institutional arrangements for facilitating a series of transactions (Ménard 1995, p. 170), and for the creation of various kinds of reserves, as Menger ([1871] 1976) observed, in the form both of goods and of capabilities, direct and indirect. None of these phenomena can be accommodated within the Arrow-Debreu system.

If we wish to incorporate the process of costs and change within our models we need to modify our use of dates: they are now required not to ensure that the set of variables is complete but in order to identify the sequence in which things happen and in which knowledge and possibilities become available. But, as has been demonstrated in many multi-stage models, this may not make much difference to the analytical strategy, as long as it is assumed that agents correctly, if incompletely, anticipate future possibilities and make correct deductions from their anticipations. However, when Hicks moved from his early definition of economic dynamics to his later view of economics as necessarily 'on the edge of history' he was accepting history as a process in which people do not know what is going to happen, even as a set of possibilities, and in which therefore it is not possible to deduce optimal choices or optimal allocations.

It was Frank Knight (1921) who first emphasised the crucial distinction between risky situations, in which there is an agreed procedure, logical or empirical, for distributing probabilities over a closed set of outcomes, and situations of uncertainty, in which there is no such procedure – and often, as Shackle was to insist, no way to ensure that all possible outcomes had been recognised. When faced with uncertainty, appraisals and choices depend on the perceptions and skills of each individual, or group of individuals, and only after the event (and not always then) is it possible to reach agreement on the appropriateness of the procedure. Knight pointed out that risk, as he defined it, was a calculable cost and that, since the correct method of calculating each risk was public knowledge, risk-bearing was a productive service not sharply distinguishable from any other and not a distinctive source of income. Profit was the reward, not for risk-bearing but for successful entrepreneurship which coped with uncertainty by means which could not be public knowledge: entrepreneurs might calculate, but the correct basis for their calculations could not be deduced from the basic data.

However, although the result of any attempt to cope with uncertainty must itself be uncertain, Knight did not believe that success was purely a matter of chance. Though there was more to entrepreneurship than alertness to opportunities which, once perceived, are clearly genuine – which is the basic case of Kirzner's (1973) theory of entrepreneurship – it was, for Knight, nevertheless a reflection of human capabilities and a distinctive and valuable resource. In his first published article, George Richardson (1953) drew on Knight's analysis of the significance for economic efficiency of the deployment of distinctive entrepreneurial capabilities (which are not among the inputs to standard models) and, as can now be seen, is only a thought away from the argument of his famous article of 1972. Equilibrium theory has gone beyond Arrow-Debreu, but it necessarily reduces uncertainty to risk in order to achieve proofs of equilibrium;

industrial dynamics does not. In the following section I will attempt to indicate the foundations of this contrast.

Connections

In an outstanding new book, Jason Potts (2000) has opened a meta-theoretical perspective on the relationship between the general practice of equilibrium theorising and dynamic analysis. The Arrow-Debreu system exists in integral space, where every element is directly connected to every other element, just as the Newtonian model of the solar system exists in a unified gravitational field. In the Newtonian system bigger masses have bigger effects, and in the Arrow-Debreu system stronger preferences have bigger effects, but whatever the magnitude of the effect in either system it impacts directly on every other element in the system. There are no gravitational shields or specialised intermediaries to constrain interactions; 'markets', which provide connections that are indirect, have no existence except as a metaphor for direct and costless exchange. Although the Arrow-Debreu model, which is very carefully located in integral space, is no longer widely regarded as the central model of economics, nevertheless the widely-adopted principle that outcomes may be directly deduced from the data relies on the same integral conception. The rhetorical purpose of invoking rational expectations is to justify this procedure by rendering illegitimate any inquiry into the way in which data are interpreted. George Richardson (1959, p. 24) long ago pointed out that there is no direct link between data and outcomes, but only an indirect link by way of beliefs and intentions; whether consciously or not, economists have recognised Richardson's observation as a threat to the concept of a fully-connected system and the theoretical technique that relies on it, and have either ignored the issue or produced some notably unrigorous stories to support their practice.

