The Future of Economic Theory: The FOCUS Paradigm

Arnold Faden

April 21, 1992

I

Organization in FOCUS

Selection Principle

Perfect Adaptation + Perfect Markets

Income concept

Index numbers

Interest rate = growth rate

Constant real interest rate

Martingale wealth share

Theory of Action

Stocks vs. States

Causality

Calculus of Values

Substitutes - Complements

Value aggregation

Organization

Transmission through time

Parts + Wholes

Hierarchies

Internal organization: Bounded rationality

Ethics, Loyalty, Conscience

Construction of organizations: the State + other Institutions

Imperfect Markets

Macroeconomics: Money, Liquidity preference, Unemployment

Risk aversion

Interest rate spectrum

Implicit valuation

Other social sciences

Individuality

Imperfect Adaptation

Wealth redistribution

Growth rate spectrum

Learning, Tracking, Imitation

Client organization

Knowledge Industry

Knowledge distribution

Statistics, Econometrics and Methodology

Bayesian inference

Role of models

II. Suppose at each time $t = 1,2,\ldots,$ an agent must choose between two options, which (increase, decrease) his wealth by 1%, respectively. The probability of choosing "increase" is $(1 + r)/2$, where r is a parameter that varies across agents. (r lies between -1 and +1). Successive choices are independent.

<u>Theorem</u>: At time T, (expected wealth/initial wealth) $= (1 + .01\ r)^T \doteq e^{rT/100}$

<u>Proof</u>: Let $x_1,..x_T$ be iid random variables taking values (1.01, .99) with probabilities p, 1-p, $p = (1 + r)/2$. Then $E(x_1x_2\text{--}x_T) = E(x_1)^T = (1 + .01r)^T$ QED

Comments
1. As T gets large, wealth shifts overwhelmingly toward the highest r that anyone possesses (Fig. 1)
2. This argument seems almost obvious - that's just the point!
3. If learning is present, the selection process toward high r goes even faster
4. If there is an upward tilt--so that the choice is between say +5%, +3% instead of +1%, -1%--the same conclusions follow for <u>relative</u> wealth levels
5. The outcome is that what may start as a trade-off between wealth and, eg., pleasure, becomes a positive association: (Fig. 2)
6. This process occurs without any agent needing to consciously pursue wealth as a goal (cf. the natural world and gene propagation).
7. This process applies just as much to households as to firms, though the outcome tends to be slower for the former, due to long gestation periods, uncertain technology, and remoteness from the market (human capital)
8. The content of the selection principle involves wealth, so there is a feedback effect from the economy (also, who or what is an agent depends on institutional structure - see Organization)

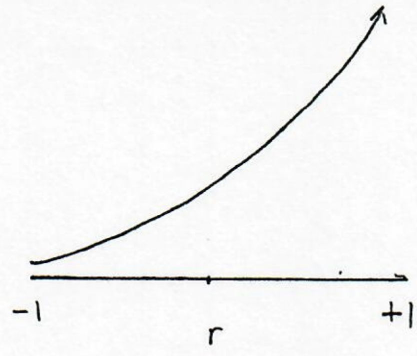

Figure 1

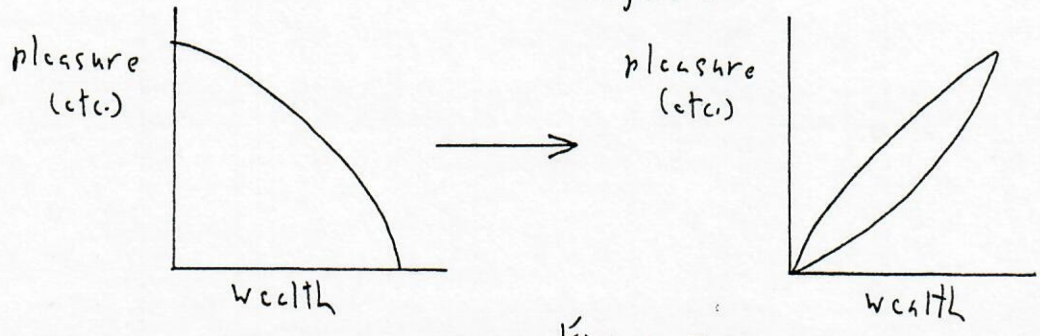

Figure 2

III. Perfect adaptation is the hypothetical situation where all agents (firms, households, etc.) are "maximizing long-run profits" (but cf. the theory of organization below). We discuss some consequences.

