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# The division and organisation of knowledge

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**Abstract.** – Hume demonstrated the impossibility of proving any general empirical proposition, and turned to the question of how people acquired 'knowledge'. Adam Smith postulated a human need to make sense of phenomena by imposing patterns, which are replaced when they systematically fail; this process is accelerated by specialisation, which leads to a differentiation of locally-efficient frameworks of thought and action. Thus the division of labour results in the division of knowledge – both 'knowledge-how' and 'knowledge-that', or capabilities – and a consequential increase in the total knowledge in a community. Marshall added a principle of variation within an evolutionary cognitive process, and also the need for multiple forms of organisation. Learning is not a distinctive activity but a characteristic of human existence; it requires frameworks, or institution, which are themselves subject to evolution. Penrose analysed the growth of knowledge within a business, Richardson focussed on the importance of similarity and complementarity across capabilities, and the consequential need for linkages between businesses. Firms need both internal and external organisation; in an important sense, learning is collective as well as individual.

## Introduction

The twin foundations of this paper are David Hume's demonstration that it is impossible to establish the truth of any general empirical proposition and his response, which was to turn to the crucial but potentially manageable question of how people come to believe that particular empirical propositions are true. Hume's problem and Hume's response provide a theme for exploring the claims of economics and the methods that are employed to generate and support those claims. If we follow Hume's example we will not expect existence proofs to demonstrate empirical truths, or find in equilibrium models any adequate guarantees of the permanence of phenomena; we will doubt the rationality of the peculiar economic concept of rational choice and deny the empirical validity of rational expectations. Instead we will look for theories of process, which will help us to identify stimuli to action and factors which influence the direction of response, paying particular attention to the development and use of conventions and patterns of behaviour which we may call institutions. Such theories may be explicitly cast in terms of the generation of alternatives and selection among them, thus producing theories which may properly be called evolutionary, although not restricted to the equivalents

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of biological concepts of random mutation and environmental pressure. We may nevertheless be interested in the technique of combining ex-ante and ex-post analysis, and may use some version of the concept of equilibrium as a convenient principle for understanding how learning, in an academic discipline, a firm, or an economy is facilitated and shaped by relatively stable frameworks (Loasby, 1991). We may find uses for the tautologies of formal logic – not least because the tautologies are often far from obvious; but we will always be seeking explanations which rest on causal sequences.

## Adam Smith's theory of knowledge

This, indeed, is how modern – though not contemporary – economics began; and it began that way because it was founded by a friend and admirer of Hume. Adam Smith's earliest surviving major work applied Hume's psychological conception of the development of human knowledge to explain the emergence of that quintessentially human phenomenon, the pattern-making activity that we call science, taking as his example the history of astronomy (Smith, 1980). Smith argued that the psychological discomfort which is caused by the apparent randomness and unpredictability of phenomena induces people to invent classification systems and causal chains in order to impose mental order and so assuage this discomfort. Apparently successful patterns are widely adopted and further developed to become institutions, first as an aid to individual comfort, and subsequently as a convenient basis for communication and co-ordination. The more formal of these systems gradually become recognised as identifiable bodies of scientific knowledge, each of which, in Smith's (1980, p. 46) words, 'may be regarded as one of those arts which address themselves to the imagination'. Once established as a satisfactory means of suppressing discomfort, either as popular wisdom or as scientific knowledge, a set of 'connecting principles' is not easily displaced; but if breakdowns become increasingly serious and the system cannot be patched up, there will be increasing psychological pressure on all those who have come to rely on that system to create a replacement which will resolve the crucial difficulties.

Using this explanatory scheme (which is itself an example of the power and appeal of connecting principles), Smith traces the sequence of the four main cosmological systems. If this sounds like Thomas Kuhn's (1962, 1970) account of the history of science as a succession of paradigms, then it should; but Smith's analysis was produced more than two centuries earlier, and in explaining the transition between 'paradigms', where Kuhn simply emphasises discontinuity, Smith provides greater comfort for the reader's imagination and thus better satisfies his own criteria for good science. Another comparison with a recent writer is worth making. In its emphasis on the importance of human imagination, Smith's account of the process by which knowledge grows foreshadows the most distinctive theme in Shackle's writing, and it is entirely appropriate that Shackle reinvented the core of Smith's theory to provide the explanatory framework for his account of *The Years of High Theory* (Shackle, 1967).

