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Bounded Rationality and Decomposability: The basis for Integrating Cognitive and Evolutionary Economics

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Introduction

Here we explore the underlying unity of two of the concepts that we have most employed from Herb Simon's work, namely bounded rationality and decomposability, and how this unity provides the starting point for merging cognitively focused approaches to behavioral economics with evolutionary/institutional economics into a coherent single framework. Our interest in merging these programs can be traced back particularly to the formative influence of Brian Loasby, who first began to wrestle with both of Herb's concepts in his 1976 book *Choice, Complexity and Ignorance* and then used George Kelly's 1963 *A Theory of Personality* to show just how much the cognitive strategies that people use for dealing with a complex world are dependent on that world's being at least partially decomposable. Once the two concepts were seen woven together at the level of the decision-maker's mind, it gradually became apparent that this had relevance for consumer theory, for corporate strategy, and for public policy, and that institutions could be seen as devices for handling bounded rationality by partitioning the world into separable units. In the process of extending this line of thinking, we have increasingly moved from a cognitive focus to a focus on structural evolution in which the path taken by economic systems becomes seen as being shaped by increasing decomposition in some areas and by increasing interconnectedness in other areas, the changing mix of which affects the ability of decision makers to manage the system and its flexibility in the face of shocks. To solve problems, hybridization of modular elements is commonly employed, adding to the menu of elements on which further creative destruction may be founded.

To explore the unity of these key concepts, and to illustrate the workings of a process of creative hybridization, we adopt a rather reflexive, and reflective, strategy, showing how our ideas developed with a blinkered focus on particular areas of the economic system considered separately before evolving a general system for making sense of the whole. It will become apparent that this is not simply our story of how Herb's work opened up a lifetime of research opportunities for us, but also a reflection of Herb's influence on Neil Kay, whose own Simon-inspired work has been a major ingredient of our research program.

Starting point: The UK De-Industrialization Problem 1975–1979

The point of view that we have reached is heavily inspired by the contexts in which we originally encountered Simon's work. Earl's first encounter with Simon (1959) and the idea of satisficing came as a Cambridge undergraduate via his tutor Ajit Singh, who subsequently prodded him further down the behavioral road by encouraging him to read Janos Kornai's *Anti-Equilibrium* (1971), a book that presents a very Simon-influenced view of the process of structural change in economic systems. These early encounters occurred at a time (1975–1977) when the de-industrialization of the UK in the face of competition from Europe and Japan was a major focus. Within the de-industrialization phenomenon lay a puzzle for satisficing theory to resolve: Why did successive major falls in the value of the pound fail to induce more UK consumers to substitute back in favor of locally produced items and away from higher-quality, waiting-list-free imported products?

The poor standards of UK products might well be accounted for in terms of low aspiration levels on the part of UK firms, and poor labour relations might reflect the inability of boundedly rational managers to see a better way to interact with their workforces. Likewise, the willingness of UK consumers to turn elsewhere might well reflect the discovery of overseas offerings when strikes or over-zealous demand expansion led to shortages of domestic products. (See Mosley 1976 for a satisficing analysis of demand management.) But the emerging discussion of the importance of "non-price factors in international trade" seemed to imply something about the choice process that no one was articulating explicitly: the inapplicability of the axiom of gross substitution. It was as if, as was sometimes said in monetary theory lectures, there could "breaks in the chain of substitution", but since no alternatives to indifference analysis seemed to be on offer, Earl lacked a way of making sense of links between non-price factors and demand inelasticity.