The income concept:

1. For firms, income and saving are the same thing, namely, change of wealth. For households, they differ by "consumption" which leads to all kinds of paradoxes (eg. breaking your leg raises national income). Is there a way out?

2. There is: Let income = saving = change of wealth for all agents. For households, wealth includes people themselves, so additions to human capital are included in income, while consumption is subtracted.

   It may be argued that "consumption" is included in income solely as a proxy for the unmeasured human capital accumulation. (When you can't measure output, use inputs. Government output is also measured this way). The paradoxes arise when the proxy is obviously doing a poor job.

3. Isoquants and indifference maps. By the same logic, a household's indifference map is to be interpreted as its isoquant map for the production of "human capital". The utility function $U(x_1,--,x_n)$ is the household's production function in terms of its flow inputs: food, fuel, etc. (This paragraph will take getting used to.)

IV. Assume perfect markets in continuous time. Let $p_i(t)$ be the vector of prices at time t in terms of unit of account i at time t, and let $r_i(t)$ be the i-own interest rate at time t. $(1 + r(t)\Delta$ is the $t + \Delta$-unit of account price of the t-unit of account, for Δ small)

Now let i,j be two units of account, and let $\pi(t)$ be the i-price of j at time t (π is a positive C^1 function, $\dot{\pi} = d\pi/dt$)

Theorem: $r_i - r_j = \dot{\pi}/\pi$ at each time t

Proof: One j-unit at t converts to $\pi(t)$ i-units at t, which converts to $\pi(t)\ (1 + r_i(t)\Delta)$ i-units at $t + \Delta$. Also, it converts to $(1 + r_j(t)\Delta)$ j-units at $t + \Delta$, which converts to $(1 + r_j(t)\Delta)\ (\pi(t) + \dot{\pi}(t)\Delta)$ i-units at $t + \Delta$. Equate these and let Δ -->0. QED
(Note this is the same as the covered interest arbitrage argument.)

Now let x(t) be a vector of weights at time t (e.g. stocks), and define

$f_i = (\dot{p}_i x)/(p_i x)$ = rate of inflation in i-units

Theorem: $f_i - f_j = \dot{\pi}/\pi$ (π is the i-price of j)

Proof: $p_i = \pi p_j$, so $\dot{p}_i = \dot{\pi} p_j + \pi \dot{p}_j$ Substitute and simplify QED
(Note: This is not the purchasing power parity argument since the price indices f_i are global, not local).

<u>Theorem</u>: $r_i - f_i = r_j - f_j$

<u>Proof</u>: previous 2 theorems

It is natural to define $r_i - f_i$ as the <u>real</u> interest rate, which is shown to be independent of the unit of account.

Also (if the x(t) are interpreted as stocks) define $(p_i\dot{x})/(p_i x)$ as the <u>real</u> growth rate. (This is also independent of the unit of account).

V. Now assume perfect markets in continuous time <u>and</u> perfect adaptation. (This model functions here somewhat like general equilibrium theory, but is much less central for us.)

Choose some unit of account. Let r(t) be the (own) rate of interest, p(t) the price vector, and w(t) the "wage" vector (the earnings per unit time of units of the various resources).

The basic equation of capital theory must be satisfied (Samuelson, 1937):

$$rp = \dot{p} + w \tag{1}$$

Let x(t) be the vector of stocks. Total income is wx, and total production is $p\dot{x}$. These must be equal (the basic social accounting identity):

$$wx = p\dot{x} \tag{2}$$

<u>Theorem</u>: (1) and (2) imply: The (real) interest rate = the (real) growth rate

<u>Proof</u>: $rpx = \dot{p}x + wx = \dot{p}x + p\dot{x}$, so $r = (\dot{px})/(px)$. Also real interest rate $= r - (\dot{p}x)/(px) = (p\dot{x})/(px) =$ real growth rate. QED

<u>Index numbers</u>:

In part IV, the inflation rate f_i could be defined in terms of any weight vector x. However, here x <u>must</u> be the vector of stocks (wx is total income only if x is stocks, and of course real growth rate is in terms of stocks).

