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Three Essays on the Theory of Money and Financial Institutions Essay 3: The Economy with Innovation, Externalities and Context

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THREE ESSAYS ON THE THEORY OF MONEY AND FINANCIAL INSTITUTIONS ESSAY 3: THE ECONOMY WITH INNOVATION, EXTERNALITIES AND CONTEXT

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Abstract

This essay is the third of three. The first is nontechnical and in part autobiograhpical describing the evolution of my approach to developing a microeconomic theory of money and.financial institutions. The second essay was devoted to a more formal sketch of a closed economic exchange system with no other externalities beyond money and markets. This essay builds on the existence of monetary exchange but also context, and active government with nonsymmetric information and many externaties indicate that the views of Keynes, Hayek and Schumpeter are all consistent with the next stages of complexity as the logic requires many different arrays of institutions to provide the necessary economic functions and adjust to the variety of socio-economic contexts.

Keywords: Schumpeter, Keynes, aggregation, information, disequilibrium, minimal institutions, innovation, playable games.
JEL Classifications: C7, D50, E4

1 Building Theories of Economic Process

In the first of two previous essays some autobiographical materiel was followed by an essentially nontechnical discussion of why I have advocated a mixture of a game theory, econophysics and evolutionary approaches to developing a theory of money and financial institutions. In the second essay a step by step approach was adopted that called for laying on successive complications to a stripped down process model of the ADM general equilibrium models so that each of the features such as price formation, competition, endogenous and exogenous uncertainty could be presented as part of a process model. The natural terminal point of this treatment does not cover, but serves as a basis from which finance, uncertainty, expectations and control can be considered. This third essay suggests that although the act of converting any general equilibrium model into one or more process models can be achieved without going further, it calls for a radical change and extension of the original paradigm to include not merely the presence of an explicit money commodity, markets and government but also the role of innovation much like the process sketched by Schumpeter [15] and an evolution of a politically guided economy as a birth death process.

1.1 The First Steps Toward Economic Process

Prior to specifying a new paradigm a comment on the unifying power of general equilibrium theory is apposite. Although we use loosely the terms theory and model, the fundamental power of general equilibrium analysis is that it is a collection of principles for building models. It is a theory of economic constraint on optimal choice imposed by exchange and production where the stress is on the equations at equilibrium rather than the inequalities dominating systems in disequilibrium.

1.1.1 The change in emphasis and paradigm

The carriers of process are mechanisms or institutions that accept and process instructions from active agents but they may or may not also be regarded as active agents themselves. This is illustrated in the laws that recognize two types of person, natural persons and other legal persons such as for profit and not for profit corporations. Much of the economic activity in a modern economy is controlled by fiduciaries acting for individual natural persons who, in many theories are presented as the ultimate owners of all institutions.

Figure 1 represents a fully integrated recursive system for a single closed economy.

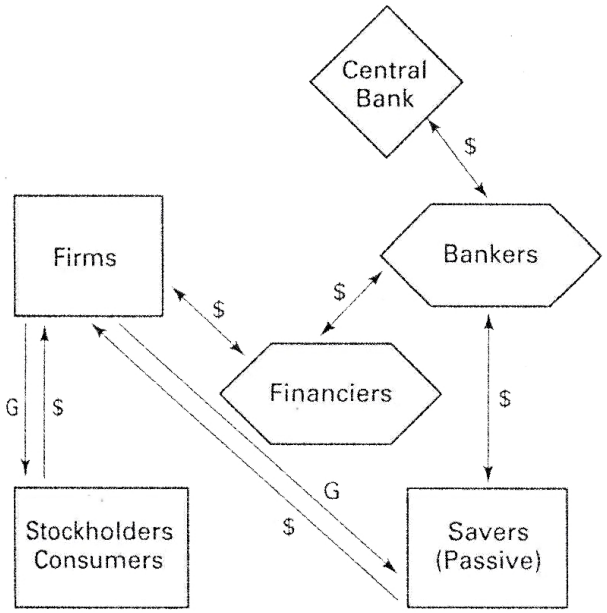

Figure 1
The closed system of a political-economy

The transition from the pure structure of economic equilibrium to unavoidable institutional and parameter ridden models of process is forced as soon as it becomes clear that the rules of the game are carriers of process and these carriers are the institutions and mechanisms of society that open the links of an abstract pure economy to the institutions of the polity and society.