In commencing his PhD studies at Cambridge in 1977, Earl began with a broad vision of the workings of economies that combined cumulative causation and multiplier ideas from Myrdal and Keynes with a mixture of Simon/Kornai satisficing/threshold-of-adjustment ideas and Leijonhufvud's (1969, 1973) thinking in terms of liquidity buffers and corridors of stability within which orderly adjustment might normally occur. This was colored by acceptance of Shackle's (1967) emphasis on the scope for surprise and the difficulties of foreknowing the future, which seemed to complement Simon's notion of bounded rationality. Also on the agenda at this early stage was the idea that some decision makers might be resistant to changing their behaviour in the face of changing external conditions, something that March and Simon (1958) explored at length in the organizational setting and which also seemed rather to apply to mainstream economists in the face of criticism from behavioralists. First on the list of books to read was Brian Loasby's *Choice, Complexity and Ignorance* (1976), which swiftly reinforced the idea that a synthesis of Simon and Shackle was in order. This book introduced Earl to Simon's (1962, 1969) notion of decomposability and pointed him in the direction of seeing that Kuhnian paradigms or Lakatosian research programs might be useful concepts for understanding how people in general, and not merely scientists, cope with bounded rationality. Having found it impossible to find a supervisor in Cambridge who was both available and interested in behavioral economics, and with a lectureship offer from Stirling University in Scotland, Earl headed north to work with Loasby, who agreed to serve as an external PhD supervisor.

The "Stirling School." 1979–1984

Initially the question of whether or not an economic system was decomposable did not seem to be linked to the concept of bounded rationality. Rather, its significance seemed to relate to the scope for economic crises to occur. First, there was the question of the long-run environmental impact of human actions. Long before discovering Simon's work, Earl had read "A Sound of Thunder", Ray Bradbury's science fiction tale of time-traveling dinosaur hunters. This fable opened up major questions about path dependence and the scope for "small" actions to have major implications in interconnected systems over the long term. One way that "small" actions might have small consequences was via the system's having some kind of slack/buffering in it, such that any shockwaves would normally dissipate. Simon offered a different perspective: the overall system might be composed of modules such that spillover effects only operated within a well-defined area, rather as if confined to islands. He also argued that processes of evolution would tend to select modular systems precisely because of their resilience in the face of disturbances. But if we could take the "island" notion only as a short run approximation, scope for long-term ecological crisis seemed considerable. The fate of wildlife on islands to which predators were introduced indicated the hazards of specialization when a subsystem was not actually closed in the long run.

The idea that small changes might have dramatic long-term implications in systems with limited decomposability seemed to link with bounded rationality in that the system might be impossible for mere mortals to fathom, Already, possible links with what we now would call chaos theory were being hinted at by Conrad Waddington in his provocative 1977 book *Tools for Thought*. Earl began to feel that for understanding whether one could get away with non-historical, partial-equilibrium analysis, it would be essential to understand the extent of decomposability and how one event might lead to another. This theme has underlain our subsequent thinking on topics as diverse as buyer–seller chains in housing markets (Earl 1995, 1998) and browsing behavior in shopping malls (Earl and Potts 2000).

A second line of thinking came from having read Piero Sraffa's *Production of Commodities by Means of Commodities* (1960), which had introduced the notion of the "basic commodity", one that figures directly or indirectly, via the matrix of production, in the production of all items in the system. At the time of Earl's arrival at the University of Stirling (1979) the second OPEC oil shock had just been engineered, and despite Brian Loasby's commenting during a seminar that he could not think of any examples of a basic commodity, oil seemed a near enough fit to the basic commodity idea. That a rise in the price of oil could cause a crisis seemed to have something to do with the sheer range of areas in which oil figures in the system. This is something that cannot be said for most products. For some products (say, sheet music of works by avant-garde composers), consumption and patterns of influence would be restricted to a very select circle. However, modern marketing techniques are increasingly recomposing the boundaries between products via complementary "product tie-ins" that generate and feed from brand ubiquity. This seems to produce highly skewed purchasing behavior compared with that which was observed in the much more decomposable consumer markets of not so long ago. (At the time of writing, Christmas 2001, *Harry Potter* is everywhere, with *Lord of the Rings* waiting in the wings.) There is much research waiting to be done linking bounded rationality's role in the significance of easily recognizable brands and superstars (Rosen, 1981) to the managerial and industrial organization implications of the need to coordinate complementary activities aimed at capturing rents, quite often within short product life cycles.

