CHAPTER 2 **COMPLEXITY AND CONTINGENCY**[1]

"Among the vast array of molecules that an organism can manufacture to serve its needs are simple carbon atoms of the methane series, composed entirely of carbon and hydrogen atoms. With one carbon atom, only a single kind of molecule is possible. With ten carbon atoms, the number is 75, with 20 it is 366,319, and with 40 it is 62 trillion. Add oxygen atoms here and there on the hydrocarbon chains, to produce alcohol's, aldehydes, and ketones, and the number rises even more rapidly with molecular size. Now select various sub-sets, and imagine multiple ways they can be derived by enzyme-mediated manufacture. You have potential complexity beyond the powers of present day imagination. ...
The greatest challenge today, in all of science, is the accurate and complete description of complex systems. Scientists have broken down many kinds of systems. They think they know most of the elements and forces. The next task is to reassemble them, at least in mathematical models that capture the key properties of the entire ensembles. Success in this enterprise will be measured by the power researchers acquire to predict emergent phenomena when passing from general to more specific levels of organization. That in simplest terms is the great challenge of scientific holism".

Edmund Wilson, 1998; 85.

"Some 165 million years ago, dinosaurs were masters of Earth. Mammals, our direct ancestors, subsisted as best they could as small animals hiding in nooks and crannies to keep out of sight of voracious dinosaurs and assorted carnivorous monsters. But something happened some 65 million years ago … that would change everything. … A huge asteroid, weighing some 10,000 billion tons and about 10 km in size, crashed into the Yukatan peninsula…. The impact had the explosive force of a billion megatons of TNT, or five billion times the power of the bomb that destroyed Hiroshima… Earth shook heavily from the violence of this cosmic impact. The impact propelled more than a hundred thousand billion tons of vaporized rocks high into the atmosphere, leaving a giant crater 180 kilometers in diameter and more than 20 kilometers deep. The vaporized rocky material cooled off in the atmosphere and began falling back down to earth as hundreds of millions of small stones. A rain of gravel pelted the earth for the following hour. Atmospheric friction was such that the air became red hot. The nitrogen in the atmosphere began to combine with oxygen to form nutric acid, creating acid rain. Fires started to consume forests and and spread rapidly over the entire planet… The winds spread the dust particles all around the globe, and a huge black cloud covered the entire earth, blocking out the suns light and preventing its heat from warming the planet. … The consequences of this severe darkening of the skies and this deluge of acid rain were devastating to both plants and animals. A total of 30 to 80 percent of plant species were wiped out. The disappearance of plants and trees in turn triggered the demise of two-thirds of living species, including the dinosaurs, which literally starved to death….

T. Thuan, 2001, 1, 43-44.

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[1] This chapter has been greatly influenced by discussions on complexity and post modernism with Paul Cilliers. See Cilliers, 1998, Dawkins, 1987, Kaufman, 1995, Horgan, 1996, Wilson, 1998, Thuan, 2001.

1. AN INTRODUCTION TO COMPLEX SYSTEMS

We live in a world of truly astonishing complexity. Molecules interact with molecules to form cells, cells interact with cells to form organisms, organisms interact with organisms to form ecosystems, societies, and economies. A complex system is one in which the interactions between the constituents of the system and the interaction between the system and its environment are such that the system as a whole cannot be fully understood solely by analyzing its micro components. The relationships among the components are not fixed but continually shifting over time.

It is exceedingly difficult to provide a working definition of complexity. There is neither something at a level below (micro constituents) nor at a level above (a meta-description) that is capable of capturing the essence of complexity. One loose characterization is that complexity is proportional to the degree of a phenomenon's improbability.[2] Another is that complexity denotes more possibilities than can ever be actualized.[3] These attributes hardly serve as definitions. But they do suggest that one should not be surprised that no simple definition of complexity is comprehensive. Instead of a definition an outline of the most salient attributes of complex systems will be presented, as a first step towards a general description of complexity.

It is perhaps useful first to distinguish between "complicated", and "complex". If a system can be given a complete description in terms of its individual constituents, and then analyzed by the method of reductionism, e.g. TV's, computers, software programs, jumbo jets, or even a snowflake, the system is merely complicated.[4]

The spontaneous self-organizing behavior of complex systems involves the nonlinear interaction of numerous uncontrollable factors. Complex systems evolve over the longer

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[2] Cilliers, 1998

[3] Luhmann, 1985; 25.

[4] As someone presumably a Frenchman said, 'A snowflake is complicated, but a mayonnaise is complex'. Cilliers, 1998.

run in a manner far too complex to ever be successfully modeled. [5] Chaotic behavior implies unpredictable outcomes, even when successive events are formally linked. Analysis of the long run behavior of complex systems is necessarily speculative and conjectural. Prediction of their future behavior is not possible. Complex systems are constituted by intricate sets of nonlinear relationships and feedback loops. They are inherently nonlinear and nearby trajectories separate at exponential rates. Linear systems would explode, since for linear systems orbits that are locally unstable, are also globally unstable. But this is not true for nonlinear systems, where local instability can coexist with bounded motion. Nearby trajectories separate exponentially, but are eventually folded back together and contained within a bounded region. This is the strange property of "hidden attractors"[6].

Complex systems are characterized by "sensitive dependence on initial conditions", possess "emergent properties," and interact with their environment. Many phenomena are emergent, and exhibit properties that cannot be predicted or understood by examining the system's components. Since our world is bounded by uncertainty, empirical measurements have only a finite degree of precision. Initial conditions can never be precisely specified and reality inevitably contains many unknown factors that we cannot hope to take into account. It follows that any 'laws' for complex systems, no matter how complicated remain only approximations. Complex systems are open, and change unpredictably over time. Since our brains are finite all comprehensible human models must be closed. This implies that only selected aspects of a complex system can be modeled, so our analysis of any complex system is necessarily incomplete.[7]

[5] This insight puts "paid" to the entire project of long-run equilibrium growth models.
[6] In statistical mechanics this is called "coarse graining". Conventional linear statistical measures such as correlation functions are inadequate to describe chaos. A chaotic process can appear to be completely uncorrelated, and yet in fact be completely deterministic. Linear properties like autocorrelation or covariance cannot provide us with the proper information to characterize chaotic behavior accurately. Statistical descriptions based on nonlinear statistical averages, such as entropy, and Lyapunov exponents, must be used. Gleick, 1988.
[7] Dupré, 1993.
8 Our empirical measurements reduce continuous time observations to a stream of discrete symbols. Changing the level of coarse graining may be regarded as analogous to changing the resolution of our instruments. Pagels, 1988.

A complex system cannot be understood without considering its history. Two objectively identical systems, when placed in identical conditions, can respond in vastly different ways if they have different histories. The history of a system is important, not merely for understanding its behavior. History co-determines the very structure of a complex system. The evolutionary history of a system is not present in a way that can be “deconstructed”. Although the history of the system is a determinant for its behavior, the history itself is continuously transformed through self-organizing processes. Only traces of history remain distributed through the system. These traces do not correspond to facts, ideas, or symbols that can be “recalled from a filling cabinet”. They are rather patterns of information, “smeared“ over many units, stored in a distributed fashion and continually altered by experience.

Complexity theory may be formally defined as the search for algorithms used in nature that display common features across many levels of organizations. Commonalties assist in pruning all the algorithms that can be conceived down to the ones that are present.[8] At their best models of complex systems can lead to understanding of the existence of a deeper new order, and in the process account for the emergence of phenomena such as cells, ecosystems, and markets. Life itself is perhaps the most striking emergent property of complex systems. In constructing themselves from molecule, to cell, to organism, to ecosystem, living systems display deep laws of complexity and emergence most of which lie beyond our grasp. All living organisms are self-assembling and adaptive, the most complex systems known. In consequence most complexity theoreticians have focused their attention on biology, in particular the human brain.

The modern science of complexity is stretching the cognitive capacity of humans to the breaking point. To understand how fertilized cells grow into complex organisms or how the human brain generates language or creates consciousness, may be as far beyond our mental capacities as our ability to track a water molecule as it falls over Niagara Falls. Science has in the past derived its power from the fact that its assertions can be checked against the real world, unlike the assertions of literature, religion, and art. This is no

[8] Prigogine, quoted in Horgan, 1996; 220.

longer the case. The door is now open to "ironic" science. Nonlinear systems have no closed-form solution, and human behavior cannot be fully defined by any mathematical model. There are no simple basic equations for life. Much of life appears to be shaped less by deterministic laws than by contingent circumstances, or 'serendipity'. Science's faith in great unifying ideas is dwindling, and society is learning how to accept a multiplicity of styles and views. The post-modern age is dawning: *"Humanity is at last arriving at the end of certitude."*[9]

Reductionist approachs are inherently flawed for the analysis of complex systems. The behavior of a complex system cannot be deduced from even the most exhaustive formulation of its micro foundations, since complex phenomena are much more than the simple sum of their parts. A complex system cannot be "reduced" to a simpler one, unless it was not really complex to begin with. The "true nature" of complex systems cannot be revealed in terms of a smaller number of logical principles. Realistic models of complex systems must "conserve" their complexity and must be as complex as the system they model.[10]

The study of complex systems has uncovered a fundamental flaw in the highly-successful time-tested analytical method of reductionism. A complex system is constituted not by the sum of its components but by the changing relationships among them. By "cutting up" a complex system, reductionism destroys what it seeks to understand.[11] In classical reductionism the behavior of holistic entities is explained by reference to the nature of their constituents. The entities are viewed as collections of lower level objects, and their interactions.

Complex systems are also the collection of their elements. But their behavior cannot be understood by reductionist examination of their components. Analysis of complex systems must avoid the temptation of looking for a "master key". Due to the mechanisms by which complex systems structure themselves any single principle can provide only a partial and

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[9]Cilliers, 1998

[11] Cilliers,1998.

inadequate insight. The analyst must be sensitive to self-organizing interactions and remain open to the play of patterns that perpetually transform both the system, and the environment in which it operates.