Figure 1 sketches a six agent simplified structure of an overall political-economy where three boxes cover the pure economy consisting of stockholder, consumer workers and saver workers. At a higher level of aggregation they could be considered as one, but this distinction calls attention to the difference between equity and debt holding. The other three boxes are financial mechanisms that supply the perception, guidance and control system over the physical economy. The central bank covers implicitly, the role of government in controlling the legal money supply, and implicitly in performing

many other government activities that often call for a more disaggregated model to include a separate government fiscal agent. In a decentralized economy, although not a logical necessity the functions of both commercial banking and investment banking are performed by separate institutions as is sketched in Figure 1. A basic distinction among different banks is in the levels of evaluation and risk taking.

As anyone with any operating or consulting experience knows the Devil is in the details. Essentially all institutions perform multiple functions. They may have been created originally for one function, but quickly they are adapted to many others. The many functions of a central bank require many pages to describe. The description of the boxes in Figure 1 and their interconnections is constrained to a bare minimum, but even six differentiated agents without further simplification produce models too complex to treat analytically with much generality.

1.1.2 The end of the first steps

In Essay 2 a reasonably complete sketch is given going into many of the details required to recast pure exchange among powerless individuals as process models. The exchange economy $E(n, m, u^i, a_j, R^+_{nm})$. is reformulated in terms of strategic market games with minimal mechanisms or institutions that enable us to define the economy as a payable game. This involves specifying how to embed a timeless set of models into games with the past, present and future made explicit in terms of history and expectations; but this is done staying with a fixed set of individually owned goods and services and the means of production modeled as passive price-taking profit-pass-through mechanisms where non-voting stockholders are paid profits in proportion to their holdings. All laws of trade,contract and default are obeyed implicitly.

As was noted in Essay 2, the transformation to process models requires making explicit the roles and nature of markets, information and money as well as the role of government as enforcer of the rules of trade.

The model of exchange and production has been opened up to the explicit existence of government, law, markets and money This provides enough structure to be able to describe mathematically the further institutions and instruments involving finance, risk, innovation and the control and guidance problems associated with private and public joint goods. This third essay is devoted to going beyond general equilibrium and showing how one can reconcile a market economy with the Schumpeter vision of innovation where increasing returns to scale aspects are due not only to physical indivisibilities but to many other factors concerning information, difficulties in evaluation and the needs for venture capital. These considerations lead to the formulation of models of oligopolistic competition based on the introduction of new goods and services in a system in disequilibrium rather than a system with a fixed set of goods and equilibrium prices. As in the other two essays the stress is on looking for whatever minimal structure there may be in the system in order to carry process and indicating how this structure can be specialized to cover the details called for in

any application.

2 A Comment on Externalities

As our main theme is the thread of economic argument concerning the properties of market mechanisms with individually owned tradable assets the role of public goods, externalities and property rights open up a whole new and different political economy. These items have been discussed in [18] Chapters 10 and 11 based in part on a suggested taxonomy noted in [16] Chapter 18. Social and political considerations technology, indivisibilities, complexity and size of institutional structures make it infeasible to own or to trade shares of many socially needed institutions such as justice, the law courts, police, and defense. Unconstrained pollution raises problems in trying to create synthetic products to provide near market solutions or to seek other solutions. For example much of the work of Ronald Coase [3] can be regarded as a pre-game theory attempt to consider an economic solution to problems of externalities based on the use of the core of an n-person game.

3 From Walras to Schumpeter

> Nature and Nature's laws were hidden in the night
> God said let Newton be and all was light.
> It did not last: the Devil shouting 'Ho.
> Let Einstein be,' restored the status quo
>
> Pope on Newton, with an addition.

Any form of applied economics is institutional and institutional economics has to be messy. Even Newtonian physics applied to a subject such as optics with a few detailed aspects of atmospheric distortion turns an overall abstraction into a parameter laden endeavor.

The paths from abstract Arrow, Debreu, McKenzie (ADM) general equilibrium to Keynes and to Schumpeter are there, albeit that they are institution laden where much of the detailed structure is dictated by the specifics of an ongoing society.

3.1 The Playable Game

Given the known results [2], [5] for the mathematical equivalence between the general equilibrium analysis and that for the solution of efficient noncooperative equilibria with a continuum of agents in a strategic market game, it is natural to ask 'Is the stress on strategic market games in these essays an instance of a pedantic distinction differentiating general equilibrium models from strategic market games where there is no operational difference?'

The equivalence result stresses equilibrium. The Nash noncooperative equilibrium solution is utilized in order to compare the equilibrium solutions to show that the SMG noncooperative equilibrium solutions yield the same or more equilibrium results than general equilibrium. However the whole spirit of the SMG is to stress process regardless of equilibrium. The basic psychology of the SMG approach is to lay stress on the construction of playable games. In doing so apart from expanding the possibility for experimentation the procedure required to debug a process model of a game or simulation provides an important check on consistency and completeness.