Earl's first discussion of the significance of whether or not economic systems were decomposable was in the context of an analysis (in Dow and Earl 1982, pp. 145-6, originally written late in 1980) of Hyman Minsky's (1975) financial instability hypothesis. Minsky's analysis is based on interconnected financial balance sheets and shifting populations of players prone to shifting moods and risk tolerances in financial markets. Not all financial crashes had the wide-ranging implications of the 1929 Wall Street Crash, and in the lesser disasters particular pockets of the economy would suffer disproportionately. This theme was revisited rather more forcefully in Earl (1990), which included not only further Minskian case study work but also a chapter on bottlenecks and buffers that affect the stability of macroeconomic systems and the size of multiplier coefficients.

A crucial lead for taking Simon's ideas further came via Stirling alumnus Neil Kay, whose dissertation-based 1979 book *The Innovating Firm* Earl purchased a few weeks before moving to Stirling. Kay provided a strong critique of aggregative, "bottom-up," reductionist mainstream economic analysis in the context of the allocation of resources to corporate research and development. In its place he offered a hierarchical, "top-down" analysis of budgeting. Kay's critique of reductionism was influenced by the work of Arthur Koestler, who in his 1975 book *The Ghost in the Machine* had been an early adopter of ideas from "The Architecture of Complexity" (Simon 1962). Koestler had made Simon's thinking the basis for a systems-within-systems, Janus-faced (looking both ways) alternative to whole-based, top-down *or* reductionist, bottom-up modes of analysis. At the same time Koestler (1975b) offered an analysis of *The Act of Creation,* in which novelty entailed hitherto untried combinations of already-existing elements, a perspective similar to that offered by Shackle (1979) in his analysis of the imagination in terms of a capacity to make fresh combinations of existing alphabetic elements. New products could be seen as emergent systems within systems.

Kay (1982, 1984) was quick to offer in a pair of books an analysis of the kind of view of economic organization implied by the Simon/Koestler perspective. In a seminar entitled "Diversification: Some Firms Do, Some Firms Don't" presented at Stirling in 1981, Kay gave a taste of what these books would contain: a striking synthesis of Ansoff's (1965) notion of synergy and Simon's decomposability perspective. Rather than focusing on the firm's activities as a set of product market involvements, he sought to reorient industrial economics to focus on linkages between product markets and the strategic strengths and vulnerabilities that came from them. Shared technologies, markets, and brand names give strength when times are good, enabling costs to be spread across different but related products. If the external environment changes as a result of new technology, government regulations, changes in fashion, and so on, the links become potentially dangerous: what is problematic for one product may prove problematic for products linked to it. Hence firms that believe themselves to be operating in surprise-prone environments should avoid having too many linkages between their different products, so that if something goes wrong and causes the unexpected truncation of a product lifecycle, they will still have other sources of cash flow.

An important aspect of Kay's 1982 book was his attempt to distinguish between system linkages at a point in time (synchronic) and linkages between things as time passes (diachronic): if a subsystem were subject to a shock, the structure of the former linkages could affect the set of events that then unfolded through time. In later work, Kay has increasingly looked at the implications of bounded rationality for industrial organization not merely in terms of decomposability of corporate activities but also in terms of the patterns of strategic alliances and

networks that emerge as means of managing, simultaneously, strategic risk and the limits of what individual organizations can know and coordinate. (See Kay 1997)

Earl set out to do for consumer behavior what Kay had been doing in the economics of industrial organization. Initially, he examined the organization of household spending in terms of top-down budgeting and the grouping of products into mental categories for comparison as a means of coping with bounded rationality. This seemed consistent with the design of real-world shopping environments, as with the division of supermarkets into separate sections for vegetables and fruit, dairy products, and so on. Simon-inspired work by James Bettman and others in marketing journals put Earl on to the trail of non-compensatory decision rules. These provided a means of making sense of consumer intolerance of products that would not meet particular standards, whether price (outside a budget range) or non-price factors. In other words, non-compensatory decision rules provided a basis for segmenting demand systems into approximately separate zones, where changes in one zone would have limited impacts on other zones. On this view, substitution in terms of price would come about because of the use of price as tie-breaking rule, or because a price cut repositioned a product within the budget ranges of buyers who previously would not have considered it; otherwise, choices would be based on relative abilities of products to match up with non-price standards of adequacy on consumers' checklists.