The succession of cosmological systems that Smith reviews are not imperfect perceptions of natural order; Hume had shown that they could not be. They are human inventions which are impelled by psychological necessities. The supreme example of this

theme is Smith's treatment of Newton. Astonishingly for that time, Smith insists that Newton's laws are the product of Newton's imagination, and might well, like earlier invented cosmological systems, eventually be superseded; but he also insists, in the conclusion and climax of his exposition, on their almost irresistible persuasive power, which derives directly from their ability to meet a pressing psychological need (Smith, 1980, pp. 104-105). The importance of rhetoric in science is inherent in this theory of the growth of knowledge; and Smith not only extols the virtue of 'the Newtonian method' of establishing a core principle at the outset of any systematic exposition in his *Lectures on Rhetoric* (Smith, 1983, p. 146), but employs that method himself at the beginning of the *Wealth of Nations*, as we shall shortly observe. Furthermore he uses the delight in successful persuasion as an explanation of the human propensity to barter, because, in modern terminology, it transforms some of the costs of transacting into benefits (Smith, 1978, p. 352).

In his causal explanation of the development of science, Smith also draws attention to the importance of specialisation. Those who take a detailed interest in a particular field will require satisfaction in detail, and so anomalies that would not be noticed in a broader view will provoke them to find more serviceable systems of classification and linkages between categories (Smith, 1980, p. 38). Thus the progress of scientific knowledge is enhanced by an increasing division of intellectual labour between the sciences. Smith (1980, p. 97) also notes that, as this division proceeds, the members of each scientific community will make increasing demands on their own intellectual systems, but will be increasingly careless – indeed increasingly ignorant – of the anomalies that their systems may be creating for members of another community, who of course may be equally ignorant of these implications. The variety of judgement that results from different institutional frameworks, on which Eymard-Duvernay's analysis is founded, may therefore be seen as a pervasive consequence of the division of knowledge that is produced by the division of labour.

The consequences of specialisation thus first appear in Smith's writing as a major element in his psychological theory of the growth of knowledge. In the *Wealth of Nations* the order is reversed, as indeed the rhetoric of Smith's economic system requires. For the 'Newtonian principle' on which Smith's theory of economic growth is based is the improvement of productivity through 'the effects of the division of labour' (Smith, 1976b, p. 13). As he quickly makes clear, the most important effects do not result from the efficient deployment of different existing skills but from the improvement and creation of skills as a direct consequence of specialisation – as in the sciences, though the connecting principles of industry are much more closely directed to achieving practical effects. In Gilbert Ryle's (1949) terminology, the content of science is 'knowledge that', whereas effective performance depends on 'knowledge how'. Common to the *History of Astronomy* and the *Wealth of Nations* is the theme that the division of labour promotes the growth of knowledge, which is a human creation. Knowledge grows by division, including the division between these two kinds of knowledge.

From our present perspective we can elaborate a little. If knowledge is to grow, it necessarily becomes increasingly dispersed; asymmetric information may cause problems (and has certainly provided scope for economists' ingenuity); but the creation of asymmetric information is, in the first instance, a solution to the problem of how the total