In practice, inflation rates (and the price index numbers obtained by chaining them ($\exp\int f_i$)) are always measured using <u>flows</u> as weights. It is curious that in the vast literature on index numbers, no one seems to have been bothered by this. One problem is that flows can be both positive and negative, which can be paradoxical: a rising price yielding a falling price index. This already shows there is something wrong.

Conjecture: The only "theoretically meaningful" index-numbers are those using stock weights. (Existing index numbers underweight durables relative to non-durables, and are excessively volatile relative to the true index numbers).

The theorem above generalizes to local sectors. Let x be the stocks owned by some agent, and let e be the vector of net exports (per unit time). Also let B be the agent's net creditor position. Then

$$\text{total production} = p(\dot{x} + e) = wx = \text{total earnings} \tag{3}$$

(This generalizes (2)). Also $\dot{B} = rB + pe$
(Credit rises by interest earnings plus balance of trade). Hence

$$r(px + B) = \dot{p}x + wx - pe + \dot{B} = \dot{(px + B)}$$

Thus all sectors grow at the same rate in value terms. (Constant growth rates across space. Quantities or prices separately need not be growing steadily of course).

<u>Uncertainty</u>

Another way of phrasing this last conclusion is this: Each sector has a constant fraction of the total pie, in terms of wealth. With uncertainty, the natural generalization is: The share of any sector is a martingale process.

<u>Theorem</u>: Suppose information is common, and current wealth is the expected present value of future wealth. Then an agent's share is a martingale.

"<u>Proof</u>": Let $v_i(t)$ be agent i's wealth at t, and v(t) total wealth at t; let R(t) be the interest factor for time o to t ($R(t) = \exp \int_o^t r$). Then, in terms of information at time o ($v_i(o)$ and $v(o)$ being known),

$$v_i(o) = E(v_i(t)/R(t))$$

Hence for the share s_i,

$$s_i(o) = v_i(o)/v(o) = E(v_i(t)/v(o)R(t)) = E(v_i(t)/v(t)) = E(s_i(t))$$

by the equality of interest rates and growth rates.

VI. The calculus of values

This refers to the valuation of complex wholes. In general, for an object A, v(A) is the loss resulting from the disappearance of A. Now consider objects A and B. v(AB) is the loss if both disappear. If A disappears, the valuation of B is v(B~A) ("B absent A"), which is not necessarily v(B): Thus v(AB) = v(A) + v(B~A)

$$\text{A,B are} \left\{\begin{matrix}\text{complements}\\ \text{independent}\\ \text{substitutes}\end{matrix}\right\} \text{iff } v(B\sim A) \left\{\begin{matrix}<\\ =\\ >\end{matrix}\right\} v(B), \text{ iff}$$

$$v(AB) \left\{\begin{matrix}<\\ =\\ >\end{matrix}\right\} v(A) + v(B)$$

These concepts extend to any number of components:

$$v(ABC) = v(A) + v(B\sim A) + v(C\sim AB) \quad , \text{etc.}$$

One case is familiar: If A,B,C, are homogeneous small doses ("drops of water"), the valuation gives the area under the (stock) demand curve for water (Fig. 3). The above generalizes this to possibly heterogenous objects in discrete lumps.

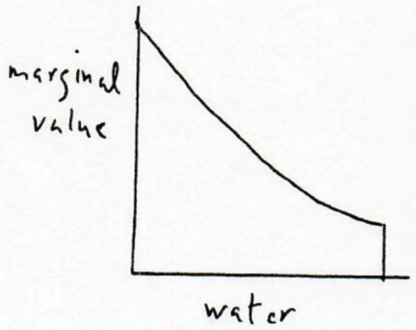

Figure 3

Comments

1. The calculus of values is analogous to the calculus of probabilities in the decomposition of joint probabilities into marginals and conditionals.