Since a fully-connected equilibrium is a completed project, it is closed to further enquiry. However, by assuming that 'in the beginning there was a fully-connected system' it is possible to generate apparently well-defined analytical problems by postulating that some carefully-chosen connection is missing from a set that is otherwise complete; it is then possible to derive a local equilibrium incorporating agents' reactions to this solitary deficiency, relying on the results of the fully-connected model to absorb that local equilibrium, and ignoring or finessing the once-powerful argument that only a general equilibrium analysis ensures validity. This reliance is often implicit, and sometimes appears to be unconscious.

The identification of a strictly-limited deficiency in an otherwise fully-connected system is the standard method of generating soluble problems in economic theory. This is how 'New Keynesians' attempt to provide scope for a caricature of Keynes's results which accepts the internal validity of new classical reasoning. An appropriate example for this audience is Oliver Hart's (1996) explanation of the firm as an optimal allocation of property rights. Here the problem-generating deficiency is a narrowly-specified constraint on the feasible contracting space which is sufficient to frustrate the contractual alignment of incentives, but which has no other implications. However the consequences, and the narrow scope, of this deficiency are so clearly defined that farsighted contracting is

possible about the right to make decisions, which is associated with ownership; thus the missing connection can be restored by an appropriate allocation of property rights. Since, by virtue of the background general equilibrium model, such an allocation is Pareto superior, it must be generally acceptable; there are, of course, no obstacles to efficient contracts for property rights. The result is an analysis that combines theoretical novelty with the apparent validation of a general equilibrium theory in which allocations are derived directly from the data, without postulating any interaction between agents. By virtue of its construction, there are no dynamics in this model; the appropriate allocation restores the connection between data and outcomes, allowing all dates and contingencies to be provided for. Thus the 'firm' which the model purports to explain is just an extension of the 'market'; neither has any organisational or institutional existence as a particular set of connections.

Oliver Williamson's approach looks more promising. Although he differs from Coase in insisting that the fear of opportunistic behaviour is a necessary condition for the existence of a firm, he follows Coase, and differs from Hart, in modelling the firm as a system of resource allocation by direction. This immediately suggests the possibility of a theory of organisational development, which may lead to changes over time both in the way in which the firm is organised and managed and in the scope of its activities. Unlike Hart's model, in which the departure from a fully-connected system is a strictly limited theoretical move for strictly tactical purposes, the Coase-Williamson conception identifies the firm with a network of privileged connections, leading naturally to Herbert Simon's vision of an economy in which firms, not markets, are the primary forces. Williamson, however, appears never to have appreciated the fundamental significance of this conception, for he has denied Simon's vision, and has never shown much interest in what firms actually do – which is to develop and use connections, of many kinds as we shall see. It is therefore no accident that he has never analysed the development of firms over time, despite Nooteboom's (1992, p. 285) observation that his theory seems to demand a time-dimension.

The limitation of Hicks's early definition, which was not obvious when he constructed it, is that it does not distinguish between an economics in which time is just one dimension of a good, and an economics which is embedded in time. This is a distinction that Hicks has subsequently employed, not least in demonstrating that Keynes' *General Theory* contains elements of both conceptions, which has caused much trouble to those trying to interpret it. Marshall's *Principles* is similarly ambiguous, with similar consequences. What we may now observe is that a fully-connected analytical system can treat time only as a dimension; an economics in time must, as a minimum, postulate incomplete connections with future dates and their associated states of the world, and allow these connections to change over time, in part as a result of the behaviour of the system itself.

All systems consist of both elements and connections between them (Potts 2000). In the Arrow-Debreu system, connections can be ignored because they are perfectly and costlessly efficient, and so attention can be concentrated exclusively on the implications of the data, and the ways in which these implications vary with differences in the data – for example, in providing the theoretical basis for international trade. With this as a

reference model, the effects of particular deficiencies can be investigated; the term 'market failure' is a clear, if rarely recognised, indication of what is going on. The idea that connections are problematic in general, *and should be treated as problematic*, is not seriously entertained.