3.1.1 Parameters that count in disequilibrium

A comparison of the modeling distinctions required in describing even a two player type model of exchange of two consumer goods is sufficient to indicate the first relatively simple steps that call for the addition of many extra parameters to the general equilibrium model [1]. Table 1 shows the features directly. The following notation is utilized. Let

1. $A_1, \bar{A}_2$ be the initial holdings of the goods.
2. $M_1, \bar{M}_2$ be the initial holdings of fiat money.
3. B be the initial holding of the central bank of funds that it can lend [2].
4. $\rho \geq 0$ is a given interest rate at which it lends [3].
5. $\beta \geq 0$ a natural discount [4]
6. $\Lambda, \bar{\Lambda}$ marginal bankruptcy penalties at the day of settlement
7. $\Pi, \bar{\Pi}$ the expected value of money at the day of settlement

Table 1 presents the basic physical, financial and expectational differnces between the models

[1] There are many ways in which a whole class of minimal game models can be constructed (see [18] for a discussion), we select a simple model with a passive outside bank as sufficient to indicate the extra considerations when the complete state space is covered.

[2] In national income accounting there is a paraxodical problem posed. If the central bank(and treasury) can create money, is there a specified legal bound as to how much it can create? In evaluating national wealth one can count only the fiat money inside the non-central bank sector.

[3] One can describe systems with an endogenous or exogenous formation (or both) of the money rate of interest. This involves including a money market for loans as well as a central bank specifying its loan or deposit rate. Futrher discussion is given in the enormous literature on banking. Further discussion on strategic game modeling are given in [17] and [18].

[4] For the model wtih one period of trade followed by settlement at the end of the game the parameter β can be absorbed into other parameters, but it is convenient to keep it separate.

	GE	SMG
Initial holdings of goods	$A_1, \bar{A}_2$	$A_1, \bar{A}_2$
Initial holdings of fiat	-	$M_1, \bar{M}_2$
Outside bank holdings of fiat	na	B
money interest rate	na	ρ
natural discount rate	na	β
bankruptcy rate	$\to \infty$	$\Lambda, \bar{\Lambda}$
expected value of money	na	$\Pi, \bar{\Pi}$

Table 1
GE compared with SMG

We see that any general equilibrium model has associated with it a class of strategic market games with an addition of eight (8) extra parameters to help characterize a relatively simple control structure.

The non strategic economic models share with the SMG the same individuals, original preferences and endowments. The SMG add 9 extra parameters as listed in Table 1. The β is not logically needed as has been noted in a footnote above, but the others are needed and merit some specific comment.

Default and bankruptcy penalties If any form of credit granting is considered a strategic description of trade among individuals requires that the mechanism be able to provide rules to account for how to proceed if the system reaches a point where an individual owes a debt she cannot pay. A rule specifying how the society penalizes the individual and treats the creditors must be given. The details concerning the specific rules have been been discussed extensively elsewhere (see [17] Chapter 11). The preference structure of the individual must be modified to take a bankruptcy possibility into account. As long as the adjustment leaves the preference sets convex without loss of generality a set of linear penalties can be used, hence for two types of agents we need only $\Lambda, \bar{\Lambda}$.The general equilibrium model with complete markets can be assumed to avoid the problem by assuming that in the region of an equilibrium point the bankruptcy penalty has been set sufficiently high to avoid active strategic bankruptcy. A dimensional analysis of the penalty requires its dimensions to be utility/money thus a numeraire is established for the price system linking fiat to real goods.

Fiat money A useful simplification preliminary to considering infinite horizon models is the introduction of a fiat money as a means of payment in an exchange economy where the money enters as a separable and linear term [5]. Suppose that the holdings in the economy of the durable good that is fiat money are $M_1, \bar{M}_2$ then the Pareto surface of the GE model without money is a curve from $P\left(A_1 + A_2 + \bar{A}_1 + \bar{A}_2\right), \bar{P}\left(0\right)$ to $P\left(0\right), \bar{P}\left(A_1 + A_2 + \bar{A}_1 + \bar{A}_2\right)$ however we need to add the predicted worth of the

[5] The full justification of this step is given in [18].

fiat owned by the agents thus a linear part of the new Pareto surface appears with the limits having added to one end $\Pi\left(M_1 + \bar{M}_2\right)$ and added $\bar{\Pi}\left(M_1 + \bar{M}_2\right)$ to the other.