2. Each agent or organization has a valuation function like the above. It is natural to define a private good as one valued at zero by all non-owners, and a public good as one with multiple (positive) evaluations.

3. It is also natural to define social value as the sum of valuations by agents - e.g. military equipment is valued positively by its owners but negatively by potential enemies ("pecuniary externalities").

4. The non-additivity of values ($v(AB) \neq v(A) + v(B)$) obviously has something to do with the concepts of economies or diseconomies of scale or scope. Indeed, one aim is to replace these latter ill-defined and misused terms.

VII. The theory of action

There are two basic ways of representing economic activity: (a) In continuous time as $F(x,\dot{x}) = o$, x a vector of stocks, $\dot{x}$ of flows. (b) In discrete time as $F(x_o, x_1) = o$, connecting an initial and final vector of stocks. Neither is completely satisfactory. The latter leaves out intermediate stages. In general, as intermediates are filled in, the number of resource-types grows without limit. (Think of a ball rolling on the floor or a tree aging. Each position or age is a different resource-type). In the limit, production is a continuous change of state and cannot be represented directly by a function of the form $F(x,\dot{x}) = o$ where the x's are stocks (Try it for the aging tree!)

There is a formal solution to this: the theory of generalized functions. I cannot elaborate here.

Comments:

1. Initial and final vectors x_o, x_1 are usually chosen where markets exist (buy x_o, transform to x_1, then sell). The continuum of intermediate stages in general have no market. Thus the vast majority of resource-types even in the present do not have markets (and of course the situation is worse with futures markets as many have noted).

   This indicates the pervasive importance of imperfect markets, since the limiting case of imperfection -- no market at all -- is actually the mode.

Causality concept:

The simplest notion is: x causes y if $\dot{y} = F(--x--)$: x enters into the law governing the change in y. The trouble is that x and y refer to system states and rarely to stocks, which are needed for economic theory. Generalized functions can disentangle this knot.

A further problem is that economic actions can themselves create, destroy or modify causal connections (e.g. by assembling parts into wholes). This leads to the theory of organization.

VIII. Imperfect adaptation

We relax the perfect adaptation assumption (The next section relaxes the perfect markets assumption). Thus different agents have palpable "non-pecuniary" behaviors, and r in Theorem 1 has a non-trivial distribution of values. As a result, different sectors grow at different rates, and a systematic redistribution of wealth occurs (as opposed to the "random" distribution occurring under a martingale regime).

Imperfect adaptation typically arises from a behavioral strategy no longer appropriate to changed circumstances (e.g. obsolete skills). This yields a class of "tracking" models in which one learns the new circumstances and adapts accordingly.

A second class of models arises from "imitation" of the more successful by the less successful.

A third class involves organization theory, in which the less successful become "clients" of the more successful.

Learning occurs on two levels: (1) The adaptation of means to ends, in which wealth is a universal means for whatever ends you desire. (2) Learning in the cognitive sense, which (ideally) takes the form of Bayesian inference, which is itself a martingale process. (The selection principle is isomorphic to Bayesian inference - the "competition of ideas").

Diversity of "cognitive states" leads to redistribution of wealth toward agents with more accurate beliefs about the world. ("Accuracy" is multidimensional, embracing better probability distributions, richer conceptual schemes, better perceptions, more efficient information processing and better problem-solving abilities).

IX. Imperfect markets

We have noted that most potential markets do not exist, even in the present, let alone the future. In general, even existing markets are imperfect, due to transaction costs, quality uncertainty, searching costs, institutional barriers and asset specificity.

Generalizing to imperfect markets allows the incorporation of the other social sciences, which deal (almost by definition) with the side of human existence not involving markets.

Further, it allows the integration of macro- and micro-economics. Macroeconomics is not (merely) the aggregation of micro-relations, but is what the world begins to look like when the implications of imperfect markets are taken seriously. For one thing, money and the finance industry are in no sense aggregations of anything else, but arise to reduce frictions in trade and credit.

Perfect markets involve the existence of multiple identical substitutes. But in the real world no two things are identical (they differ at least in location): Taking <u>individuality</u> seriously requires imperfect markets.