We appear to have arrived simply at a series of truisms: Complexity is complex. A complex system cannot be reduced to a simple one if it wasn't simple (merely complicated) to begin with. Complex problems can only be solved with complex resources. Nevertheless these truisms offer a powerful destructive critique of reductionism. A complex system cannot be reduced to a collection of its basic constituents, not because the system is not constituted by them but because the critical relational information gets lost in the process. Strict quantification of the output is ordinarily infeasible for complex systems. Nonlinearity and incompressibility are central.

2. SOME CHARACTERISTICS OF COMPLEX SYSTEMS: EMERGENT PROPERTIES, SELF-ORGANIZED CRITICALITY, AND SANDPILES

Complexity results from the changing interactions between the components of a system and is manifested at the level of the system itself. Due to their complex patterns of interaction, complex characteristics "emerge" through interaction within the system. [12] Complex systems exhibit novel features such as "emergent properties," and "self-organized criticality," and are particularly associated with although not confined to living organisms.[13] Of particular interest for complexity is the human brain and all its products; consciousness, self reflection, languages, cultures, politics, arts, and … economics.

Emergent properties are possessed by the complex whole not by its parts. Take the case of a glass of water. There is nothing extremely complicated about a water molecule. Yet put a few zillion of these molecules together, and you have a thing that shimmers, sloshes and gurgles. Collectively the molecules have acquired a property of 'viscosity' which none of them possess on their own. Unless you know precisely where and how to look for it, there

[12] Dupré, 1993.
[13] Wilson, 1988.

is nothing in the fundamental equations of physics that even hints at such a property. Viscosity is another example of an “emergent property”. A critical current issue in molecular biology is which emergent properties can be explained in terms of their constituent parts, and which cannot.[14]

Water is as simple a molecule as one is likely to find. If it can withstand reductive analysis one need not worry about proteins and molecules of DNA. As is well known water molecules undergo a “phase transition,” whenever you cool them down or heat them up sufficiently. Quantum theory can provide a complete explanation of the structure of water in its gaseous phase but in neither of its condensed phases.[15] As a result none of the properties of water vapor are emergent. But the properties of liquid water and ice are irreducibly emergent. Deciding which properties are emergent, and which are not is far from easy.[16] At each level of complexity new properties appear, and for each stage, new laws, new concepts and new theories are necessary.

One astonishing and much less well-known emergent property of water is “critical opalescence”:

“Critical opalescence is a strikingly beautiful effect, that is seen when water is heated to a temperature of 374 degrees Celsius under high pressure. 374 degrees is the critical temperature of water. It is the temperature at which water turns continuously into steam without boiling. At the critical temperature and pressure water and steam are indistinguishable. They are a single fluid, unable to make up its mind whether to be a gas or a liquid. In that critical state the fluid is continually fluctuating between gas and liquid, and the fluctuations are seen visually as a multicolored sparkling. The sparkling is called opalescence, because it is also seen in opal jewels which have a similar multicolored radiance”. [17]

[14] Van Regenmortel and Hull, 2003

[15] R. Williams, in Van Regenmortel and Hull, 2003.

[16] “Modeling aggregation requires us to transcend the level of individual cells. In dealing with systems with large numbers of components, we must make recourse to “holistic concepts”, and refer to the macro behavior of the system as a whole. These system properties need not ultimately be definable in terms of the states of the individual components. Yet this fact does not make them fictions. They are causally efficacious (hence real), and have definite causal relationships with other system variables, and even to the states of the individuals.” Garfinkel, 1987; 202-203.

[17] Dyson, 2003, 42.

Self-organization is another “emergent property” of complex systems, which enables them to adapt to cope with their environment. Self-organization describes the emergence of macroscopic behavior through the activity of microscopic units responding to local information. A self-organizing system is suspended between active and passive modes. It reacts to the state of the environment, and simultaneously transforms itself in response affecting in turn its environment.

For complex systems the distinctions between active and passive, causal and caused themselves come under pressure. Self-organization is a self-transforming process as the system acts upon itself. A meta-level description may be constructed, but can yield only “snapshots” of the system as it exists at given moments. The temporal complexities produced by the reflexive nature of self-organizing systems cannot be represented by any meta-description.[18]

The classical definition of stability holds that small causes produce small effects. Since the relationships in complex systems are nonlinear, this definition no longer holds. The notion of the “structure” of a dynamic system pertains to the mechanisms developed to receive, encode, transform, and store information on one hand and to react to such information by some form of output on the other. “Structure” evolves through a process of self-organization, as a result of a complex interaction between the history of the system, the environment, and the present state of the system. Classical considerations would term complex systems unstable. But for living systems static “equilibrium” implies death.

Poincaré suggested a probabilistic definition of instability, and defined unstable events as events that have no observable cause: “chance” events as opposed to “deterministic” ones. But complex systems reveal that unpredictable behavior is not the result of “chance”. It is the result of (“caused by”) the interaction of complex system factors. Although complexity is not “randomness”, it is also not describable in first-order logical terms:

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[18] Cilliers, 1998.

"I find no alternative but to accept multiple, formally incompatible descriptions as a satisfactory explanation of many types of biological events ... a theory based on chance events, including those of quantum theory, ...serves only as an escape from classical determinism: it is not a theory of self-organization".[19]

To fully comprehend complex phenomena is very likely to be forever beyond our mental reach. Some scientists believe that for complex phenomena:

" Insight seldom arises from complicated messy modeling, but more often from gross simplifications".[20]

Bak developed the simple metaphor of the "sand pile" to illustrate how complex phenomena self-organize into "critical states". Minor disturbances, like a few additional grains of sand, can lead to avalanches of all sizes even catastrophes, due solely to the dynamical interactions among individual elements of the system. A sand pile self-organizes into a "critical state". Avalanches can be understood, but never predicted only from holistic descriptions of the properties of the entire pile. They cannot be modeled by a reductionist description of the properties of individual grains of sand.

"The metaphor of the sand pile helps us understand why it is impossible to predict the occurrence of complex phenomena such as earthquakes and business cycles. Like sand piles such events are contingent on minor local details of the historical configuration of the entire system. A reductionist approach cannot uncover the emergent properties possessed by a sand pile. The system remains posed at the critical state, as grains of sand interact and cause others to topple. We understand much about avalanches. They follow the Gutenberg-Richter power law, have fractal slopes emerge from the slides, and the slopes differ with different materials. But as Richter (the developer of the Richter scale) insisted: "Only fools, charlatans, and liars will predict earthquakes"[21]

The laws of physics are simple and can be expressed by mathematical equations. Sand piles are complex and complexity is a "Chinese Box" phenomenon: in each box there is a new surprise. The underlying mystery of chaos is how does such incredible complexity emerge out of simple invariable relationships? What are the underlying properties of biological and social events that render them sensitive to minor accidental events? Solar

[19] Patte, 1987: 329-30.
[20] Bak, 1996; 132.
[21] Bak, 1996. The identical statement could be made with equal truth about stock prices.

flares, sand piles, earth temperatures, earthquakes, the water levels of the Nile, the English language, business cycles, stock prices, foreign exchange rates, speculative prices and an astonishing variety of other phenomena follow deeper types of order, termed "power law" distributions. These distributions may be chaotic, fractal, and characterized by scale-invariance. They may have no "characteristic" size, and the frequency of events is inversely proportional to their magnitude.[22] Mandelbrot found that stock prices follow a "Levy Distribution", characterized by "fat tail" power law distributions for large events.[23]

A wide variety of phenomena follow different power law distributions. Economists traditionally have discarded large fluctuations as "outliers" and considered them "atypical". But economies are complex systems and each agent has only limited choices, "bounded rationality", and attempts to do her best to increase her utility, based on her expectations of the future behavior of others. Each agent's decisions affect other agents who in turn adjust their expectations and behavior to increase their expected welfare. Each agent's expectations of the future are influenced by the behavior and the expectations of other agents. This yields a whole new level of complexity which renders prediction of future economic behavior impossible.

For nonliving complex phenomena, the relations between the planets, or the geological history of the earth, self-organization takes place over eons and encompasses unimaginably lengthy transient periods. For complex events the expression "we cannot understand the present without understanding its past" takes on deeper meanings. There are many more small events than large events. But for most complex phenomena system changes are associated primarily with large, infrequent and catastrophic events.

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[22] In a few cases this inverse proportionality appears in such an astonishing manner that when expressed in logs their ranking is linearly inversely related to their frequency! Compare the probability frequency that a word is used in the English language with its relative use ranking. "The" is the most commonly used word in English, and the probability of its use is on average ten percent (0.1). The tenth most commonly used word is "I", and the frequency with which it is used is on average one percent (0.01). The one hundredth most frequently used word is "say" and its frequency of use is on average one tenth of one percent (0.001). The one thousandth most frequently used word is "quality" and it is used on average once every ten thousand words (0.0001)! This astonishingly intriguing relationship is known as Zipf's law. Zipf, 1949.

[23] Mandelbrot, 1978.

[24] "*Cockroaches are extremely likely to outlast humans*". Per Bak, 1996.

Due to the inherent imprecision of language verbal descriptions view events that occur with some degree of regularity as “periodic”. But in all power-law phenomena strict periodicity is nonexistent. Complex events are clustered in time. The longer you have waited at a given location for a certain phenomena, e.g. a bus, the longer you can expect to wait. The longer a species has been in existence, the longer it can be expected to be around in the future.[24]

3. COMPLEX SYSTEMS

As stated complexity is the result of a rich interaction of simple elements, which respond to the limited information with which each of them is presented. Complexity emerges as a result of the pattern of interactions between the elements. Complex systems have the following general characteristics:[25]

1. A complex system consists of an indefinitely large number of individual elements, conventional means of description (e.g. a closed system of equations) cease to assist a full understanding of the system.

2. To constitute a complex system, individual elements must interact dynamically.

3. The interaction must be fairly rich, so that any element in the system influences and is influenced by many other ones.[26]

4. Interactions are local and nonlinear, small causes have large effects and vice versa. (Non-linearity is a precondition for complexity.)

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[25] These characteristics have been derived from Nicolis and Prigogine (1989), Serra and Zanarini (1990), Jen (1990), and Cilliers, 1998

[26] The behavior of the system is not determined by the number of interactions associated with any specific element. If there are enough elements in the system, some of which are redundant, a set of more sparsely connected elements can perform the same function as a more richly connected element.