Trade, borrowing and lending There are many means of payment, ways of trade and ways of borrowing. Here a minimal model has individuals only able to borrow from an outside bank at a given rate ρ and to bid only with bank money and offer goods for sale.

Out of equilibrium a welter of inequalities and boundary conditions must be accounted for. An attractive way to face up to them is look only for equilibrium conditions in multistage dynamics. This can be done even at this level of a one stage process model with an evaluation for any left over assets at a day of settlement. The rational expectations analysis does this by selecting ex ante predictions that by perfect foresight and coordination of all match the activity of all.

As this holds there will be no bankruptcy and no need for a special monetary asset as all books will balance thus the full apparatus of the strategic game is unnecessary.

If we wish to be able to study motion for even one period without the assumption of universal coordinated rational expectations the full apparatus of the strategic game is necessary.

An elementary mathematization of Schumpeter's ideas calls for the addition of at least one random variable and the creation of new products as is noted below.

An elementary mathematization of the observation of Keynes is already implicit in the structure once the possibility of error and initial conditions out of equilibrium are considered.

3.1.2 GE to SMG to Schumpeter and Keynes

The specific challenge faced in the production of playable games is the production of minimal process models showing that with the appropriate empirically relevant enlargements the insights both of Keynes and Schumpeter are naturally reflected in SMGs that are consistent with the abstraction of general equilibrium.

In Sections 3 and 4 below Schumpeter and then Keynes are dealt with. In some sense both appear to deny the elegant simplicity of general equilibrium, but both arise from attempts to extend the static virtues of an institution free economic price system by adding carriers of process and then by considering the nature of motivation and the problems of coordination and information in actual processes.

3.1.3 An aside on the explosion of complexity

Considerations from basic extensive form game theory, combinatorics and elementary physics and biology and any social science tell us that in any topic considered as soon

as there are more than two or three time periods [6]; two or three persons, and two or three states of the system at any time, the explosion of cases becomes hyper-astronomical. A simple example is provided by a 2×2 matrix game often used in teaching elementary game theory. If we consider that the two players can rank order their four payoffs there are 726 strategically different games. If each had three choices, giving a 3×3 matrix game there are billions of strategically different games. The lesson to be drawn from the overarching availability of special cases is that there is an art as well as a science in selecting basic assumptions in the construction of fruitful models in the sciences. In political economy the difficulties in observation and validation are such that on many (but not all) topics of critical concern in the design of economic policy it is still possible to find professionals of repute with diametrically opposed views of economic dynamics. This is noted not as a statement of despair but caution when extending models of economic statics such as the competitive price system from conversational dynamics as offered by Schumpeter and Keynes, to formal mathematical models. The essay is the great instrument for hortation and the crusade for new ideas and insights. It, in most instances, is preformal. It does not deal with the many problems in data aggregation and disaggregation or the time lags in implementation, all of which must be considered in bringing a perception to a concretion. It is over a century since Schumpeter and Keynes started to elucidate their insights and much is still in contention.

3.2 Competitive Equilibrium to Mutation and Schumpeter

Without having to add more complications than production and one Bernouilli random variable it is possible to construct a strategic market game model with an innovation well defined and directly comparable with the general equilibrium system.

A striking concept from the work of Schumpeter is the need for breaking the circular flow of capital. The maintenance of the circular flow is central to balancing the books in the static general equilibrium with only an accounting money.

The new essential ingredients that must be added to go from a general equilibrium model to Schumpeterian innovation are:

1. A process model where the presence of any cost to trade implies the existence of a money as an asset [6].

2. A potentially variable number of products in contrast with the fixed number of products in the GE model.

3. At least one two state random variable to indicate a risk associated with an attempt to produce a new commodity, where the cost of one's investment is lost if the innovation fails.

[6] Such as the aggregate past, the present and an aggregated expected future.

4. A specification as to how to evaluate a new good.

5. A definition of the market clearing mechanism.

6. A specification for the minimal existence of a debt or equity market or both.

7. A specification of default and bankruptcy rules if an innovator is unable to repay a loan.

8. A specification of whether the process is finite or infinite

9. Initial and terminal conditions must be defined.

Even the simplest of models with only one opportunity for innovation turns out to be somewhat complicated to formulate in a manner that it is amenable to a dynamic programming analysis.

The specifics of a complete model amenable to analysis are presented in [19], [18], Chapter 9.