The obvious objection is that whereas there is necessarily only one way in which a system can be fully connected, there are very many ways in which it may be partly connected; how then are we to know what connections to include in our model? My response to that is to ask a set of similar questions. How are we to know what connections to emphasise in the design of any particular organisation – for every organisation is a partly connected system? How are we to know what connections should be made with other organisations? What connections are most effective in gaining customers? Who are the potential competitors? What are the factors we should take into account when designing a regulatory system for a privatised industry – and is the answer different for each industry? As economists, in what aspects of what other disciplines should we take an interest? What are the connections that are missing from our models of purportedly fully-connected systems? Fundamentally, every organisation, every theory, every set of expectations, every plan, and every policy privileges a very small subset of possible relationships; its applicability is therefore always problematic, and can be established only over time – and never for all time. Like the economic agents who are our nominal subjects of study, we have to work in time; why not therefore try to develop theories which take time seriously? In the remainder of this paper I will discuss three themes which seem to me central to such dynamic analysis: knowledge, institutions, and organisation. I shall argue that these themes are closely related.

Knowledge

Economists nowadays quite often write about information; it is a convenient way of removing a particular connection from the basic fully-connected model and thus generating a potentially-publishable paper. Information may be coarsely rather than finely partitioned, so that agents are unable to discriminate between states in which different actions are optimal; particular items of information may be missing – notably information about future actions by others; or information may be unevenly distributed. But the content of information is not itself treated as problematic; often indeed it is explicitly information about the probabilities of a closed set of possible states of the world. Underlying knowledge is complete, even if information is not. Thus even when information is dispersed and incomplete, the information sets of all agents within a model are drawn from a single and complete set. This is crucial for the analytical strategies that are used.

The assumption of an underlying single and complete information set motivates the standard treatment of complexity, which thus rests on the denial of Knightian uncertainty. It ensures that all simplifications are derived from a single correct source, which provides a common basis for all transactions among agents (or rather for the analysis of all transactions). It is then natural to treat bounded rationality as equivalent to a cost of information, and satisficing as an optimal response, and to avoid asking how boundedly

rational agents can know enough about the correct model to be certain that their simplifications, though not the whole truth, are nothing but the truth. The answer to that unasked question may be found in Hayek's Impossibility Theorem: 'any apparatus of classification must possess a structure of a higher degree of complexity than is possessed by the objects that it classifies; and that, therefore, the capacity of any explaining agent must be limited to objects with a structure possessing a degree of complexity lower than its own' (Hayek 1952, p. 185).

The question may also be applied to those who analyse complexity in this way: how do they know that their models of complex systems are adequate representations of the systems to which they are applied? To this question also, Hayek supplies the answer. Just as our analysis of systems should not take as its reference point a fully-connected system, which directs us to questions about specific failures and their remedies, but start from the problem of creating and maintaining connections that are appropriate for particular purposes, so the problem of complexity is not one of simplifying a complete model but of constructing some representation by selecting and linking elements. Both are exercises in Knightian uncertainty, for which there are no correct procedures, but the possibility of rewards for skill.

This is how we develop knowledge. Knowledge is structure, in the form of categories into which phenomena or concepts may be grouped, or in the form of relationships between such categories; and structure implies a non-integral space. It is an imperfectly connected system of imperfect connections in which, as Knight (1921, p. 206), observed, we focus on similarities and ignore differences that we hope will not be relevant to our current enquiry; and any of these connections may change over time, as Paul Nightingale (2000) shows in a recent analysis of pharmaceutical research strategies. The world system of knowledge is far from complete, and the knowledge possessed by – or even accessible to – any individual is a very small proportion of that world system. Nobody knows how a Boeing 737 works; and nobody knows how the Boeing Company works.