5. Interactions have a short range, since information is received primarily from immediate neighbors. This does not preclude wide-ranging influences, since the influence may be mediated (enhanced or suppressed) along the way.

6. There are loops in the interactions, and the effects of any action feed back on itself positively (enhancing) and negatively (inhibiting). Both kinds are necessary. (The technical term is 'recurrency'.)

7. A complex system is open, and interacts with its environment. It is difficult to define the border of a complex system, since the position of the observer influences the scope of the system.

8. A complex system operates under conditions far from equilibrium. There must be a continual flow of energy to maintain the system and ensure its survival.

9. A complex system has a history. It evolves through time, and its past is co-responsible for its present

10. Each element in the system is ignorant of the behavior of the system as a whole, and responds solely to the local information available to it.

Economic systems are also complex and self-organizing. Their structure continuously changes in response to a large number of factors, changes in technology, in the environment, in aggregate demand. Consider how the above characteristics of a complex system are manifest in an economy:

1. There are a large number of individual agents: each agent belongs to more than a single cluster of agents: e.g. family, business, occupation, residential area, political party, recreational activity, etc. and occupies a different rank and status in the hierarchy of each cluster.

2. Economic agents do not know what other agents are thinking or doing. Their current decisions (investment expenditures in particular) are based on their expectations of the future behavior of other agents. Agents interact to earn and spend income, buying and selling, borrowing and lending, and taking and giving goods and services. Means of payment are created and extinguished in the process. These relationships are dynamic and continually changing.

3. Each agent interacts in many different markets with many other agents, some are more active and important than others. Agents differ widely in the amount of purchasing power they control.

4. Economic systems are self-organizing, their structure changes continuously in response to a large number of factors, e.g. changes in technology, in the environment, in aggregate demand. Agents interactions are nonlinear, so small changes can have large effects.

5. Agents interact with other agents in their economic (not spatial) vicinity in highly specialized markets.

6. Agent behavior depends on expectations of the future behavior and so the expectations of other agents. As the future becomes present, past expectations are confirmed or disappointed and expectations are continuously reformed. Expected (*ex ante)* returns must be positive if investment expenditures are to be undertaken, but realized (*ex post*) returns on investment are positive or negative.

7. Agent expectations are both contagious and self-fulfilling. Expectations of higher future activity lead to current increases in deficit spending which generate increases in the money supply, money income, nominal aggregate demand, and in higher ex post returns on investment projects. Expectations of future events may be formed extrapolatively, or regressively, by different agents, and by the same agent at different times.

8. Economies are open and are influenced by continual changes in tastes, output, income, production, technology, factor supply, political developments and international relationships.

9. Economies never stand still, and are driven by continual changes in aggregate demand and aggregate supply. Expectations of future events change continuously over time.[27]

10. Agents' expectations of the unknowable future state of the economy are based on the expectations of other's, and since they are based on fragile conventions are extremely unstable.

Economies are obviously relational structures, and the above characteristics are widely recognized and could easily be extended.[28] Changes in an indefinite number of variables, prices, quantities, legislation, institutions, interest rates, exchange rates, tax rates, public expenditures, property rights, laws, etc. have significant effects. Some exogenous interventions by governments and their short-run effects may be predictable in a cardinal or ordinal sense.

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[27] Economies are greatly influenced by their histories. In the very short run their behavior is largely predetermined, as today's output, wages, costs, prices, capital stocks and technology are determined by yesterday's history. For most prices and quantities, expectations of future values ordinarily change slowly. But expectations of prices of homogeneous assets, traded in well-organized markets with low transactions costs like stocks or foreign exchange or tulips, may vary sharply and discontinuously, as associated with rapid changes in the collective consensus about the economy's future prospects.

[28] In this light it is certainly strange that, when it comes to the formal description of private enterprise economies, there is such strong emphasis among today's mainstream economists on the desirability of building macro-models on rigorously well-defined micro-foundations, to yield closed-form equilibrium models. One of the reasons for this predisposition is that economics like other behavioral sciences has inherited its methodology from a classical analytical tradition, which is at its core deeply deterministic.

29 This section has been influenced by John Horgan's *The End of Science*, New York, Addison-Wesley, 1996.

CHAPTER 5. THE IMPLICATIONS OF COMPLEX SYSTEMS FOR ECONOMIC ANALYSIS

"Monetary theory especially has to be developed in time, (with) future becoming present, and present becoming past, as time goes on … One must assume that the people in one's model do not know what is going to happen, and know they do not know just what is going to happen. As in history." John Hicks, 1977.

"In a world where all economic units are continually revising and rearranging their plans over time in their attempts to anticipate future events, equilibrium can never occur… Time and equilibrium are incompatible". George Shackle, 1972.

"The future waits not for its contents to be discovered, but for that content to be originated." George Shackle, 1980.

"I should, I think, be prepared to argue that in a world ruled by uncertainty with an uncertain future linked to an actual present, a final position of equilibrium such as one deals with in static economics, does not properly exist." John Maynard Keynes, XXIX, 222.

1. TENSIONS IN NEOCLASSICAL ECONOMICS

Economists are confounded by the turbulence of economic events and are unable to answer most important questions posed to them. They are notoriously unable to forecast turning points in economic time series, to discern when a high price-earnings level of stock prices denotes a bubble; when economies will spin into catastrophic slumps; how to attain a higher rate of output growth; what forces shape changes in the distribution of income, or even if the average rate of increase in money wages next year will be higher or lower than current rates. Not only are economists unable to predict most future events, they have equal difficulty retrodicting past events. For example the causes of the Great Depression of the 1930's remain highly controversial.

The general high esteem that economists enjoy does not arise from a record of successful predictions. It stems solely from the fact that business and government desperately want to know what the future will bring, and have nowhere respectable else to turn. Many who have wrestled at length with methodology have concluded that economics has serious problems as a science. [29]

Economists have attempted to resolve the aggregation problem from micro- to macro-phenomena by attempting to build increasingly "rigorous" micro-foundations for macroeconomic models. This has involved introducing increasingly restrictive assumptions: e.g. all economic distributions are ergodic, all agent behavior is based upon rational utility-maximization and all markets are perfectly competitive. As one well-known economist has put it, the result has been "rigor without relevance".[30]

Economics is currently in methodological disarray. Its tests of 'significance' are widely misused and most of its theoretical models and existence proofs are irrelevant to real world problems.[31] Once it is recognized that economies are complex systems, it is immediately evident why economic agents cannot perform "rational utility-maximizing calculations". To maximize anything, an agent must have complete information about all possible alternatives. In complex systems agents are bounded by ignorance. Information is inherently incomplete and agents have neither sufficient information nor the processing ability to maximize 'optimal' behavior.[32] "Satisficing" behavior, making the most satisfactory choice out of those reasonably available, is the best we humans can do.

While reasonable as a broad guide to economic behavior, self-interest does not dominate in all situations. Real world agents are buffeted by surges of competing emotions. The behavior of the **same** agent may at different times be described as careful or impetuous, considerate or insensitive, generous or selfish, loyal or spiteful, noble or sadistic, loving or cruel. For poorly-understood reasons altruism and patriotism are at times powerful determinants.[33] People also seldom act completely independently. Social influence varies widely by age,

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[29] A list of "Devastating Internal Criticisms of Modern Economics That Have Not Been Answered,' may be found in McCloskey, 2003, 244. See also Dow, 2001, Lawson, 1997, Eichner 1986.

[30] What Heilbroner and Milberg have termed "*Rigor Mortis*" (1995).

[31] See McCloskey, 1996, 2003.

[32] They are unable to formulate the "optimum" move in a game of chess. Life is more complex than a chess game.

[33] These phenomena may have a genetic basis and an epigenetic history. Wilson 1998.

experience and type of behavior. When faced with the complete ignorance of possible future outcomes, economic agents follow simple rules of thumb to reduce the complex task of judging among a huge set of alternative possibilities. The most common response to near complete ignorance is simply to imitate the behavior of others, as we do when evaluating a stock, or choosing a restaurant in a foreign country. Such heuristics frequently work but can also lead to systematic errors. Economists are now finally attempting to consider more seriously the psychological foundations of human behavior.[34]

A large number of distinguished economists have reflected critically on economists' methodological application of methods to conditions for which they are unsuited: Marx, Veblen, Hayek, Keynes, Hicks, Schackle, Boulding, Kaldor, Vickrey, Tobin, Eisner, Solow, McCloskey, Davidson, Dow, and Lawson. Most have been exceedingly critical of unquestioned reliance on the neoclassical assumptions of perfect information and utility-maximization.

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5. CONCLUSIONS: PROCESS ANALYSIS

Complex systems have no closed-form solution. They never stand still and so never approach any GE configuration. Successfully modeling the future behavior of an entire economy is forever beyond our grasp.[35] Fundamental uncertainty cannot be eliminated by the accumulation of additional knowledge. The unique features of complex events are their non-repeatable quality. Change is continuous and inherent, and is not attributable to "external shocks". The current values of variables are related to the current and previous values of their own and other variables in continuously changing nonlinear ways. Economists must give up "destination oriented" comparative static equilibrium analysis, with its attempts to formulate

[34]See Thaler, 2001. There is now a whole the new area of 'behavioral' finance, e.g. Shefrin, 2002. Becker has argued persuasively that economists should incorporate the motivations of other social sciences.1990.

35 Like meteorologists economists must give up attempting to make long run predictions. They must publicly acknowledge that all long run forecasting models are worthless and have no predictive ability. A successful model must be as complex as the system to be modeled. If such a model could ever be constructed it is unlikely it would be understandable. Stock markets and exchange rates clearly have important macroeconomic effects. Consider economists' complete inability to predict the ordinal movement of stock prices and exchange rates. In the short run levels of most variables are well-explained statistically by the lagged value of the dependent variable. The process of vector regressions (VAR) provides great promise for process analysis. See Stock and Watson, 2001. The most that can be attempted from long run analysis of complex systems is to propose alternative possible "scenarios".

deterministic future outcomes and move to “history creating” process analysis, the examination of the process how systems change and evolve over calendar time.[36] The object of process analysis is to explain first differences (the proportional change) of selected variables. As is well known first differences are much more difficult to explain successfully than levels.