Even with the highly simplified model that we analyzed some important features emerge. In particular the Schumpeterian concept of breaking the circular flow of capital is reflected in the mathematical feature that even with only one attempt at innovation at least one resulting state of the economy must be in disequilibrium with no general proof available that there exists a dynamic path that attains the equilibrium state of the system [7]. Many of the rational expectations dynamic programming models applied to economics by Robert Lucas and his associates concentrate on equilibrium states with little stress or attention to the adjustment possibilities of disequilibrium.

3.2.1 Schumpeterian oligopolistic competition .

As was shown by Brian Arthur and colleagues in his broad study of increasing returns [1] that in particular with stochastic processes once a competitor establishes a lead the probability that the lead enlarges may increase. This rules out the possibility for more than weak probabilistic prediction.

My interests have been in seeking the underlying basic abstractions required to provide the many economic functions utilized in a financially controlled economy. Some simple experimental models can be formulated to test their plausibility by playing the games described as experimental games. Unfortunately this has not yet been done for more than a few models. however the applications and empirical evidence for the relevance of the Schumpeterian models requires considerable institutional detail and the ability to manipulate to investigate far higher dimensional models than those provided by Lucas [12] or by Ioannis, Karatzas, Shubik and William Sudderth

[7] Technically the check for the stability of the system involves solving the Lyapunov equations and this is often not feasible.

[9] and others. The examination of the Schumpeterian models has been pursued far more in Europe than in the United States. The works of Richard Nelson and Sidney Winter [14], Nelson [13] and Giovanni Dosi [4] and an active group at Pisa have both run large simulations of Schumpeterian models where there is little if any hope for attaining analytical results but they have attempted to match these simulations with empirical data.

The important feature to stress is that the first description of Schumpeterian system began with the assumption of the existence of a highly complex financial control system over the productive resources of the economy. It had a high level of competition present, but competition does not necessarily mean price competition. The basic feature covering any profit oriented society is not whether the main strategic variables are price, quantity, quality, manipulation of the legal system or methods of financing, but it is in profit seeking by closing existing arbitrage opportunities by whatever the strategic tools that are available happen to be. There is no guarantee that the motions in closing these gaps necessarily lead to an equilibrium or even offer us the ability to define more than local Optimality. This leads to considering the political-economy relevance of government guidance.

The nature of the models modified from a general equilibrium background to reflect process appears to conform to a biological interpretation. There is a clear analogy between innovation and mutation in a birth death process. In our model the individual faces the choice of continuing in a riskless state or buying a lottery ticket where the payment represents the removal of resources currently used for production or consumption to be employed in a risky venture that will either fail or will introduce a new activity that can be added profitably to current activities. There is the danger that the venture fails, if it does there is no innovation or mutation, if it succeeds there is also the possibility that the innovation is born but is unable to recoup its financial costs and cannot become profitable over the long run. In either instance the innovator may go bankrupt. When a bankruptcy occurs the only items that are destroyed are the IOU notes issued by defaulting borrowers. The physical resources including legal money are redistributed. The same holds for the stillbirth of a failed mutation even if only the vultures gain. There are good reasons to refer to bankruptcy financial experts as 'vulture capitalists'.

3.2.2 Unfinished business

In the work with Karatzas and Sudderth and in the book with Eric Smith it was evident to us that the basic concepts underlying the Schumpeter assertions could be modeled and mathematized using either discrete or continuous time methods; but even for relatively innocuous problems such as a full life death process with ongoing mutations the treatment of the complexity for a five or six agent model in any generality calls for other methods such as simulation.

Although we have not yet been able to construct satisfactory fully rigorous models

of them, there are at least two outstanding problems concerning the Schumpeterian system worth noting, one is general and somewhat vague and the other more specific. I sketch both of them together with my guesses and conjectures.

The first item involves the investigation of the ergodic properties of a constantly mutating system. For simplicity limit consideration to only one perishable commodity that can be either consumed or sold in a market. A simple form of innovation might be that each firm is able to improve its production efficiency by investing in a risky procedure that consumes resources and either fails or succeeds in improving production by making a more efficient process available to the firm. Suppose that there is a given constant population n of individuals, each of whom owns all the (nontradable) shares of a firm with a single output and that each owner can tell the firm how to use its resources on production, investment and dividends. Can we describe the general conditions under which when we flesh in the details and select reasonable representations of production, consumption and investment, the system is non ergodic?

My guess is that the selection of plausible production, trading, uncertainty and time lag conditions is so large that in general the system may be highly dependent on initial conditions. Many agents, commodities, uncertainty and time lags can be discussed easily in rhetoric and in essay form but a sufficiently precise specification of the state space of a broad class of financial control models is difficult to produce and probably at best is useful in indicating limits on dynamic models. A more fruitful approach is to have a specific question on a specific hand tailored empirical model where the institutional constraints enable the investigator to bound the dynamics and attempt empirical verification.