Rather than bounded rationality, which (as already noted) is usually interpreted as a particular limitation in processing knowledge, it is better to begin with bounded cognition. In the early stages of evolution, standard behaviours were genetically programmed; later creatures were genetically endowed with some capacity to vary behaviour; and in the pre-conscious stage of evolution towards *homo sapiens*, individuals formed classification systems and linkages between sensory perceptions and actions which proved sufficient for the survival of the species. These structures of knowledge were necessarily backward-looking; in Jim March's phrase, they followed 'the logic of appropriateness'; but what appeared to be appropriate could differ between individuals because of differences in the sequence of their experiences. This is still the basic method of knowledge formation in modern humans; that is why 'we know more than we can tell', and in particular why we can perform many actions that we are unable to specify in detail. However, the emergence of consciousness introduced the important novel possibility of creating ideas about the future by making conjectures about new categories and relationships as yet unrecognised, leading to the possibility of taking novel actions with the intention of producing novel effects. The scope for variation between individuals

was correspondingly increased, and with it the rate at which knowledge could grow. This new possibility, we should remember, is a modification of the old capabilities, which are not displaced, and although it is augmented by logical reasoning, such reasoning, as psychologists have shown, is still primitive in relation to the ability to make novel connections.

The need to construct knowledge, and the role of imagination in doing so, was emphasised by Adam Smith ([1795] 1980) in his psychological theory of the emergence and growth of science as a combination of classification systems and causal links, which he illustrated by the *History of Astronomy*. The stimulus to imagination was provided by the failure of existing patterns of knowledge to account for newly-observed phenomena – an intrinsic motivation, beginning with unwelcome surprise and concluding with delight in creating a new pattern that worked, that appears to have substantial survival value and to be still effective, but which is not prominent in economic theory. Since new 'connecting principles' (Smith's prescient phrase) led to new expectations, new activities and new observations, what began as an aid to daily living gradually incubated a new category of knowledge called 'scientific'. As the psychological and practical value of this knowledge became more apparent some people came to devote particular attention to it; and as its growth accelerated it began to divide into distinctive branches, each with its own set of connections which gave rise to its own anomalies and consequent stimulus to imagination. Having explained how the dynamics of scientific development led to specialisation which accelerated the process, Smith later transferred this analysis from science to the economy, and made the power of the division of labour to increase productivity the basis of his dynamic economic theory (Smith 1976b). Smith was well aware that increased specialisation had its opportunity costs in the neglect of potentially important connections; this led him to include education as an important function for government, and to give a special role to 'philosophers or men of speculation' who imagined novel connections between divergent specialisms – or, in Schumpeter's (1934) language, conceived of 'new combinations'.

Institutions

Individuals develop structures of knowledge, including the knowledge of how and when to perform particular actions, and how to frame sets of premises as a basis for deductive reasoning. They learn how to make sense and how to make decisions, both of which require more than logic, as Chester Barnard (1938, p. 305) emphasised. However, unless they live a purely solitary existence they do not have to do this on their own. The activities of others create a range of vicarious experiments which they may use to test their own conjectures or to incite their imagination to produce new conjectures; or they may go further and simply adopt apparently successful patterns of behaviour or satisfying ways of organising knowledge. (This is how we all start as infants.) It is an obvious economy to free-ride on other people's wisdom; that is how Smith explained the diffusion of new cosmological theories which appeared to resolve worrying problems, and also the adoption of rules of behaviour which appeared to conform with moral sentiments (Smith 1976a). Ways of thinking and ways of acting that are common within a

community need not originate as solutions to co-ordination games; they may arise from individual efforts to solve individual problems.

If the sharing of patterns and routines has such origins, that helps to explain how members of a group who have been acting in parallel may converge on a particular set of procedures for managing interactions. (Smith was well aware of the importance of this sequence in making civil society possible.) What we call 'institutions' when they are interactive routines are not inherently different from the routines and assumptions on which people necessarily rely in order to economise on cognition for their own private purposes; they are an external supplement to the structure of internal cognition. Access to this external cognitive capital depends on the appropriate absorptive capacity, the development of which is a major function of education; and studies of organisational learning have shown the importance of social interaction within and between productive organisations in facilitating such learning. In both private and interactive contexts, predominant reliance on routines is necessary in order to create space for thought; and in both contexts, variation between individuals widens the range of material about which to think. Codification is an institution which partially formalises tacit knowledge and thus provides the basis for the creation of further tacit knowledge.