As was shown in the previous chapter all economic variables have unit roots, so the coefficient of the lagged dependent variable in autoregressive equations is not significantly different from unity. The best estimate of next period’s value is simply the current period’s value.[37] Process analysis focuses on explaining and when possible forecasting the sign (ordinal value) of the first difference of the dependent variables over a short run period. When the analyst is very lucky, she may be able to successfully forecast the cardinal change in variables, within a wide error band, which cannot be reduced to a statistical probability since all economic distributions are time-dependent.

Analysis can never hope to discover the future "destination" of economic systems, since no future "equilibrium" position exists. In complex systems all variables change continuously over time. It can never be known with certainty when even the most stable historical relationship will cease to hold in the future. In economics there are no objective probability distributions on which expectations can be based. All distributions possess a unique component applicable to the space-time position in which they occur. Economic agents are unable to discover the future by studying the past. They can only create their own future, by their present behaviour. The long run analysis of complex systems is a purely speculative enterprise. As the time period extends further into the future prediction errors increase exponentially.

Economic phenomena are complex beyond human comprehension. Any theory that takes complexity seriously must be a theory of processes through historical time. Economies must be modeled as complex systems and economists must focus on the temporal process by which

[36] When a time series is sufficiently long, the estimated coefficient on the lagged dependent variable can ordinarily be shown not to be statistically different from unity.
[37] Farmer, 1994.

change occurs. Variables must be explained in terms of first differences (changes from their current level), with no attempt to close the process with any "equilibrium" outcome. It is impossible to forecast with certainty even the ordinal change in economic variables, even over the shortest of short runs. Agents' subjective probability distributions are continually changing. This can lead to 'bubble' models where *"prices change simply because they are expected to."*[38]

Accurately modeling the future behavior of an economy is forever beyond our reach. Economists must content themselves with building dynamic models of complex subsystems using a select number of variables, not an entire economy. Successful short run ordinal predictions (greater or less) may be successful with such models, but in most cases even accurate ordinal forecasts are impossible. Changes in stock prices have important macroeconomic effects and no one knows today whether stock prices will rise or fall tomorrow. Forecasts of cardinal quantities must include a wide range of indeterminacy, which increases exponentially as the time horizon lengthens.

Process analysis focuses on explaining and forecasting the sign and ordinal or cardinal value of the first difference of dependent variables over the short run. The current level of all variables is taken as given and may be regarded as predetermined. For most economic variables with sufficiently long time series the coefficient on the dependent variable is not significantly different from unity. When variables have a unit root the value of the coefficient on the lagged dependent variable is unity. The goal of process analysis is to explain and predict proportional changes (first differences) in the endogenous variables. As empiricists know first differences of variables are much more difficult to model and predict successfully than are levels.

The above complex systems implications are thoroughly destructive of the mainstream vision of how economies function. When absorbed they will reshape the "trained intuition" of modern economists.

Economies are complex systems where strict event regularities do not occur. Economic outcomes reflect the consequences of volitional and non-volitional behavior of imperfectly-informed agents who must each form expectations of other agents' behavior. Seen in this light, it is not surprising that economic forecasters do not make accurate forecasts, and deductive theories are unable to illuminate economic behavior. Since economic events can never be precisely forecast, positivism the ability to successfully forecast outcomes is not an appropriate criterion for discriminating truth value between alternative economic hypotheses. But increased illumination and understanding of the dynamics of complex events is both possible, and sufficient for successful stabilization policy.

Complex systems impose a different conception of "explanation" from deductivist-constant-conjunction mainstream methodology. The goal of explanation for complex systems is not the scientific deduction of future events. It is the illumination of tendencies inherent in complex phenomena. Social science should be re-demarcated as *"dependency upon intentional human agency"*.[39] Accepting that humans are continually faced by real choices, and frequently make 'wrong' decisions, is the first step in the recognition that the economic sphere is complex, inherently sensitive to initial conditions and pervaded by emergence and novelty. There are no invariant 'laws' in economics. Economists can only hope to discover 'order' in the chaos.

One telling point against mainstream methodology is that despite the enormous resources that have been allocated, no stable event regularities have been uncovered. Econometricians continually puzzle over why carefully estimated relationships 'break down', frequently as soon as new observations become available. This not surprisingly has led to increased skepticism in the profession concerning the validity of empirical results:

"I have a sense that most economists feel that conclusions from data sets are fragile. Somebody will add another variable, or they will control for some aspect of the time series phenomenon in some other way, which will yield a substantially different conclusion. One of the reasons we don't trust empirical work seriously is that there have been so many cases of fragile conclusions. Somebody claims to have found something and six months later a new

[39] Lawson, 1997.

equation is estimated, and the same finding seems to be reversed. It creates the feeling among economists that conclusions from data are very fragile".[40]

This unhappy situation is rendered intelligible once economies are recognized as complex systems reflecting intentional human agency under fundamental uncertainty. The most order we can expect to find are semi-regularities, what Kaldor termed "stylized facts". Constant event-regularities [linear relationships] never occur. How is it possible to model rigorously complex systems in the absence of both strict experimental control and strict event-regularities to account for? Can we make a "science" out of imperfectly smart agents, endowed with a range of discretionary free will, exploring their way into effectively infinite spaces of unknowable future outcomes, where phenomena do not repeat with law-like regularity, and only partial event-regularities occur? In such systems outcomes can never be accurately predicted. If you can never predict the future, can you have a science?

Scientists have recently discovered that the goal of science can no longer be accurate prediction, but only increased comprehension and greater explanatory power.[41] Consider the science of meteorology. The meteorological universe never settles down and never precisely repeats itself. Within wide and variable bounds the weather is completely unpredictable. Meteorologists are unable to predict local weather events accurately more than a very short period in advance. Yet they are able to understand *ex post* most meteorological phenomena: the formation of weather fronts, jet streams, high and low pressure systems, and explain how they interact dynamically to produce weather on a local and regional scale. What they cannot do is to predict. Unlike economists meteorologists understand why they cannot predict future weather conditions. They have explicitly recognized that the weather must be modeled is a complex and fluid system, extremely sensitive to initial conditions, whose future behavior can never be known in advance. Meteorologists now model weather events as nonlinear systems that can be simulated but never solved.

Precise prediction is impossible for all complex systems. But a "science" of meteorology exists independent of meteorologists' ability to predict future weather outcomes. Storms are

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[40] Hendry et al. 1990; 187.
[41] Hacking, 1990

like earthquakes and meteorologists can never accurately forecast the occurrence of most meteorological phenomena. But the goal of all complex sciences is the greater understanding of particular complex phenomena which for many purposes is sufficient. Chaos theory has revealed that extremely complicated phenomena can be the outcome of extremely simple nonlinear systems. All complex systems must be modeled as nonlinear systems, implying sensitive dependence on initial conditions, self-organization, critical states and all the other characteristics of complex systems that render accurate prediction impossible.

It is difficult (and may even be impossible) to rank complex systems in a cardinal manner. Nevertheless the social universe may be loosely termed more complex than the physical universe, since its agents are not homogeneous molecules, but sentient and heterogeneous agents endowed with intelligence, memory, self-consciousness, and most importantly, within a circumscribed area have free will, and with it the freedom to fail or to succeed. Each agent bases its behavior on its attempts to anticipate the behavior of others, in a world where successful predictive ability is nonexistent. In consequence the group behavior of social systems is more time-dependent than physical systems, and cannot be summarized by *ex post* distributions.

Process analysis takes the existing position of variables as historically predetermined, and attempts to explain how they change over time. To analyze complex systems all variables and their inter-relationships must be dated. Frequently only ordinal changes (positive or negative, greater or less) can be explained or forecast due to the sensitivity of complex systems to initial conditions. Complex systems differ in the chronological period over which changes occur and may be loosely characterized as fast- or slow-changing systems. With fast-changing systems, jumps occur, and wide-bounds must be imposed on predictions of cardinal changes even in the shortest of short runs.

The goal of the analysis of complex systems is to build dynamic models to explain the changes (first differences) in selected variables over the short run. The detailed modeling of macro-system behavior will be forever beyond our capabilities. Economists will never simulate the behavior of economies. Process analysis abstains from any attempt to impose future outcomes, destinations, or "centers of gravity"[42]. Errors in forecasting increase exponentially as the time period is extended into the future. Formal modeling will never be able to predict long run system behavior. For long run analysis all that can be attempted is the exploration of alternative 'scenarios'. One must beware of any linear explanations of complex events.[43] In contrast to mainstream analysis which attempts to model a final "equilibrium" position of the system in logical time, real time process analysis models how economic variables change over time with no attempt to impose 'final' outcomes.

Process analysis examines the manner by which economic variables change from their current value, which is taken as historically determined, to their value in the subsequent period. All variables are dated and the concept of "equilibrium" is abandoned. For most variables only ordinal explanations and forecasts can be given. Since the distributions continually change over time it is not possible to assign quantitative probabilities to summarize the uncertainty, Prices of many variables e.g. equities and foreign exchange rates under flexible exchange rate regimes, change continuously whenever their markets are open. For some financial variables markets are open continuously in some part of the world. In this case it is impossible to precisely forecast even short run ordinal changes. To the extent all variables and markets are interrelated, this provides a persuasive explanation why for many variables even short-run cardinal prediction is beyond our grasp.

Meteorologists now understand why they are unable to forecast weather events more than a few hours in advance. Complex systems exhibit sensitive dependence on initial conditions, sometimes called "the butterfly effect". Even though real world economies are unimaginably complex, the first steps in computer simulation of simplified nonlinear models of real world markets and institutions exhibiting hysteresis and path-dependent dynamics of cumulative causation and are now being explored. Once the profession fully recognizes that economies

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[42] Process analysis models the process of complex systems over calendar time without imposing any future "equilibrium" outcome. It attempts to explain how economic variables change from their current value to their value in the subsequent period.