of human knowledge is to be increased, despite the limitations of individual human cognition. As economists may be pleased to note, the creation of asymmetric information is a response to scarcity; but it is not a response which can be accommodated by orthodox concepts of equilibrium, though it does entail a notion, less precise than the orthodox, of the efficient allocation of knowledge-creating activity within a system. The orthodox focus on information has two major deficiencies. First, it gives no attention to the development of asymmetric skills, which is no less important for economic activity than asymmetric information, but is much less amenable to the standard remedies proposed by economists for information problems. Second, within its restricted field it ignores the differences between the frameworks within which even shared information is interpreted, and the consequent importance of providing relevant interpretative schemes as well as appropriate incentives (Witt, 1998). Different kinds of knowledge, within the broad categories of 'knowledge how' and 'knowledge that', require different frameworks to be fitted to different categories of phenomena – it is best not to say 'different experiences' because what constitutes 'experience' is the intersection of phenomena and the framework within which they are interpreted (Kelly, 1963, p. 73). Satisfactory intersections, within which we may include adjustments to the interpretative framework, enhance the credibility and comfort of that framework; interpretative failure, in Smith's account – as, much later, in Popper's (1959) – provides the psychological stimulus to new theoretical constructions or to new practices.

All these constructions, we should remember, exist in the space of representations, or in what Popper (1972) calls World 3 – the world of ideas; and as Popper has pointed out, the conjunction of ideas sometimes generates problems that may have no counterpart in the material or psychological worlds, but which have similar effects in directing the growth of knowledge within the world of ideas. Smith (1980, p. 77) himself noted the rhetorical power of the psychological need 'to preserve the coherence of the ideas of the imagination', a need which illuminates much of the history of economics. Before leaving Smith it is important to point out that, guided by Hume, he declined to enquire whether his theory of the growth of knowledge implied any increasing correspondence with truth; but its essential features of human conjecture, guided but in no sense determined by empirical confrontations, reappear in Popper's account of scientific discovery, which is linked to a belief in the possibility of objective truth – though Popper was no less insistent than Smith and Hume that the truth of any scientific proposition could never be proved.

Though starting from a different philosophical tradition (that of Aristotle), Menger ([1871] 1976) presented his theoretical system of economics as a causal sequence, based on purposeful attempts at discovering how various objects could be put to use, in increasingly roundabout ways, to satisfy human needs. Since knowledge enters into Menger's definition of a good at the very beginning of this causal sequence, it is not surprising that Menger saw the relationship between the division of labour and the growth of knowledge as closer to that in Smith's *History of Astronomy* (which in Menger's scheme would be classified as a causal explanation of the creation of scientific theories as goods) than to the *Wealth of Nations*; the division of labour in production, as in science, presupposes a significant development of human knowledge. This difference between Smith and Menger, though of considerable historical and theoretical interest, is

marginal to this paper; what matters here is that purpose and process, not equilibrium – and especially not general equilibrium – are central to Menger's conception of economic questions and the methods of analysing them.

## Marshall's evolutionary system

In his *Principles* (1961) Marshall explicitly followed Smith in giving priority to the division of labour as a guide to new schemes of organisation which generate new knowledge; but before turning to economics he had retraced Hume's sequence – though without apparently being aware of doing so, (for a detailed account, see Groenewegen, 1995). At home and at school Marshall had absorbed the truths of religion and mathematics, which were then seen by many as closely related. The Mathematics Tripos at Cambridge, where he became Second Wrangler, derived its prestige from its power to deliver 'necessary and inevitable truth, derived axiomatically' (Groenewegen, 1995, p. 116); and the most obvious demonstration of this power was provided by the theorems of Euclid. It was this demonstrated capacity of establishing empirical truth by pure reason on which some theologians drew as evidence that the truths of Christianity were equally demonstrable. Thus, the claim, in a once-famous series of lectures, that the search for such demonstration was misguided, and that religion was necessarily a matter of revelation and faith, evoked spirited debate, in which both those who sought to rebut the claim and those who used it to argue for religious scepticism accepted the principle that empirical knowledge must be provable. But this principle was soon devastatingly refuted by the development of non-Euclidean geometry, which was most vigorously expounded in Britain by Marshall's closest friend Clifford (who nevertheless maintained his Christian beliefs): a simple change of premise led axiomatically to implications which were no less necessary and inevitable than those of Euclid, but which contradicted them.