An obvious but neglected application of the importance of institutions in encouraging the growth of knowledge is the emergence of markets. A market reduces the costs of making certain kinds of transactions by establishing powerful connections. Mark Casson deserves the credit for noting that the costs of continuing transactions may be reduced by appropriate investment, and identifying the entrepreneurial role of those who make such investments – though as recent events have amply demonstrated many entrepreneurs may be unfortunate or misguided. When a particular class of transactions has been substantially reduced to routine, those using that market, as buyers or sellers, no longer have to think about how to transact and are therefore free to think about what to transact, how to produce the goods or services to be transacted and how to make good use of them (Loasby 2000). Thus the institutionalised connections provided by a market allow the formation of new connections, both in trading relationships and in the form of knowledge about both production and consumption. The emerging interest in the role of the consumer builds on an understanding of market institutions.

Institutions provide the connections which support dynamics; they also have their own dynamics, primarily of adjustments at the margin, but also of regime changes, which typically draw on patterns of connections from some other sphere of activity. Knowledge changes institutions, as institutions shape knowledge. This process drives the history of economic thought, as well as the development of productive knowledge and both managerial and entrepreneurial skills.

Organisations

According to Roger Myerson (1999, p. 1068), 'today economists can define their field more broadly as the analysis of incentives in all social institutions'. Economic organisation, which at one time focussed on the effects of various market structures on

economic performance, is now interpreted as the organisation of incentive structures. This is certainly a broadening in one dimension, but imposes serious constraints in others. Incentives matter; but co-ordination, both within and between firms (and for individuals too – see Kelly 1963) is first of all a cognitive problem. Marshall (1920, p. 138) linked organisation specifically to knowledge, and half-explicitly linked different forms of organisation to different kinds of knowledge. Even Williamson, who considers the merits of different organisational arrangements, treats governance systems as protective devices against pernicious incentives and does not, like Penrose (1959, 1995), consider them as bases for the generation and application of knowledge. Williamson's (1985, p. 48) declaration that 'were it not for opportunism, all behaviour could be rule governed' ignores Knightian uncertainty and its counterpart, Shackleian imagination; opportunities, rather than opportunism, drive the growth of a Penrosian firm.

These opportunities result from new knowledge which is shaped by institutions that are fostered by organisational arrangements; the Penrosian process in its administrative framework combines cognitive, institutional and organisational dynamics. The organisation of a new activity requires new connections to be made, in formal responsibility, in patterns of interaction and in individual cognition. If the activity is successful most of these connections cease to require conscious attention; a new set of institutions releases cognitive skills and organisational capabilities for other purposes. This is 'the receding managerial limit'. At the same time, the absorbed patterns of behaviour, at all levels, change the firm's resources, which may be deployed in directions which are conjectured by the use of these cognitive skills. That such connections between resources and profitable uses are not simply deduced from the data, as in standard theories which are located in integral space, but need to be made is a clear and fundamental difference between Penrose's theory and the standard 'theory of the firm', a difference emphasised by Penrose's distinction between resources and productive services. We may also think of a firm's resources as equivalent to Lachmann's conception of capital: they are elements which may be substituted between uses but which in any particular use are valuable because of their specific complementarity (or connections) to certain other elements. If this complementarity produces what was once called synergy or what we now call superadditivity, the additional productivity may be attributed not to the elements but to the connections between them. Chemical bonds may provide an appropriate analogy.