[43] This explains why there is so much controversy about the world's future temperature, the "Greenhouse effect".

are complex systems, "equilibrium" analysis in logical time will be replaced by history creating process analysis in real time.[44]

Process analysis models the process of complex systems over calendar time, without imposing any future "equilibrium" outcome. It attempts to explain how economic variables change from their current value to their value in the subsequent period. Different systems differ hugely in the speed in which their prices and quantities vary over time. For many fast-changing variables such as equities, foreign exchange, and all homogeneous financial assets traded in well-organized markets, prices change and "jump" continuously whenever the market is open, and even ordinal forecasts over very short periods will not be accurate. The prices of heterogeneous assets and commodities are slow-changing variables. In markets where prices change more slowly, accurate short run ordinal and cardinal forecasts are sometimes possible.

[44] See Arthur, 1994, Day, 1998. Rosser, 2000.

CHAPTER 14. INTEREST RATES AND THE AGGREGATE DEMAND RELATIONSHIP

"A large portion of our positive activities depend on spontaneous optimism rather than on mathematical expectation, whether moral or hedonistic or economic. Most … of our decisions to do something positive … can only be taken as a result of animal spirits: of a spontaneous urge to action rather than inaction, and not of the outcome of the weighted average of quantitative benefits multiplied by quantitative probabilities. Enterprise only pretends to itself to be mainly actuated by the statements of its own prospectus, however candid and sincere."
John Maynard Keynes, 1936; 161-2.

"*In a world that is always in equilibrium there is no difference between the future and the past, and there is no need of Keynes."* Joan Robinson, 1974; 28.

1. THE POST KEYNESIAN CASE FOR DEMAND MANAGEMENT

Keynes insisted that even perfectly competitive flexible prices and wages would not transform economies into homeostatic systems that maintain a dynamically stable equilibrium state on their own, without government intervention. Flexible wages and prices do not eliminate the effects of exogenous shifts in animal spirits as ii the case of a perfectly flexible price in a single market. Factor and product markets are independent but highly interdependent. The supply and demand for factors and products are linked by the relationship between the price of labor and capital. Coordination between prices and wages is essential for the successful performance of all market economies.

As Keynes argued the result of greater wage and price flexibility is more rapid rates of inflation and deflation, greater fluctuations in real wages, and greater counter-cyclical rather than pro-cyclical variation in real interest rates. Greater price and wage flexibility would result in greater variability in and greater uncertainty about the future behavior of prices, incomes and AD. The increased uncertainty would operate to raise risk and lower investment spending. Countercyclical variation of real interest rates would operate to increase and extend cyclical fluctuations in income and output. Keynes argued that the unintended result of stable money wage rates was more stable price levels and a corresponding unintended reduction in agents' uncertainty about the unknown future.[45]

[45] Keynes, 1936; Ch. 19

3. PROCESS ANALYSIS: THE BR-AD and the BR-ΔAD DIAGRAM

If the above case for lower interest rates is so clearly in the public interest, why do so many CB's appear to have a bias towards tight money? Since economies are complex systems to understand more clearly the role of interest rates, finance and saving in the growth process it is necessary to replace comparative static equilibrium analysis with process analysis, to examine how deficit spending is financed and how it affects aggregate demand (AD) and aggregate supply (AS) over time. The goal of process analysis is to understand how complex systems evolve over historical time and to explain and if possible predict the future change in each of the variables under consideration. In order to simplify as much as possible the explanation and prediction of future economic behavior, the change in variables will be over the shortest future time period for which data are available. For most macroeconomic variables this period is one quarter or one year.

In process analysis all variables of interest must be dated, and no attempt will be made to determine any future "equilibrium" position or state. Process analysis takes the current value of all variables as predetermined, and attempts to explain the ordinal and cardinal changes in variables over the short-run future period. Economies comprise slow-changing and fast-changing variables, and assets differ greatly in the period over which price and quantity changes occur and are measured. For all data in National Income Accounts the chronological time unit is one quarter or one year depending on data availability. For many financial variables traded on well-organized markets, the time unit is much shorter: one month, one week, one day, one hour or even one minute.

For homogeneous financial assets, like corporate equities and foreign exchange, that are traded on well-organized markets with very low transactions costs, agents will continuously speculate about the different possible future price movements. Prices will change whenever the markets are open, to reflect changing asset holder expectations. Accurate prediction of future cardinal changes then becomes impossible, even for the shortest of short-run periods. Any patterns discerned will be immediately exploited by speculators and influence current prices. Accurate prediction of future price movements is then impossible since the current values will equal to the market's expected future value minus any transactions costs. Complex systems are in continuous flux. For many fast-changing variables the change over even the shortest of future time periods cannot accurately be forecast.

Comparative static equilibrium analysis is not merely useless for complex systems it is positively misleading.[46] Economic macro-variables like GDP have no tendency to approach any future "equilibrium" level or growth rate. Changes in autonomous spending have no determinate "multiplier" effect on future income. When firms are price-setters and quantity-takers the change in AD directly determines the change in AS, apart from unintended inventory changes. The system does not approach any "equilibrium" position where planned saving is equal to planned investment. Change is continuous, and in complex systems is generated endogenously. Actual saving is always identical to actual investment, since saving is simply the accounting record of investment. But change is continuous and planned saving will never equal planned investment. Providing inventories are maintained at target levels and there is no quantity rationing, the change in ΔAS is equal to the change in ΔAD over the period.

Post Keynesian economists have embraced endogenous money and exogenous interest rates for nearly 30 years. Nevertheless the IS-LM diagram with its explicit assumption of monetary exogeneity and interest rate endogeneity remains widely accepted by most mainstream economists, and still appears in most money & banking and macroeconomic textbooks. Most central bankers, financial market participants, and financial journalists by now (2005) recognize that the supply of credit money is endogenously credit-driven, and is not controlled by the CB through the monetary base-multiplier relationship of the textbooks.

They also recognize that interest rates do not adjust to equilibrate saving and investment or the supply and demand for "loanable funds" as the textbooks maintain. Bank Rate is now widely recognized as an exogenous instrument of monetary policy, set by the CB to attain its stabilization targets and held constant between monetary policy meetings. CB's spend much effort in attempting to forecast the future direction of the economy, which are due at root to

[46] By focusing on the final state-change in all variables, equilibrium analysis ignores all events that occur during the transition process but disappear when change ceases. See Stock and Watson, 2003, Rogoff, 2003.

changes in unquantifiable agent "animal spirits." CB's change Bank Rate based on their expectations of the future change in GDP, and are explicitly forward-looking in their analysis. By an arbitrage process, Bank Rate determines the level of all other short-term market rates. Long term rates are time-arbitraged, and reflect capital markets' expectations of the future levels of Bank Rate that the CB will set in the future, plus a positive or negative term premium that reflects differences in maturity, risk and income preferences among debtors and creditors.

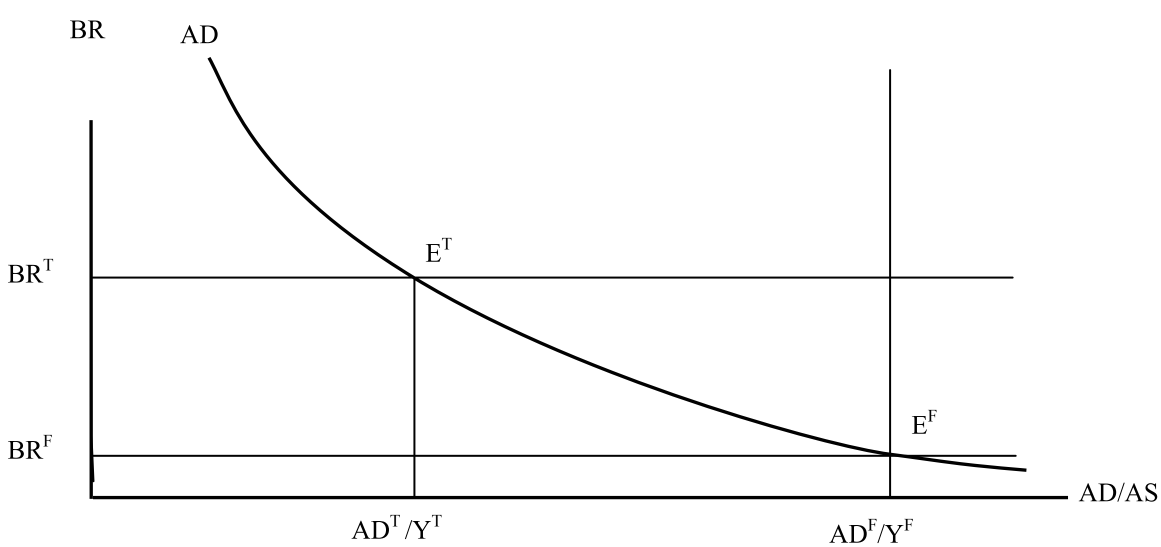
Changes in Bank Rate may be viewed as a proxy for the CB's expectations of the future change in investment and AD over the subsequent quarter or year. As a result the change in Bank Rate becomes an excellent and operational proxy for the non-measurable changes in "Animal Spirits." Agents' heterogeneous expectations of the future heterogeneous expectations of other agents in response to exogenous future changes, are intrinsically unknowable and completely non-operational. But changes in Bank Rate reflect changes in the CB's expectations of agents' current and expected future changes in expenditures and GDP. Once changes in Bank Rate are viewed as a proxy for the CB's expectations of the change in "animal spirits" it is no longer surprising that changes in investment expenditure vary positively rather than negatively with changes in Bank Rate.

The academic profession seriously lags practitioners in the teaching and appreciation of endogenous money. In IS-LM analysis the upward-sloping LM curve, defined as all positions where the demand for money is equal to the supply of money is based on the false assumption that CB's exogenously set the money supply as their policy instrument, through the high-powered base-money-multiplier process. Once the money supply is recognized as endogenously credit-driven, and Bank Rate is recognized as the CB's exogenous instrument of monetary policy, the LM curve must be drawn as a horizontal line at Bank Rate.

The IS curve, defined as all positions where planned saving is equal to planned investment, is also false, but for other reasons. Since saving is the accounting record of investment spending, actual saving is identical to actual investment at every level of income and at every interest rate. The IS curve is a nonsense relationship: planned saving is never equal to planned investment. One implied message of IS-LM analysis, *"changes in the money supply cause* *changes the level of interest rates and income,"* is a reversal of the "true" direction of causality between money and income. It provides a classic example of the "reverse causation" error which results from the confusion of identities with behavioral relationships.