As a part of this checklist view of consumer choice, Earl developed a synthesis between (a) Simon's work, (b) George Shackle's (1979) theory of choice under non-probabilistic uncertainty and (c) the personal construct psychology of George Kelly (1963), to which Loasby had drawn his attention. Kelly's work presumes that people cope with the world by modeling it as if it is, in Simon's terms, decomposable; that they construct their view of the world in a hierarchical manner; and that they have limited dimensions in terms of which to see things. Consumers' checklists will be of finite length, dependent on their expertise and interest in the particular market. Where the performance of a product is uncertain in respect of a particular dimension, it will be deemed acceptable if a sufficiently good outcome seems sufficiently plausible in prospect and an unduly bad performance seem sufficiently implausible. (This is a kind of four-target/two-point test, rather than a simple aspiration level of the kind they would employ as a filter if not uncertain.) Earl (1983, 1984) explores these ideas were explored at length, with a particular focus in the latter work on how non-compensatory decision rules related to the UK's de-industrialization problems..

The further Earl got into the clinical psychology literature associated with personal construct theory, the more it seemed that there were similarities with issues that Kay was raising in corporate strategy and that Kuhn and Lakatos had wrestled with in the philosophy of science. Kelly saw most people as organizing their constructs into hierarchical systems, assigning determining roles to some ("core") constructs, in much the same way that businesses assign staff to positions at particular levels within particular departments in order get things done and avoid internal chaos. By contrast, people who get into a mess tend to have a lack of linking threads to bind their thoughts into some kind of order, or so many threads linking constructs to each other that they cannot change one idea with producing massive change in their view of the world. For Kuhn and Lakatos, scientists seem to have certain key ideas, which they are very reluctant to change, on which they build their views of the world, and they are prepared to add in all manner of ad hoc notions to preserve their viewpoints if the latter seem at odds with evidence. In typically imposing hierarchical architectures that result in points of view that are vertically layered (with some ideas more to the periphery than to the core) as well as divided horizontally

into subsystems, people are able to make the task of thinking about the world manageable. They also are not overwhelmed by the Duhem-Quine problem that asserts it is impossible to know when a particular idea is wrong because one is always testing a nested set of ideas.

For world-views to be resilient and yet amenable to evolution, people must assign some firm spots on which to build their lives. They also need to segment their lives into different sections with limited spillover allowed between them. People who choose to build their entire lives around particular assumptions, such as the ongoing availability of a particular career path, person, or personal capability will be devastated if these are falsified. For example, when Lee Iacocca lost his job at Ford, the disruption to his life was, until he was hired to revive Chrysler, every bit as problematic as the disruption felt by the Ford Motor Company decades before on the death of the Model-T, to whose production the firm had become specifically dedicated (Earl and Kay 1985, Earl 1986a). In a world of turbulence, people need partially decomposable ways of thinking and lifestyles, just as firms need to be diversified around a variety of business themes.

At the end of his time at Stirling (mid-1984), while finishing the final version of his PhD dissertation, Earl began to see inelasticity of demand and the marketing notion of consumer "involvement" in relation to the extent of decomposability in consumers' world-views and/or lifestyles. Even if choice involved some kind of more orthodox weighing of attractive and off-putting aspects of a product, resistance to change as price or non-price features were varied still seemed to be underpinned by the mental architecture people used to organize their thoughts. Crucial here were (i) the patterns of "implications" that particular changes were seen to entail and (ii) which thoughts about change were ruled out of court or unthinkable by higher-level constructs. Some changes are easy to make because their overall implications are limited; other have such dramatic negative implications that they are unthinkable (Earl 1986a, 1986b; see Laaksonen 1994, for a marketing perspective on involvement). On this basis, what seem from the standpoint of onlookers with more decomposable points of view to be "minor changes" may cause people with highly interconnected points of view to get very hot under the collar.