The second problem can be stated reasonably simply with some precision and the phenomenon is easy to verify but has not yet been fully formalized. It is, "Can we construct and solve a plausible economic model that attains an equilibrium state with a constantly positive level of bankruptcy as part of this state without having to resort to behavioral economic assumptions?" My conjecture is emphatically yes and that the construction of such a model is consistent with the empirical observation of the ever presence of bankrupt agents This suggests that even without having to resort to the many different noneconomic behavioral explanations for active bankruptcy the phenomenon can occur within a structure calling only for economic optimization.

I conjecture the possibility that some individuals may be more perceptive or professional than others is sufficient. Von Neumann and Morgenstern [22] even considered the possibility of different refinements of perception many years ago.

An intuitive sketch of the process can be had from an ongoing Poker game. There may be one or more regular patsies who always are net losers. They get cleaned out during the game and are permitted to rejoin after they have paid their debts. They accumulate enough money from an occupation outside of the game, pay their debts and resume play. Given common knowledge of perceptions at different grid sizes does not imply that the agents can learn to change these sizes or that they are

irrational, mathematically the phenomenon is reflected in different constraints in the optimization.

4 From General Equilibrium to Keynes and Beyond

In spite of the counterrevolutions against John Maynard Keynes his brilliance, advocacy and broad brush approach crystallized economic thought in its relationship to the role of government in the guidance of the economy. Although he had both the training and the abilities of a great theorist [10], [11] he excelled as a polemicist for political economy. He understood the lack of coordination between the forces of investment and consumption and advocated government action to help cure the mismatch. Although a reasonably competent mathematician he was no great friend of mathematical economics. It is almost ironical that Keynes having been liberated from the chains of statics and equilibrium should have found that John Hicks in his famous article Keynes and the Classics [8] should try to put the genie back into the bottle by an ingenious construction for restoring equilibrium. As a great applied economist and advocate in a world with few decent statistics he cut the Gordian knot and invented items such the propensity to consume in order to be able motivate a description of broad aggregate behavior of consumers to assemble the several pieces need to provide for even the most elementary of dynamics. possibly one of the great contributions of Keynes was the impetus given to many nations to start to gather macroeconomic statistics which have served as the great empirical base for the construction of the many and varied macoeconomic models that have been built.

The birth and growth of econometric methods since the 1930s provided the basis for the large NBER and other multiple equation ad hoc models of the overall economy. The macro models now range politically from the far left to the far right [17], p86 Table 3.3 and items such as Keynes' propensity to consume and various investment models have been challenged and rejected or affirmed by econometric studies. Utilizing extremely low dimensional models and rational expectations (that in game theory terminology is a form of noncooperative equilibrium) Lucas [12] and his colleagues have offered an enterprise viewpoint of dynamics far closer to competitive equilibrium orthodoxy then to a Keynesian dynamics; but essentially all of the applied macroeconomic models of any size or political persuasion do not have a horizon of more than five years. The difference are more in the equations of motion and the behavioral dynamics than in structure. One of our major concerns has been in providing a general methodology for model building ([18], Chapter 7) in doing so we have stressed that the strategic market game provides the natural extension for the construction of a process model for the general equilibrium model to encompass dynamics. We observed that the general equilibrium model per se requires no equations of motion both the work of Lucas [12] and his followers [**?**] and the work of Karatzas, Shubik

and Sudderth [9] stay close to the competitive equilibrium paradigm, but Keynes and many successors have encompassed many other behavioral assumptions that can be justified by social-psychology, behavioral economics and the empirical evidence that can be mustered to support them.

Keynes was highly instrumental in liberating economic dynamics; Pandora's box was opened and a swarm of dynamic models emerged that are being fought over today as different intellectual boosts to policy.

5 The Future of Political-Economy

There is no royal road and no magic Philosophers' Stone that is going to provide for an all encompassing economic dynamics at the same level that general equilibrium answered the highly restricted but extremely pertinent questions it posed about the conditions required for the existence of efficient market clearing prices.

The dynamics of a mass economy with government and laws poses a host of problems far more complex than the existence proof of an efficient price system in a pre-institutional economy.