In short IS-LM analysis is nontransparent, confusing and false. As a guide to understanding the interaction between money, interest rates, prices and incomes, the IS-LM diagram is a misleading fiction, and should be banished from the textbooks. The underlying truth buried in the IS-LM diagram is the downward-sloping IS curve, implying that AD is inversely related to the level of interest rates. This IS-LM insight is both correct and critically important. It is at variance with the positive empirical relationship estimated between changes in Bank Rate and changes in investment and AD. The slope of the IS curve in interest rate-output space should be explicitly analyzed and estimated. Once Bank Rate is acknowledged to be the CB's exogenous policy instrument, whose level can be set discretionarily over a wide range, it is enlightening to visualize a downward-sloping aggregate demand function (AD) in interest rate-output space.

FIGURE 14.1 THE BR-AD DIAGRAM



In FIGURE 14.1 Bank Rate set by the CB is measured on the vertical axis and AD is measured on the horizontal axis. The slope of the AD curve summarizes the interest-elasticity of aggregate demand (AD). The position of the AD curve shifts widely to the right and to the left over the cycle with changes in "animal spirits." Bank Rate as set by the CB in period t (BR^t) is associated with a particular level of aggregate demand (AD^t). As Bank Rate is reduced towards zero aggregate demand increases indefinitely and asymptotically approaches the horizontal axis.

Firms are price-setters and quantity-takers, so the AS curve is a horizontal band in inflation-output space. Changes in AD are immediately reflected in changes in AS and GDP. FIGURE 14.1 clearly reveals why output in market economies is demand-constrained: **Central banks set BR at too high a level (BR^T) to achieve a full employment level of AD.** CB's fail to set Bank Rate at a sufficiently low level (**BR^F**) to increase AD to the full capacity-full employment level of output (**Y^F**) of the economy. This simple insight is of central importance for analysis of monetary policy.

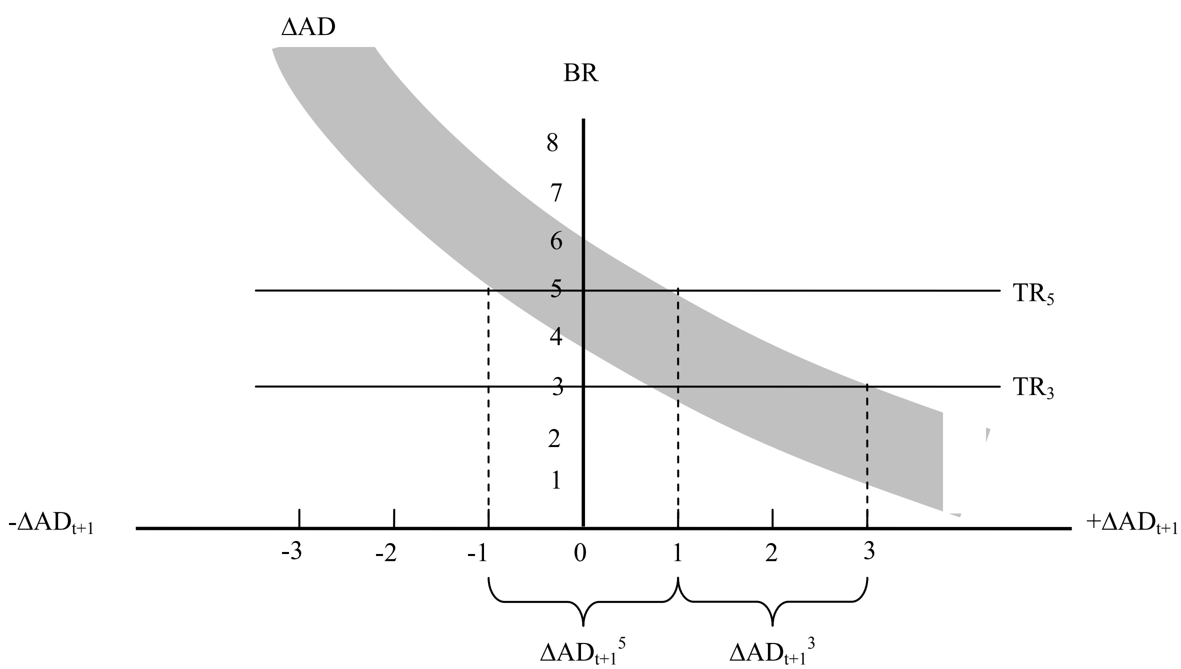
The following chapters will consider various economic-historical-political-sociological-institutional reasons why many CB's appear to have an aversion to cheap money, and consistently set interest rates at too high a level to generate full employment aggregate demand. It will be argued that so long as economies are demand-constrained, the primary goal of the monetary authorities should be to reduce Bank Rate to the lowest level consistent with zero excess demand inflation (BR^F). Cheap money is in the public interest.[47]

FIGURE 14.1 is comparative-static equilibrium analysis. It purports to solve for the "equilibrium" level of aggregate income that would occur at different rates of interest (e.g. E^t and E^F). But the use of comparative static equilibrium methodology has been explicitly rejected as false and misleading for the analysis of complex systems. FIGURE 14.1 must be reformulated in terms of process analysis, to determine the **short-run change in aggregate demand (ΔAD)** that associated with the rate of interest set by the CB rather than the hypothetical long run **"equilibrium" level of AD**.

[47] The author has spent the last decade in South Africa, where the Governor of the Reserve Bank has well absorbed the view of the IMF and the World Bank that high interest rates are an indicator of a CB's virtue and "hang tough" machismo. South Africa currently has the world's highest unemployment rate, and the world's highest real Bank Rate. Over the past two years the Rand has enjoyed the world's highest rate of appreciation to the complete despair of all export industries. The Governor has never met a high interest rate he didn't like.

The BR-ΔAD diagram of FIGURE 14.2 is the BR-AD diagram of FIGURE 14.1 as revised for process analysis. The current value of all variables is taken as predetermined. The change in AD over the subsequent period (t+1) is measured diagrammatically on the horizontal axis, to the right or to the left of the origin, which denotes a position of zero change. Positive changes in AD are measured rightward from the origin and negative changes are measured leftward from the origin. The time unit is the shortest for which GDP data are recorded, one quarter for developed countries, but for many developing economies one year. Bank Rate is measured on the vertical axis, and the change in aggregate demand from its current value (+/- ΔAD^t) is measured on the horizontal axis.

FIGURE 14.2 THE BR-ΔAD DIAGRAM



The expected change in aggregate demand (ΔAD) in the subsequent period (t+1) is represented as a downward-sloping function of Bank Rate. The AD relationship illustrates the relationship between the current level of Bank Rate and the change in AD over the next period. In complex systems all relationships are time-dependent and exhibit only "demi-regularities." The current level of Bank Rate is associated with a range of changes in AD over the next quarter or year rather than a particular value of AD. The AD relationship is drawn as a fractal band that takes up space rather than a deterministic function. The width of the AD band denotes the variability of the demi-regularities characterizing complex relationships. The ΔAD band shifts widely to the right during periods of cyclical expansion, and widely to the left during periods of cyclical recession due to changes in "animal spirits." Bank Rate is varied positively by the CB as its policy instrument, according to its expectations of the future shift in aggregate demand (ΔAD).

"Animal spirits" (agents' expectations of other agents' future expectations) vary cyclically over the cycle, and shift the AD relation widely to the right and to the left. The CB varies Bank Rate pro-cyclically over the cycle in pursuit of its stabilization goals. When the CB expects the ΔAD relation to shift rightward, it raises Bank Rate. When the CB expects the ΔAD to shift leftward, it lowers Bank Rate. Both the ordinal and the cardinal change in Bank Rate are completely at the CB's discretion. The change in Bank Rate can thus be regarded a proxy for the CB's expectation of the change in "animal spirits" in the subsequent period.

The CB's "Policy Reaction Function" describes how the CB has changed Bank Rate in the past in response to the deviation of the economy from its stabilization targets.[48] The CB's "Policy Reaction Function" is now termed the "Taylor Rule" (TR), after an important paper by John Taylor, which successfully described empirically the historical rate-setting behavior of the Federal Reserve System.[49] In FIGURE 14.2 the Taylor Rule TR is drawn as a horizontal line at Bank Rate set by the CB (BR_t). As shown when the CB sets Bank Rate at 5 percent (TR_5) the expected change in AD (ΔAD) over the subsequent quarter is zero with a fan range over the period from -1 to +1 percent. When the CB sets Bank Rate at 3 percent (TR_3) the expected change in AD (ΔAD) over the subsequent quarter is +2 percent with a fan range from +1 to +3 percent. In complex systems all relationships are time-dependent and exhibit only "demi-regularities."

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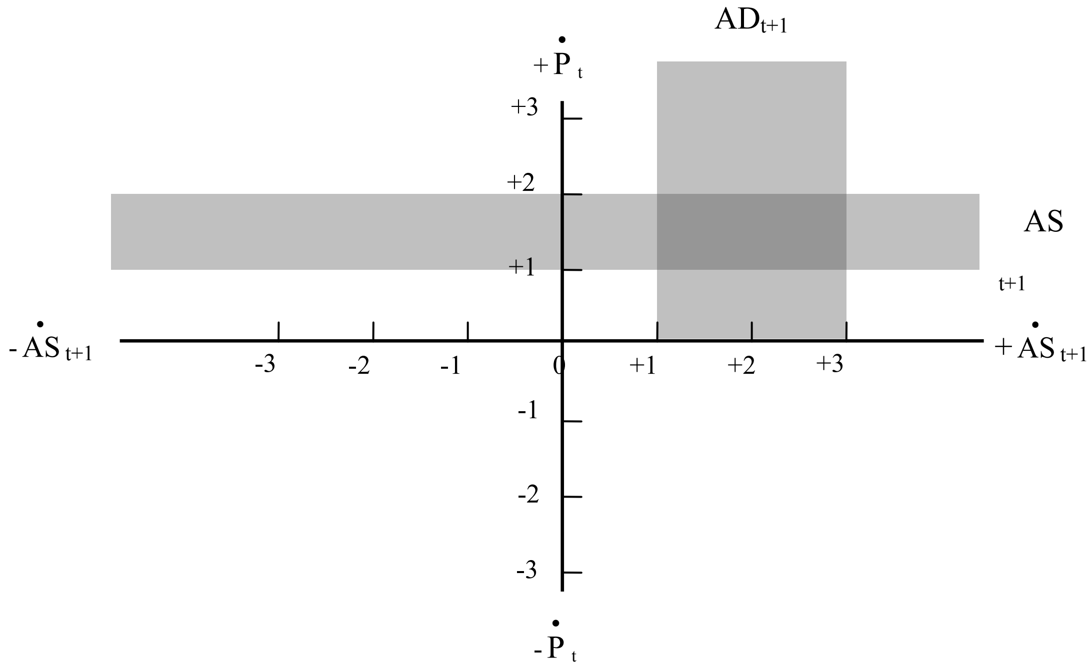
[48] Moore, 1988.
[49] Taylor, 1993.