That Euclid had produced a remarkably successful representation of empirical facts could not, therefore, be attributed to his use of the axiomatic method. Marshall, whose own religious beliefs were fading, was very well aware that the implications extended far beyond mathematics and religion, and sought help among the philosophers. He learnt German in order to read Kant, with the unintended consequence that he became well acquainted with the work of German economists, who figure prominently among the citations in the first edition of his *Principles* (Streissler, 1990). Thus he was well prepared to respond to his later discovery that Cournot's axiomatic system, when applied to industries which exhibited increasing returns, led to necessary and inevitable empirical falsehood (Marshall, 1961, p. 521). Marshall's response was not only an aversion to long chains of reasoning, the dangers of which are rarely acknowledged by economic theorists, but a general methodological rejection of timeless questions about the existence of a universal solution (which lie at the heart of general equilibrium theorising), in favour of time-embedded questions about particular processes of change.

In seeking to answer these questions, before he had shown any particular interest in economics, Marshall had already turned to causal, and indeed cognitive theory. Raffaelli (1991, 1994, 1995) has drawn our attention to the significance of a paper, written for a Cambridge discussion group, in which Marshall devised a mental experiment which

suggests how human learning may be represented within a model of the brain, conceived as a machine. More than a century after Smith, Marshall was able to take advantage of Darwin's theory of evolution, in which perhaps he found, like some of his contemporaries, a substitute for religion as a means of restoring his own imagination to the 'tone of tranquillity and composure' (Smith, 1980, p. 46); and he used it to produce a sketch of evolutionary psychology, which now looks like a precursor of modern classifier models. For the present context, what is of particular interest in Marshall's (1994) account of the development of the brain as a learning machine, is his distinction between the first level of the brain, which develops routines that are matched to categories of perceptions, or in James March's terminology follows the 'logic of appropriateness', and the second level, which appears only when the first level is functioning effectively, and which deals with ideas of routines and perceptions and can therefore employ the 'logic of consequences' – though it does not attain rational choice. What is of even more interest, is Marshall's view of the persistent importance of the first level, not least in its linked roles as an embodiment of the results of handling ideas and as the generator of interpretative failure which requires the manipulation of ideas, as in Smith's account of the development of both science and productive skills.

There appears to be no evidence that Marshall ever read Smith's *History of Astronomy,* for which his model might have provided a physical underpinning. However, as Raffaelli has pointed out, it is easy to believe – though impossible to prove – that this early interest in the neurological processes by which people create and store knowledge, and in particular the crucial links between operational and exploratory levels, had a significant influence on Marshall's emphasis in Book IV of the *Principles* on the importance of daily activities as a stimulus to new ideas, and even on Marshall's use of his Principle of Substitution to include both switches between established techniques in response to perceived changes in circumstances and deliberate experimentation with novel variants, guided both by individual experiences and individual circumstances.

In this paper, I cannot expect to do justice to Hayek's much more elaborate and well-informed treatment of evolutionary psychology (Hayek, 1952), though it is essential to recognise the significance of Hayek's distinction between the ordering systems which are developed within the brain and the scientific orderings which claim to represent the same phenomena. One correlate of this distinction, noted by Hayek (with references to Ryle), is that between 'knowledge how' and 'knowledge that', which was introduced earlier; another is the implausibility of any notion of the human brain as a general purpose problem solver, including the special case of a general purpose rational chooser. There is no credible evolutionary process which could have produced such a brain; the survival of the emergent human species depended on rapid identification of specific problems and the rapid implementation of satisfactory solutions, before the development of language and indeed by modification of brains that had permitted the survival of pre-human ancestors. 'Knowledge how' has evolutionary priority, and its organising principles need not coincide with those which are imposed in the construction of scientific theory.

As a natural consequence of this evolutionary process, the contemporary human brain is remarkably effective in storing and retrieving distributed knowledge and in creating and maintaining cross connections; it is much less effective in performing the operations of formal logic, or at constructing and using a well-defined hierarchy of knowledge

(Cosmides and Tooby, 1994). In fact it is much more like a market system, guided by entrepreneurial initiative, than a planned economy. However, although each human brain has the potential for creating an enormous variety of patterns of knowledge, it is able to realise only a minute fraction of that potential. This is the fundamental opportunity cost of human cognition; but for a human population, this cost can be greatly reduced if different people realise different fractions of what is possible. That is why the division of labour is essential to the continued growth of knowledge.