The challenges and the dangers of bridging the gap between theory and practice were eloquently noted in Edgeworth's inaugural address in 1891 [7]. He commented

> It is worth while to consider why the path of applied economics is so slippery; and how it is possible to combine an enthusiastic admiration of theory with the coldest hesitation in practice. The explanation may be partially given in the words of a distinguished logician who has well and quaintly said, that if a malign spirit sought to annihilate to whole fabric of useful knowledge with the least effort and change, it would by no means be necessary that he should abrogate the laws of nature. The links of the chain of causation need not be corroded. Like effects shall still follow like causes; only like causes shall no longer occur in collocation. Every case is to be singular; every species, like the fabled Phoenix, to be unique. Now most of our practical problems have this character of singularity; every burning question is a Phoenix in the sense of being sui generis.
>
> F.Y. Edgeworth, 1891

One might regard Edgeworth's comments as an observation of extreme pessimism however it contains a basic nub of truth when directed at application to economics. When dealing with application there is no substitute for knowing your business. The basic reason why applied economics is split into so many fields is that in application, each of these specializations requires that relevant special details be added. The structure, mappings, functional forms and parameters are *ad hoc* and require knowledge and expertise pertaining to the questions at hand.

Virtually all applied economics deals with dynamics. In developing a special topic such as banking or macro-economics or health economics a confusion between the roles of theory and practise can easily arise.

5.1 What is a theory?

Different disciplines utilize the word theory differently. Furthermore model and theory appear on occasion to be used interchangeably [8].

A conventional way to approach this question is to go to the dictionary for aid, and it is useful to do so providing that one recognizes the weaknesses of dictionary construction. Another way is to seek currently institutionalized scientific authorities. The National Academy of Sciences of the United States suggests:

> A plausible or scientifically acceptable, well-substantiated explanation of some aspect of the natural world; an organized system of accepted knowledge that applies in a variety of circumstances to explain a specific set of phenomena and predict the characteristics of as yet unobserved phenomena.

It also defines a fact as:

> In science, a "fact" typically refers to an observation, measurement, or other form of evidence that can be expected to occur the same way under similar circumstances. However, scientists also use the term "fact" to refer to a scientific explanation that has been tested and confirmed so many times that there is no longer a compelling reason to keep testing it or looking for additional examples (*pace* Black Swans*).*

Aristotel contrasted theory to "practise". Praxis, the Greek term for "doing", is concerned with application; while pure theory is not concerned with immediate application. An often used example comes from medicine. Medical research may be concerned with attempting to understand the causes for a disease without being immediately concerned with practise. In contrast good practitioners are more concerned with curing patients of a disease, and if they find a cure but not a deep explanation they are reasonably content (as are the patients). Central bankers may have the same view of the current financial system. Unfortunately, as yet, their level of success appears to be far from that in medicine.

A mathematical view of a theory is deductive. A

theory's (possibly full sensory or empirical) content is given by basic axioms and a formal logic develops the theory. The logical consequence of the axioms are presented as theorems.

[8]Much of the material in this section is a paraphrasing of our joint work, hence I wish to acknowledge again the lengthy and jointly productive discussions with Eric Smith.

A semantic view of theories, is as models providing a logical framework connected with some aspect of observation. They are abstractions or simplifications of some aspects of the real world.

In economics there are many subdivisions that tend to intermix theory and practise. Possibly the major rift is between micro- and macro-economics

There are many subdivisions of microeconomics where practitioners and theorists are highly intermixed.

A distinction often made to sort out the pure theorists as contrasted with those with empirical concerns is between those devoted primarily to normative concerns "what should be" as contrasted with those more inclined to positive economics stressing "what is". Recently in finance and macro-economics the term "engineer" has been used to indicate those involved with problems at hand. This may even include retreaded PhD physicists or top probability theorists devising complex derivatives or algorithms to take advantage of local correlations in time series in stock trading.

Small purist areas are the bastion of some mathematical economists and philosophers. Thus models abound varying the axioms on formal concepts of fair division, bargaining and the mathematics of preference theory. The use of these models in experimental economics and social psychology is increasing.

5.1.1 In praise of specialization

Beyond the major divisions of micro- and macro-economics not only are there many economic theories with adjectives attached such as international economics, welfare economics, labor economics, health economics and so forth; there are also divisions such as behavioral economics where the assumptions on behavior, including individual optimization and the standard models of utilitarian economic agents are challenged. For example, some results in experimental gaming have indicated that the double auction market is reasonably efficient even when operated by agents with limited intelligence.

The main thrust of macroeconomics is clearly operational. It deals with the dynamics of the whole economy encompassing features such as inflation, economic cycles and growth, unemployment, and monetary and fiscal policy. An honorable employment for the macroeconomist is to give operational quantitative and qualitative advice to governments.