FIGURE 14.3 THE AD-AS DIAGRAM



In FIGURE 14.3 the aggregate supply relation summarizing the price-setting and quantity-taking behavior of business firms is drawn as a horizontal band (ΔAS_{t+1}). The "core" inflation rate in the current quarter is predetermined by the excess of the average rate of increase in money wages above the average rate of growth of labor productivity in the previous quarter.[50] Increases in money wages in excess of the rate of growth of average labor productivity raise unit costs unless they are accompanied by a squeezing of business markups. Ordinarily firms are able to maintain their markups and pass on increases in unit costs in higher prices. The rate of change in unit costs determines the "core" inflation rate. Changes in "animal spirits" in the current quarter do not directly affect the current "core" inflation rate.

The position of the horizontal ΔAS band depicts the "core" inflation rate, between 1 and 2 percent in period (t+1), predetermined by the change in unit costs in period (t). The inflation rate is cost-determined, and is largely independent of current changes in aggregate demand (ΔAD). The position and interest-elasticity of the ΔAD band, and the Bank Rate set by the CB

[50] Blinder, 1998.

in FIGURE 14.2, determine the change in AD shown in FIGURE 14.3. The expected future change in aggregate demand ($\Delta AD_{t+1)}$) of 2 percent with a fan range of 1 to 3 percent was derived from FIGURE 14.2 when the CB sets the level of BR at 3 percent.

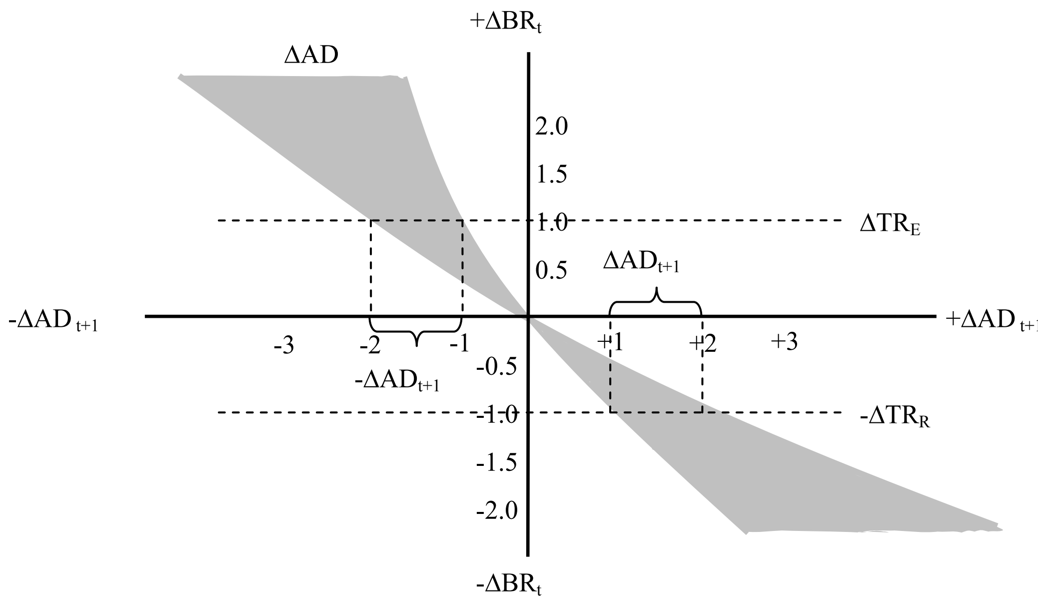
The more deeply shaded intersection of the AD and AS fractal bands in FIGURE 14.3 does not denote any "equilibrium" band of inflation and output change. It rather denotes the change in inflation (1-2 %) and real output (1-3%) expected to occur in the next (t+1) quarter.

4. PROCESS ANALYSIS: THE ΔBR-ΔAD DIAGRAM

Bank Rate is the CB's chief policy instrument, changed discretionarily and instantaneously in the pursuit of its policy targets, so changes in Bank Rate may be taken as the CB's proxy for changes in "animal spirits". The theoretical case why *ceteris paribus* changes in aggregate demand (ΔAD) are powerfully inversely related to changes in Bank Rate was outlined in a previous section. The basic problem is that in complex systems, the *ceteris* seldom remain *paribus.*

When interest rates are changed, it is informative to decompose the change in AD into the change associated with the **level** of Bank Rate, and the change associated with the **change** in Bank Rate. Unfortunately there is frequently insufficient information to distinguish the effects of the change in Bank Rate on AD from the effects of the level of Bank rate on AD. Whenever Bank Rate is changed more frequently than once a quarter the effects of the change in Bank Rate on AD cannot be directly estimated since GDP is only measured quarterly.

FIGURE 14.4 THE ΔAD-ΔBR RELATIONSHIP



In Figure 14.4 the Taylor Rule curve is drawn for a one percent increase ($+\Delta BR_E$) and one percent decrease in Bank rate ($-\Delta BR_R$), *ceteris paribus*. As shown a rise in Bank Rate is associated with a reduction in AD, and a fall in Bank Rate is associated with an increase in AD. The implicit assumption which on the surface appears perfectly reasonable is the customary *ceteris paribus* assumption that AD remains unchanged in the absence of a change in Bank Rate. But this ignores the fact that changes in "animal spirits" determine both the changes in AD and in BR.

As was shown in FIGURE 14.2, the expected change in aggregate demand is zero only under an extremely restrictive set of assumptions: Bank Rate must be set at the level where AD remains constant. (In the diagram this occurs when Bank Rate is set at 5 percent). But in general "animal spirits" continuously change pro-cyclically over the cycle irrespective of the level of Bank Rate. In the real world the change in aggregate demand does not remain constant when Bank Rate is unchanged, but increases when the economy is in an expansion phase and the CB increases Bank Rate, and decreases when the economy is in a contraction phase of the cycle and the CB reduces Bank Rate. In consequence AD and investment spending vary positively rather than inversely with Bank Rate

The problem is that even when Bank Rate is held constant AD is continually changed by cyclical shifts in "animal spirits." In complex systems the *ceteris* never remain *paribus.* Figure 14.4 is thus not based on the general case but is drawn under a highly restrictive assumption that the current level of BR is set at the particular rate (5 percent in FIGURE 14.2) which keeps animal spirits and AD unchanged over the cycle. Extremely restrictive assumptions must be imposed for AD to remain unchanged over the cycle, so that the effects of a change in Bank Rate will be negatively related to the change in AD. Shifts in "animal spirits" will cause the ΔAD relation to shift pro-cyclically over the cycle. The position and the shape of the change in aggregate demand band (ΔAD) in response to changes in Bank Rate is highly time-dependent.

As shown in FIGURE 14.5 the AD relation will shift widely to the right during expansions and widely to the left during recessions. Even when the interest elasticity of AD is very substantial, as is shown by the slope of the AD curve in FIGURE 14.5, this will not result in an inverse relation between changes in AD and changes in BR, because due to CB countercyclical monetary policy changes in Bank Rate (ΔBR_t) become a proxy for changes in animal spirits and so in expected future changes in prices, output and aggregate demand (ΔAD_t).

The empirical effects of a change in interest rate on AD will be substantial whenever the interest-elasticity of AD is high. But since changes in BR due to CB countercyclical policy are a proxy for changes in "animal spirits," AD empirically will be highly positively correlated with changes in Bank Rate. Both BR and AD fall in recessions and rise in expansions. The observed empirical relationship of changes in AD and changes in Bank Rate is positive whenever BR is varied pro-cyclically over the business cycle. So long as CBs shift Bank Rate pro-cyclically, changes in Bank Rate are a proxy for the CB's well-informed expectations of a change in "animal spirits." In consequence the estimated empirical relationship between changes in interest rates and changes in investment spending and AD will be positive in both expansions and recessions.

In FIGURE 14.5 the behavior of the BR- ΔAD relation is shown in periods of expansion (AD_E) and recession (AD_R). During expansions the change in AD_E is positive. Expected returns on investment projects are high due to expected increases in future ΔAD and accompanying higher capacity utilization. The demand for investment increases and is more likely to be responsive to changes in interest rates as shown by the more interest-elastic AD_E relationship. During expansions the CB raises Bank Rate. During recessions expected returns on investment projects fall and AD and capacity utilization rates decline. The demand for investment falls and becomes less responsive to reductions in interest rates, as shown by the less interest-elastic ΔAD_R band. But during recessions the CB lowers Bank Rate.