## Frameworks and processes of learning

If we are all continually fitting events into frameworks, or adjusting – and occasionally inventing – frameworks in order to encompass events, then it is easy to agree with Kelly (1963, p. 75) that learning is not a special category of human activity but a fundamental characteristic of human existence. We may therefore expect it to be a fundamental characteristic of any human group, such as a firm. Marshall implicitly accepted this – his firm is an agent of progress as well as production (Loasby, 1999b); but it is Edith Penrose's (1959, 1995) distinction to have constructed a theory of the firm which rests on this principle. To do so, she had to define an intellectual domain to which the conventional theory of the firm (in which, as Denis O'Brien (1984, p. 39) observed, the firm does not exist) had made no claim. She therefore created space for a theory of growth by avoiding any discussion of the determination of price, output, or the combination of inputs. This immediately made possible her most important analytical innovation, which is the distinction between resources and the productive services for which they might be used. If resources are identically equivalent to inputs in a production function, as in standard equilibrium theories of production, then technology and resources cannot be separated; and conventional assumptions about knowledge neither can be problematic. But once we allow Penrose's distinction, we introduce ambiguity about the scope and quality of any resource, as Nelson and Winter (1982) recognise, and also about the possible uses to which it might be put, which gives force to Penrose's concept of a firm's 'productive opportunity', which, she takes care to emphasise, is a product of entrepreneurial imagination (Penrose, 1959, 1995, p. 5).

George Richardson (1972) amended Penrose's terminology to that of 'capabilities' and 'activities', making explicit reference, as Hayek had done, to Ryle's (1949) distinction between 'knowledge that' and 'knowledge how'. Ryle's further differentiation between 'knowledge how' as a potential of the mind and its realisations in specific actions precisely matches Penrose's distinction between resources and productive services; it also suggests connections to the writers mentioned earlier, and reinforces the argument for an evolutionary and institutional analysis. No two persons will have identical sets of capabilities, and no two persons will deploy capabilities in identical ways; and that will be equally true of organisations. Each of the 'productive opportunities' which direct the growth of a firm embodies a double conjecture, that the opportunity is genuine and that the combination of resources allocated to it can deliver the requisite productive services. Every perception (true or false) of a productive opportunity rests on institutional structures which are differentiated but nevertheless provide apparent coherence between areas of knowledge.

The requirements of coherence are not merely epistemic. Though in discussing the growth of knowledge, it is natural to give priority to the epistemological dimension of the coherence of both 'knowledge how' and 'knowledge that', nevertheless co-operation between people, as Lazaric and Mangolte both remind us, is also a social and political issue, and the ways in which these issues are handled, for example by the definition of spheres of interest, by formal coalition or informal truce, are likely to have significant impact on the interpretative frameworks within which knowledge is developed. Smith's awareness of these dimensions is amply demonstrated by his *Theory of Moral Sentiments* (1976a), which was an exploration of the basis of a civil society, and should be considered in any comprehensive treatment. This paper makes no claim to comprehensiveness; but it is certainly relevant to note (as Choi (1993) does) Smith's observation that people's readiness to adopt rules and representations from others to help with their own epistemic problems tends to promote social cohesion.

If people and organisations are moderately free to choose their own actions, they provide continuing sources of variety, and at the same time contribute to an environment in which this variety is tested, and which simultaneously provides the stimulus for the development and novel application of capabilities. That the selection process is also part of the process of variety generation, not only because of the environmentally-specific adaptive sequences in the equivalent of Marshall's lower level of the brain, but – more significantly – because the equivalent of his higher level can be directed, in Menger's terms, towards the purposeful creation of goods, implies a fundamental difference of specification between theories of biological and economic evolution, as Penrose (1952) had argued in criticising Alchian's (1950) appeal to biological analogy in defence of the traditional assumption of profit-maximisation.