Simon's general vision of the mind being usefully seen as a system of computer-like programs increasingly became a backdrop for Earl's thinking as he framed the nature of choice in the manner outlined above. There seemed to be a need for a limited set of rules that were hard-wired at birth, that would limit the kinds of ideas that decision makers could find acceptable as a basis for constructing further ideas, just as particular kinds of software will only run on particular kinds of computers. Some people simply will not buy some things or ideas. However, the hierarchy of ideas that a person employs might, like a constitutional system, include self-denying clauses that specified the conditions under which core notions would be abandoned and a radically new point of view taken on board. Put it another way: the mind's core is not simply like a computer operating system, but like a computer operating system that is open to upgrading in certain ways.

Just before leaving Stirling for the University of Tasmania, Earl got together with Kay and together they mapped out their 1985 article employing many of the foregoing lines of thinking to argue that notions of hierarchy and decomposability provided a basis both for policy design and for replying to critics of subjectivist economists such as Shackle who emphasize the potential for kaleidic change in decision making environments. Their core notions have not changed significantly since then. What has changed is the appreciation of what makes this kind of economics both different at its core and, in consequence, its breadth of scope. This heightened appreciation required a shift to the other side of the planet and the passage of ten years.

Complexity, and So On

Potts began his PhD studies in 1995 at Lincoln University in New Zealand. He had been properly trained in neoclassical economics and therefore knew nothing of Herbert Simon or, for that matter, of anyone else mentioned above. But he was a great admirer of Veblen, he had, by chance, read Robert Pirsig's 1991 novel *Lila* and Stuart Kauffman's 1993 book *Origins of Order*, and he had dimly perceived how these ideas might apply to economics, if only economics could be interpreted in terms of evolutionary theory. He wanted to work on evolutionary economics, and with unabashed naivety he presumed, post-Veblen, he was the first to ever think of this. He went looking for a supervisor. Through a random search he discovered Peter Earl, whom someone characterized en route as the only economist in New Zealand who did "that strange sort of economics." And an otherwise unlikely connection was made.

Potts thus was introduced to Simon by Earl, and subsequently to Loasby (1991). He already had a complex systems view of the nature of economic evolution in mind, and one of the first books he read was *The Sciences of the Artificial* and in particular the reprinted version of "The Architecture of Complexity."

In time, Potts's PhD dissertation emerged as a high-level synthesis of complexity theory, evolutionary theory, computational theory and economic theory. It was published in 2000 as *The New Evolutionary Microeconomics: Complexity, Competence and Adaptive Behavior*. At the heart of this book is the idea that an economic system is a complex system of complex systems. The agents are complex behavioral systems, composed of systems of decision rules, as Simon, Kelly and Earl had explained. Yet Potts soon realized, through reading Simon, Leijonhufvud, Richardson, Shackle, Loasby, and Kay, that firms, industries, and the entire macro system, including expectations, were also complex systems. There occurred an awakening in which the whole economic universe seemed to be made of complex systems and perhaps that was the key to a general framework. This was eventually synthesized with a graph-theoretic conception of the geometry of economic space (Potts 2000: chapter 2). This scheme was in direct contrast to the standard basis of microeconomics in field theory; instead it was based upon an ontology of connections and the definition of a system as a set of elements connected in specific ways. A complex system was defined as a structure of connections with the property of partial decomposition. An economic system is then a complex system of complex systems and naturally an emergent product of boundedly rational agents. Economic evolution is a creative and destructive process of the dynamics of connection within and between systems, which sometimes involves the emergence of new systems.

Potts's graph-theoretic superstructure further illuminated the relation between bounded rationality, decomposability and economic evolution as a growth-of-knowledge process. Bounded rationality is the dual statement that economic agents use systems of rules for thinking and that they are only partially connected to their environment. Most connections will be local. Some will be global. Sometimes changes will have dramatic effects. Sometimes large changes will have small effects. Dynamics, in this view, depend on the geometry of connections. This is true at the level of the individual agent, as Earl had long realized, but it is also true throughout the economic system and determines its ability to evolve as a growth-of-knowledge process (Loasby 1999; Quine 1951). Evolution entails systems attaining and maintaining complexity without losing coherence (too few connections) or freezing up (too many). This is how we both came to re-read Simon's views on the architecture of complexity. But now we had a framework that revealed the deep relation between bounded rationality and decomposability as a story about the evolutionary dynamics of partial connectivity in complex systems.