FIGURE 14.5 CYCLICAL SHIFTS IN THE ΔAD RELATIONSHIP

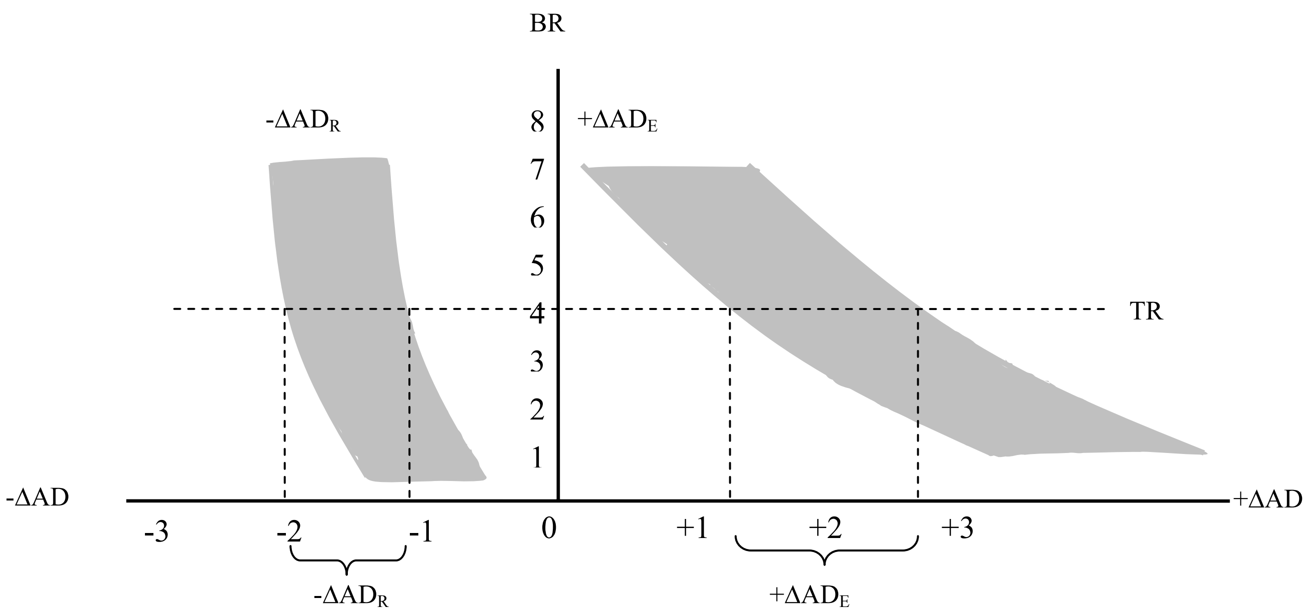
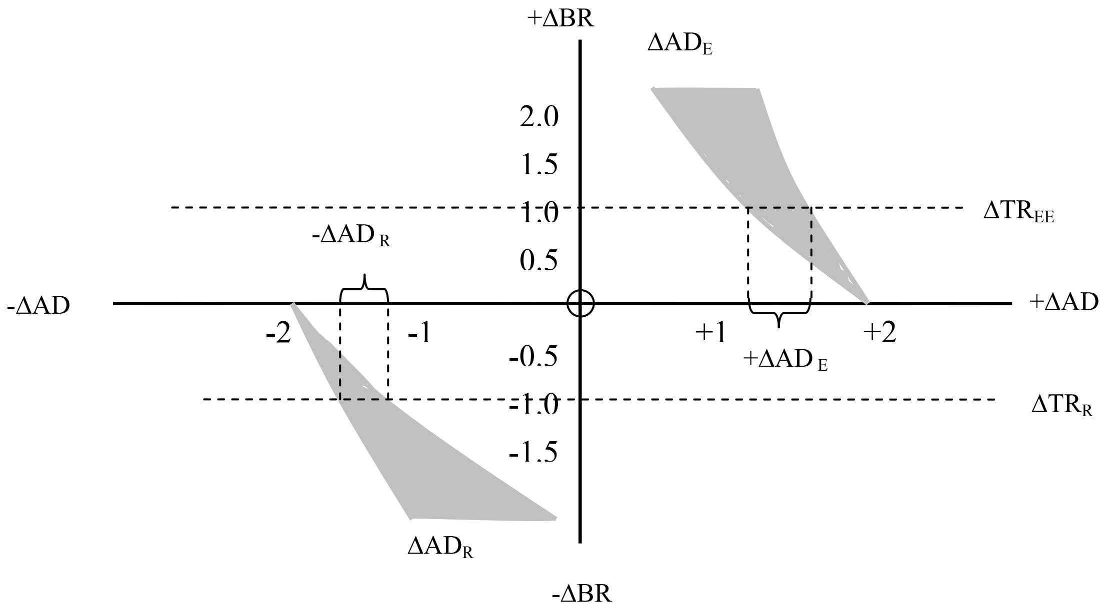


Figure 14.6 shows how ΔBR and ΔAD both shift pro-cyclically over the cycle. During expansions the ΔAD relationship expands (shifts right) and the CB raises Bank Rate. During contractions the ΔAD relationship

FIGURE 14.6 CYCLICAL SHIFTS IN THE ΔBR-ΔAD RELATIONSHIP



declines (shifts left) and the CB reduces Bank Rate. In developed economies Bank Rate is varied pro-cyclically by the CB through the cycle. The inverse effect of interest rate changes on AD are assumed to be substantial as indicated by the high interest-elasticity of the ΔAD_E and the ΔAD_R relationships in FIGURE 14.6. But the observed empirical association of increases in Bank Rate is merely a diminution in the rate of expansion ($+\Delta AD_E$) during economic expansions, not an absolute decrease. Similarly during recessions reductions in Bank Rate are associated with merely a diminution in the rate of decline of AD ($-\Delta AD_R$), not an absolute increase. Even when the interest elasticity of investment is very high, they are outweighed by the pro-cyclical shifts in "animal spirits" and so in AD.

Changes in Bank Rate may be regarded as a proxy for the CB's expectations of future changes in "animal spirits." CB's raise interest rates when they expect investment spending and AD to increase and lower interest rates when expect investment spending and AD to decline. Changes in Bank Rate may have very powerful inverse theoretical effects on capital spending, as illustrated by the high elasticity of the ΔAD curves in Figure 14.6. But the observed empirical relationship between changes in AD and changes in the interest rate will be positive during both expansions and recessions.

These empirical results have led most economists to conclude incorrectly that changes in interest rates have only small and perverse effect on investment behavior. But the true explanation for the failure to find significant negative coefficients on interest rates in investment regressions, and for the positive coefficients frequently found are due to the fact that changes in interest rates act as a proxy for changes in the important but unobservable shifts in “animal spirits.” This causes pro-cyclical shifts in both investment spending and AD over the cycle, and explains why single equation estimates of the effect of changes in interest rates on changes in AD are biased, due to the “missing variable” problem and as a result are positively and not inversely related to Bank Rate.

There is another quite separate set of reasons why economists have not found strong negative empirical relationships between changes in Bank Rate and changes in AD. CB’s directly administer the level of **nominal** Bank Rate. But most real investment projects are more influenced by ***ex ante*** **real** long term rates than the current nominal rate. To a changing extent inflation varies pro-cyclically, causing *ex ante* real rates to move counter-cyclically, and fall during expansions and rise during contractions. Unless the CB targeted pro-cyclical movements in the real Bank Rate, this counter-cyclical variation in real rates reinforces the positive empirical coefficients typically found between changes in nominal interest rates and AD.

Monetary policy operates primarily by altering agents’ expectations of future inflation and future ΔAD. Both investment spending and *ex ante* long term rates are dependent on the capital markets’ current expectations of changes in future inflation and future short term rates. When CBs wish to lower current long term rates to expand current AD but can operate directly only on short-term rates, to be successful in reducing current *ex ante* long-term rates they must persuade agents in financial markets that short-term rates will be maintained at their current low levels over a substantial future period. It is difficult for CB’s to consistently succeed in such persuasion necessary to reduce the long end of the yield curve. The more successful CB’s are in stimulating AD by lowering current interest rates, the greater will be market confidence that the economy will soon recover, and the market will expect that rates will be raised again in the future. CB credibility is the *sine qua non* for successful monetary policy.

5. CHANGES IN BANK RATE: A PROXY FOR "ANIMAL SPIRITS"

The ability of monetary policy to succeed in its targets of internal and external balance depends on the value of Bank Rate set by the CB and the position and interest-elasticity of the AD curve. Powerful theoretical grounds have been summarized which imply investment spending and AD are strongly inversely related to the level of interest rates. Surprisingly, economists have found little or no empirical support for the expected strong inverse association between Bank Rate and changes in investment spending. Using single equation investment equations, regression analysis fails to find a strong negative relationship between investment spending and the level of or the change in Bank Rate. [51] The coefficient on the interest rate in investment equations is typically positive, and frequently statistically significant. Using instrumental variables the data still fails to reveal the theoretically expected powerful inverse relationship between interest rates and AD.[52]

"Animal spirits," the current heterogeneous expectations of agents about the future heterogeneous expectations of other agents about future events are generated by fundamental uncertainty, and constitute the non-measurable but central causal variable governing investment behavior and Ad growth in a complex world. As stated the reason regression analysis has failed to find the theoretically expected strong negative relationship between interest rates and economic behavior is because changes in Bank Rate are a proxy for the expected change in "animal spirits." Since the future is unknowable changes in "Animal spirits" are the key variable determining changes in investment spending and AD, but are completely non-measurable. "Animal spirits" are the single most important variable explaining investment spending, but since they cannot quantified they cannot be entered as an explanatory variable in investment or AD equations. Once changes in Bank Rate are recognized as a proxy for CB's

[51] See Fazzari, 1993.
[52] See Cochrane, 1989; Taylor, 1993; Christiano, Eichenbaum and Evans, 1996; Bernanke and Woodford, 1997; Evans and Marshall, 1998; Bernanke, Laubach, Mishkin and Posen, 1999; Clarida, Gali and Gertler, 2000, and Walsh, 2003.

expectations of changes in “animal spirits”, it is no longer surprising that changes in Bank Rate are positively and not negatively associated with the change in investment spending.

CB’s vary Bank Rate pro-cyclically over the cycle, in their attempt to attain their stabilization goals of price stability, full employment and rapid growth. In consequence Bank Rate may be regarded as the CB’s proxy for changes in “Animal Spirits”. Investment spending varies pro-cyclically with changes animal spirits so and investment spending and its proxy Bank Rate will be strongly positively correlated. The volatile quality of “animal spirits” and the looseness of the linkage between exogenous short term rates and partially endogenous long-term rates provide additional reasons why the relationship between changes in AD and Bank Rate will be non-deterministic and time-dependent, as portrayed by the width of the [ΔAD] fractal band.