Richardson's crucial contribution to our understanding is his proposition that clusters of capabilities may be cross-classified according to their degrees of similarity and complementarity; the resulting matrix provides the basic tool for explaining the organisation of industry at any particular time, and allows – or rather requires – us to go beyond the simple distinction between firm and market and investigate the variety of relationships between firms, as Maj Andersen (1999) has done in a thesis recently presented in Copenhagen. Richardson's earlier exploration of the need to obtain 'market information' before business men could make reasoned commitments to investment programmes had already led him to the conclusion that the anonymity of all transactions, which has been considered essential to perfect competition, is incapable of supporting intelligent decision-making (Richardson 1960, 1990. His recognition of the need to co-ordinate expectations about not only competitive but also complementary investments may have helped, unconsciously, to prepare the way for the analysis of the later article, though this was developed as a separate solution to a different problem. The retrospectively-perceived complementarity between these two contributions provides an excellent basis for revisiting both Smith's ideas on the importance of specialisation in creating knowledge and Marshall's (1961, pp. 138-139) classification of the types of business organisation which aid knowledge – within a firm, between similar firms, and between complementary firms.

Penrose (1995) recognised that her theory requires a firm with 'insides'; resources have to be developed and arranged, like the capital structures of Austrian theory, within

an administrative framework – which itself is a distinctive resource for each firm, capable of providing a range of productive services. Both mental and administrative organisation shape knowledge, and each influences the other: mental models include principles of organisation, and the allocation of responsibility and prescription of decision premises combine to indicate what events are relevant and what kinds of response are appropriate in the relevant mental models (as they do within an academic community). If there are many firms within an industry, these mental and administrative structures, applied to firm-specific sequences of events, ensure the 'tendency to variation' (Marshall, 1961, p. 355) which was Marshall's distinctively Darwinian extension of Smith's theory of economic development. Marshall's second form of organisation – of firms within a trade – supports the process of variety-generation by facilitating the exchange of ideas and experiences within an industry, so that no firm is restricted to its own cognitive systems. The third form of organisation facilitates the co-ordination of complementary activities and the intersection of complementary capabilities as a source of 'new combinations'; these are rarely on a Schumpeterian scale, as Penrose (1959, p. 36fn.) noted, being better represented by Smith's third category of inventions, those produced by people who specialise in making connections between distant and dissimilar objects.

## External organisation

Interactions between firms have typically been seen by economists as evidence of the search for market power, or, more recently, sometimes as efficiency-enhancing devices for constraining opportunism. That co-ordination may be problematic, even in a world of unlimited virtue and benevolence, is a proposition that would not be generally welcome, though it is entirely consistent with Coase's (1937) explanation of firms; but it is a natural consequence of human cognitive limitations, and of the division of knowledge which is the most effective response to those limitations. At any moment the need to organise co-ordination may be readily explained by the differences, not only of knowledge, but also of the principles on which different kinds of knowledge are organised. However, as Langlois (1992) has explained (and as Schumpeter had previously indicated) if knowledge, though widely dispersed, did not change, then a system of co-ordination, once established, could be maintained perfectly well by routine; and this structure of routines could be mimicked by a model of rational choice, as Schumpeter (1934, p. 80) pointed out. What makes co-ordination a continuing requirement, and not simply the product of an efficient set of contracts or property rights, is the inseparability of learning from human action, which has been recognised by all the authors cited in this paper, and which has led them to favour analytical methods which are compatible with that recognition.