These Penrosian single-firm dynamics should be supplemented at least by the two other Marshallian categories of forms of organisation that aid knowledge: the firms within a single trade provide vicarious experiments and vicarious hypotheses to supplement and interact with the particular knowledge of each, and the network of complementary trades is structured on Richardsonian principles of dissimilar ways of organising knowledge to gain the advantages of the division of labour while avoiding unhelpful connections (Richardson 1972), and linked by incremental adaptations and by speculative visions. The organisation of production is also the organisation of knowledge, and both kinds of organisation change over time as the result of what happens in time. The dynamics of industrial organisation have never been better presented than by Allyn Young (1928) in a paper which rejected the applicability of equilibrium modelling to an understanding of

this process of generating value as a consequence of rearranging connections. Increasing returns are returns not to the elements but to the connections between them. That the concept of general equilibrium is not applicable to these dynamics is also my view, but local and temporary equilibria may serve very well to indicate the knowledge and relationships – connections of various kinds – on which people may reasonably rely in order to construct useful novel connections. Innovation is carried by continuity, and continuity may be expressed by an appropriate concept of equilibrium, applied to particular structures of knowledge, insitutions, or organisation.

Dynamic variety

Industrial dynamics relies on differences, not only between but also within industries; indeed it is the effects of these differences on behaviour, continually modifying and occasionally disrupting the environment in which firms are operating, requiring new interpretations and sometimes prompting new perceptions, that provide the dynamics. Since this process combines the generation of variety and the elimination of variants which do not match the criteria by which they are judged – criteria which themselves are a proper and neglected field for analysis – it is not surprising that some writers on industrial dynamics are attracted to evolutionary concepts; but that is not a requirement. On the contrary, there is danger in simply replacing the field theory of physics with neo-Darwinian biology, which excludes human purpose; it is safer to draw inspiration from Adam Smith's evolutionary model, which includes complex motivation, imaginative conjecture (often driven by aesthetic considerations), selection and diffusion, increasing differentiation and means of integration. Neo-Darwinians seek to confront us with a stark choice between design and natural selection among blind mutations; standard economic theory opts decisively for design, occasionally supplemented by appeals to selection processes to ensure that the design is optimal. Both are corner solutions in the space of theoretical strategies; industrial dynamics avoids corner solutions by choosing a sequence of ex-ante decisions and ex-post realisations that may lead to fresh decisions.

As we have noted, contemporary models of economic organisation often depend on the concept of asymmetric information, which certainly corresponds to an aspect of reality. But I suggest that the more important asymmetry is of interpretation and of perception, which leads some individuals and some organisations to take actions that others have dismissed, or never even thought of. Frank Knight's theory of entrepreneurship and the firm was based on interpersonal differences in the capacity for judgement – what we might call making connections that prove to be appropriate – and of differences for each individual between fields of activity (Knight 1921, p. 241). Shackle's (1979, p. 26) beautiful phrase 'the imagined, deemed possible' invites us to consider the stimulus and sources of imagination and why some products of the imagination are deemed possible by particular individuals while others are not.

Imagination and the assignment of possibility require the making of new connections, and often the discarding of old connections, a process that is easier to understand in retrospect than it is in prospect. Since the number of connected networks that are conceivable is unimaginably greater than the number that can be handled by any human

brain – or indeed by any organisation that depends on manageable interactions between human brains – it is not surprising that there will be a great variety of opinions about what will work, and what will be profitable. There will be a high rate of failure; economic dynamics requires both ex-ante and ex-post selection. This variety, and its potential, justify concluding this sketch of industrial dynamics by invoking George Richardson's (1975, p. 359) principle: 'Surely it is of the essence of competition that the participants hold uncertain and divergent beliefs about their chances of success'. This is competition between different ways of thinking; and the co-ordination problem within an economy is that of achieving the necessary compatability between different ways of thinking while preserving the differences. There are difficult incentive issues here, but they are not the incentive issues that dominate Myerson's conception of economics. Knight (1921, p. 268) observed that '[w]ith uncertainty absent . . it is doubtful whether intelligence itself would exist'. Why should we be satisfied with the analysis of rational choice when we have the opportunity to study intelligent action?