The political economists, economic historians and historians of economic thought still provide broad insights utilizing the essay form as their way to deal with the imponderables.

Especially in application the closely related disciplines of finance, accounting, and law intertwine with many economic investigations. The disciplines of sociology, social psychology and psychology serve to challenge the axioms underlying many economic models. And recently the disciplines of physics, ecology and biology have been considered as potential contributors to economic understanding of growth, innovation

and evolution.

5.1.2 What is an application?

The applications of economic theory to society at the best are an intermix of substantive knowledge of a specific aspect of the economy together with at least one reasonably well defined operationally relevant question such as how do we compare the relative effectiveness of grade school education among the states of the United States; or is world trade in foreign exchange derivatives of benefit to United States ' trade? Such studies utilize ad hoc investigation bound together with economic principles, methods from econometrics, operations research and the social and physical sciences. Such work both nourishes theory and helps to support it.

5.2 Contact with sciences of both the material world and of behavior

It is not the purpose of economics to describe all aspects of life. It should be the purpose of economics to treat those domains it does describe with concepts and models that can be made consistent with sound scientific understanding of the other aspects of life, when they are needed to provide context.

At a minimum, economic behavior is embedded within the organic system of the society; it affects extraction, production, utilization, exchange, consumption, and disposal of physical entities and services which exist in the material world and in time; it is supported by both informal and formal institutions, both of which rely on cognitive propensities of people.

The economy may be viewed as a mechanism to organize a subset of the decisions in a larger, highly distributed society. The social organization obeys no simple model of control flow; its dynamics is often evolutionary at many scales of time, space, and material content; and with these, it is subject to both historical contingency and great complexity.

Within this dynamic context, the economy can be considered as an organ of memory and of control [9].

Within the economy as well as in its embedding in context, actors with different natural scales interact. Differences in scale exist between private citizens, firms, central banks, and the government. In cases of incomplete contract (which should be regarded as the norm rather than the exception) any of these may also interact informally with social norms, cognitive constraints, or other frameworks that carry *power*. Although such cases are difficult to model formally, it must be acknowledged that they reflect much of reality. The models in the Shubik Smith book for the most part contain only two levels, private citizens and a central government, but they are

[9] Particularly they enable coordination.

intended to represent the more general case of interaction between agents of different scale.

Leaving explicit roles for both government and cognition within the formal structure of economic theory can acknowledge a mismatch without necessarily having to explain it, and can provide a starting point to study the *limitations* of markets as well as their capabilities.

One of the defining features of governments is pre-commitment as an alternative to contract, with mechanisms of policing based on power to enforce commitments. In this respect governments are fundamentally different from either markets or the other participants in market activity.

5.3 Finance, econophysics, biology, law and the renewal of institutions

The three essays have focussed on the central role money and the development of financial institutions as a control mechanism for the economy.

The body of the economy with its economic activities provides and utilizes the products that support society. Money and financial institutions provide not only the neural net of the body economic but connect and subserve it to the sociopolitical direction of that society where the never ending philosophical problems of fairness, equity, efficiency, transferability, measurability and comparability (all of which are still in the domain of the theorists and philosophers) are manifested in fresh party platforms where their operationalized versions are presented by politicians and their advisors, often with neither the knowledge nor the care that economic theorists were aware of and had discussed the subtleties and pitfalls one or two hundred years ago.

The financial institutions also serve another basic purpose they provide the perceptual devices in the markets to enable the evaluation of loans, insurance and a whole array of other risks where progress is made towards better resolution, finer grids in time and physical and probability measures. There is an intrinsic drive towards better description and measurement. The Holy Grail of efficient and complete markets may always be there, but it is never attained. Instead in perpetual disequilibrium the institutions change.

It has been said that "Science is measurement", this aphorism is attributed to Henry Stacy Marks[10], however this view has been rightly contested over time . I suggest that science is a combination of ever improving description (as the work of Santiago Ramon y Cajal illustrates) and increasingly accurate measurement, when measurement can be defined usefully. The 'hunting' overshoots in the financial markets and the disclosure and counter disclosure battles in the law courts are brothers to races for scientific discovery.

The search for a final theory of money and financial institutions is clearly in the

[10] A relatively minor English painter (1829-1898)

spirit of the scientific imperative of better and better approximations. We represent our work as a step in the escape from the earlier approximations based on the great and previously useful simplifications of equilibrium and comparative equilibrium studies. The shift in paradigm to process models calls up a different and more dynamic view of the economy with government, money and finance.

6 References

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