Smith (1976b, p. 26) very properly derived the co-ordination problem from the division of labour; he also defined it as a problem for the individual to solve. Each person requires access to the capabilities of many others, and access, like any other activity, depends on capabilities. As previously noted, Choi (1993) has drawn on Smith's *Theory of Moral Sentiments* to explain how people try to supplement their own limited cognitive power by adopting apparently successful patterns of behaviour; individuals require

an external, as well as an internal, mental organisation. Similarly, firms require 'outsides' as well as insides, and on a much larger scale than each individual; this is a major theme of Andersen's thesis. It therefore often makes sense for firms to take the initiative in developing 'mediating institutions' for the benefit of individuals, as Mark Casson (1982, 1997) has explained. A major part of the costs of transacting is borne by firms, especially in the form of investments in various kinds of transaction technology. But the benefits lie not only in making access by customers easier; they may also facilitate the collection of information which can be used to improve the attractiveness of the goods and services on offer. Ingeniously designed websites may be exceptionally valuable for this purpose.

Relationships between firms and consumers are a neglected area of economics; but it may be easier, at least for economists who have some acquaintance with evolutionary and institutional ideas (and with the history of the subject), to explore the contributions to the growth of knowledge which give attention to the relationships between firms along the sequence of production and distribution. In particular, it would be appropriate for such economists to examine the ways that these relationships are built up, maintained, modified, and sometimes depleted or abandoned, and the effects of particular kinds of relationships on the kinds of knowledge that is produced. (Andersen's (1999) dissertation exemplifies this kind of analysis.) Such an examination clearly must incorporate the costs of transacting, but it differs from more conventional transaction cost theory in two ways. First, it is concerned not only with productive activities and the 'information' that is required to co-ordinate them, but also with novelty – and perhaps with the connections between commercial transactions and the development and transfer of knowledge. Second, it will treat transactions, like production, not as technologically determined, but as activities which depend on capabilities, the scope, quality, and application of which result from the ways in which labour is divided, the organising principles within each specialism, and the kind and sequence of events to which individuals and groups respond.

A modern economy is a highly interdependent system; in production as well as consumption, each of us relies on the complementary activity of a great multitude. It is also a perpetually changing system, not only because of exogenous factors, but also and more importantly because its operation continually generates new problems and new possibilities, leading to new experiments and new conjectures. Such experiments and conjectures cannot be derived from initial conditions, either by economists or by those who are working within the system. (This is, of course, true of the development of economics itself.) The rate at which such experiments and conjectures are generated depends on differences between people, which may be traced to differences in their patterns of thought and action; but their success is conditional on the compatibility of their perceived productive opportunity with other elements of the economic, social and political systems within which they are applied, or at least with the capacity to create the relevant compatibilities. In this important sense, all learning must be collective as well as individual.

## Conclusion

For this kind of study of the growth of knowledge, I offer the seven principles which are set out in Chapter 1 of my recent book (Loasby 1999a, pp. 10-14), which deals more extensively with the topic of this paper.

1. All action is decided in the space of representations. The representations employed are never copies of reality; they truncate complexity and suppress uncertainty. Nevertheless, they may sometimes serve very well – indeed sometimes so well that the possibility of failure becomes unthinkable, as we may observe in business, in politics, and in academic disciplines.
2. Viable processes must operate within viable boundaries; the 'framing' of problems is not an aberration but a necessity, despite its opportunity costs.
3. Frameworks are useless unless they persist – even when they sometimes do not work well. All businesses, and all individuals, need 'theories' and 'policies', some of which may be unformulated, or even unconscious, to provide their local institutions.
4. All decisions require closure – an assumption, not necessarily explicit, that everything that matters has been included in the process of reaching the decision. This may require some heroic gap filling, perhaps through recourse to representations which emphasise their own internal rather than external coherence.
5. The study of decision processes entails the study of institutions – the patterns, procedures and conventions which limit the definition of problems and the requirements of solutions.
6. The processes which are framed by these institutions may usefully be placed in an evolutionary setting. Decisions and actions may be considered as conjectures, typically selected from a range of possibilities during the decision process, and subject to confirmation, adaptation, or rejection when the apparent results are recorded.
7. These processes operate at a variety of levels and over a variety of timescales; what is a framing institution on one timescale may be subject to selection on a longer timescale. However, although the creation of novelty is necessarily not predictable the supersession of major institutions (or theories and policies) is itself a proper topic for study.

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