References

Barnard, Chester I. (1938) *The Functions of the Executive*. Cambridge, MA: Harvard University Press.
Coase, Ronald H. (1988) *The Firm, the Market and the Law*. Chicago: University of Chicago Press.
Hart, Oliver D. (1996) *Firms, Contracts and Financial Structure*. Oxford: Clarendon Press.
Hayek, Friedrich A. (1952) *The Sensory Order*. Chicago: University of Chicago Press.
Hicks, John R. (1948) *Value and Capital*, 2nd edn. Oxford: Oxford University Press.
Kelly, George A. (1963) *A Theory of Personality*. New York: W. W. Norton.
Kirzner, Israel M. (1973) *Competition and Entrepreneurship*. Chicago: University of Chicago Press.
Knight, Frank H. (1921) *Risk, Uncertainty and Profit*. Boston: Houghton Mifflin.
Loasby, Brian J. (2000) 'Market institutions and economic evolution', *Journal of Evolutionary Economics*, 10, 297-309.
Marshall, Alfred (1920) *Principles of Economics*. London: Macmillan.
Ménard, Claude (1995) 'Markets as institutions versus organizations as markets? Disentangling some fundamental concepts', *Journal of Economic Behavior and Organization*, 28, pp. 161-82.
Menger, Carl ([1871] 1976) *Principles of Economics*, translated by J. Dingwall and B. F. Hoselitz. New York: New York University Press.
Myerson, Roger B. 'Nash equilibrium and the history of economic theory', *Journal of Economic Literature*, 37, pp. 1067-82.
Nooteboom, Bart (1992) 'Towards a dynamic theory of transactions', *Journal of Evolutionary Economics*, 2, pp. 281-99.

Nightingale, Paul ‘Economies of scale in experimentation: knowledge and technology in pharmaceutical R&D’, *Industrial and Corporate Change*, 9, pp. 315-59.
Penrose, Edith T. (1959, 1995) *The Theory of the Growth of the Firm*. Oxford: Basil Blackwell (1959); 3rd edn. Oxford: Oxford University Press (1995).
Potts, Jason (2000) *The New Evolutionary Microeconomics: Complexity, Competence and Adaptive Behaviour*. Cheltenham and Northampton MA: Edward Elgar.
Richardson, George B. (1953) ‘Imperfect knowledge and economic efficiency’, *Oxford Economic Papers*, 5 (2), pp. 116-56.
Richardson, George B. (1959) ‘Equilibrium, expectations and information’, *Economic Journal*, 69, pp. 223-37.
Richardson, George B. (1972) ‘The organisation of industry’, *Economic Journal*, 82, pp. 883-96.
Richardson, George B. (1975) ‘Adam Smith on competition and increasing returns’, in A. S. Skinner and T. W. Wilson (eds) *Essays on Adam Smith*. Oxford: Oxford University Press.
Schumpeter, Joseph A. (1934) *The Theory of Economic Development*. Cambridge, MA: Harvard University Press.
Shackle, George L. S. (1979) *Imagination and the Nature of Choice*. Edinburgh: Edinburgh University Press.
Smith, Adam (1976a) *The Theory of Moral Sentiments*, ed. D. D. Raphael and A. L. Macfie. Oxford: Oxford University Press.
Smith, Adam (1976b) *An Inquiry into the Nature and Causes of the Wealth of Nations*, ed. R. H. Campbell, A. S. Skinner and W. B. Todd, 2 volumes. Oxford: Oxford University Press.
Smith, Adam ([1795] 1980) ‘The principles which lead and direct philosophical enquiries: illustrated by the history of astronomy’, in *Essays on Philosophical Subjects*, ed. W. P. D. Wightman. Oxford: Oxford University Press, pp. 33-105.
Williamson, Oliver E. (1985) *The Economic Institutions of Capitalism: Firms, Markets and Relational Contracting*. New York: Free Press.
Young, Allyn A. ‘Increasing returns and economic progress’, *Economic Journal*, 38, pp. 527-42.