Research opportunities abound when everything is a complex system. One project is to synthesize evolutionary psychology with behavioral and evolutionary economics. Interestingly, this project has its roots in one point where Simon was wrong. He had argued for the idea of the mind as a general problem solver. Although seminal to artificial intelligence research, it has been rejected by evolutionary psychology, which has instead championed the notion of the mind as a massively modular system of *specialized* problem solving—as indeed Simon himself might have portrayed it if he had seen it in terms of his work on decomposability. These mind-modules are adaptations to particular problems recurrent in the ancestral environment. The mind is then viewed as what the brain does, which is to coordinate these specialized competencies into a near-seamless complex parallel system of cognition: Simon was not so wrong after all. Earl and Potts (forthcoming) argue that his concept of bounded rationality would have been much better appreciated if he had made a distinction between inborn preferences and learned knowledge. If consumers can discover how the technologies of consumption impinge on the relatively limited set of high-level things that they desire, choice is relatively straightforward. Even when people know they face dilemmas, they are capable of jumping one way rather than another as their gut instincts dictate. Bounded rationality thus seems only to apply to information and knowledge that must be learned or acquired about contents of the set of feasible choices and the different implications of selecting any one of these options. We have come to see that this line of thinking has implications for the relation between information, knowledge, markets and competence.

A second project is to explore the geometry of connections in economic systems, as the maps of associations, complementarities and in general of connections by which the whole is greater than the sum of the parts. At present, very little is known about the connective structure of an economic system. We do of course know a lot about resource flows (input–output tables) and spatial aspects of industry and factor markets. And we do know something about the inter-connective structure of corporations (Kay 1997). But we know little about the geometry of knowledge in economic systems, and in particular the structure of specialized knowledge as an ecology of expertise. There are many aspects to this, such as the bundling of commodities (store design, menu selection, product tie-ins, and so forth) and strategies (consultancy, marketing, management) and also the deep structure of knowledge that connects some industries more closely than others. What we might hope to learn from such analysis of the connective structure of economic systems is not just the architecture of consumer lifestyles and organizational competencies but also the spaces into which entrepreneurship moves by creating and destroying these connections. The direction this heading is toward a new evolutionary growth theory.

Post-Simon Economics in a World of Globalization

A third research task implied by our Simon-inspired approach to economic evolution is a thoroughgoing exploration of the relationship between globalization, decomposability and bounded rationality. Our earlier comments regarding the analogy between systems of though that are open to change, and computer operating systems that can be upgraded, might strike some readers as rather similar to Thomas Friedman's popular writing on globalization. Friedman sees different nations as having different rules of operation and openness to change, which determine their relative performance in an increasingly interconnected global economic environment. Yet much of the best-selling writing of Friedman and others on globalization remains questionable when viewed from a post-Simon standpoint.

International labor mobility certainly becomes easier the more that firms operate in identical styles, lessening switching costs for boundedly rational workers and their colleagues.

However, modern knowledge workers are often portrayed as moving in response to job opportunities regardless of any ties in terms of family and community links. Whether in the age of the Internet and cheap telecommunications such ties become much less significant is an open question: are virtual relationships a close substitute for "being there"? (See Simon's Travel Theorem, in Simon 1991 pp. 306–7). If the ties continue to bind, the field perspective does not apply.

Likewise, with search engines and other Internet services, it may be possible to obtain excellent advice on what to choose and where to obtain supplies at the cheapest price, from anywhere on the planet. Yet running against this field perspective on markets is the possibility that demand will become increasingly driven by web links that enable specialized cells of demand to operate like never before. Within them, consumers may find a bewildering array of appealing items between which to choose, many of which they would otherwise have had little chance of discovering without great effort.

Finally, we return to the first policy area mentioned in relation to decomposability: financial markets. Perhaps the field conception of markets applies most strongly to the financial sector, at least in terms of that sector's ability to obtain information rapidly any time, anywhere. However, as far as the system's ability to operate in an orderly manner and promote real investment is concerned, it is the pattern of interconnectedness between balance sheets that is the crucial thing.

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