A special problem arises in the credit market (the money-rental market) since the lender needs some assurance of being repaid. Perfection is impossible here even in principle. Firms and households are treated alike in the credit market, terms depending on character, collateral and credibility in both cases. (The lifetime budget constraint for households is fictitious).

Here is a simple picture of the credit market incorporating these ideas. All credit is for one period. At the beginning of the period the agent chooses Q_o, net loans outstanding ($Q_o<o$ for a borrower). This gets transformed to Q_1 at the end of the period. In a perfect market $Q_1 = (1 + r)\ Q_o$, where r is the interest rate. In general, $Q_1 = F(Q_o)$, F being a concave function through the origin. (Fig. 4)

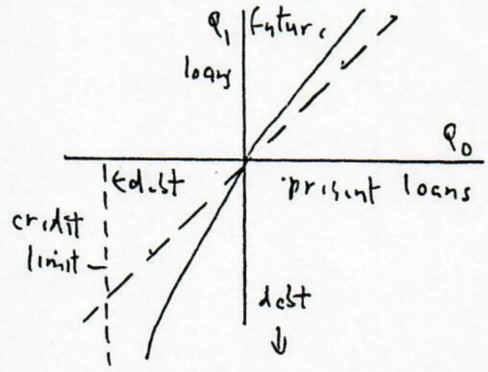

Figure 4

(Further, there is an upper limit to borrowing: $Q_o \geq -L$). Function F depends on personal characteristics of the agent, such as net worth, liquid assets and collateral. Concavity in the negative Q_o range arises from lenders' greater risk of default (partial or complete) with greater lending. It also depends on general business conditions: "tightness of credit".

<u>Risk aversion</u>

Risk aversion (= strictly concave utility function of money, income or wealth) is a common assumption, but there is a basic argument against it: It is selected against relative to risk neutrality, in the sense that an ever larger expected share of future wealth accrues to the latter relative to the former.

On the other hand, a large number of phenomena seem to require explanation in terms of risk-aversion: Buying insurance, diversification of portfolios, higher expected yields for riskier securities, and a rising yield curve. We will argue that these phenomena are all not only compatible with risk-neutrality and the selection principle, but actually implied by them in the presence of market imperfection.

Let x_1, $--x_n$ be the quantities of assets owned by an agent. (For physical assets these are stocks. For financial assets they may also be thought of as notional "stocks" in the sense that, in transactions among agents they are universally treated as if they were stocks - e.g. successive bank deposits are added together. Financial assets may be negative -- i.e., liabilities).

Conventional accounting evaluates total wealth as $\Sigma p_i x_i$. But with imperfect markets this is not correct. Write $V(x_1, --, x_n)$ as the agent's total wealth, in the spirit of the calculus of values. Suppose <u>next</u> period's wealth is evaluated conventionally, as $\Sigma p_i(t+1)x_i(t+1)$, and suppose the agent faces a credit curve as in Fig. 4. Then, holding all else fixed, next period's wealth is a concave function of this period's net creditor position. Since present wealth is a reflection of future wealth, V is a concave function of net creditor position.

But why should next period's wealth be evaluated additively? Doesn't it in turn reflect the still more distant future? Suppose wealth T periods in the future is evaluated conventionally (T large). It appears under fairly general conditions the "concavity" effect propagates: $F_1(F_2(--F_T(x)))$ is an increasing concave function if each F_1, ---, F_T is an increasing concave function. Thus, fairly robustly, V is a concave function of net creditor position--and, by extension, of each financial asset separately.

But then a truly risk-neutral agent who maximizes expected future wealth will maximize $EV(x_1, --x_n)$, where V is a concave function of present financial assets. The agent then acts <u>as if</u> he were risk-averse. This analysis holding for all agents, the familiar phenomena of insurance, diversification, etc. will appear.

Doesn't this amount to smuggling risk-aversion in by the back door after throwing it out the front? No:

1. The phenomena are now endogenous, following from first principles, rather than from an unexplained "fact" about preferences (which contradicts first principles).

2. Predictions are different. Consider credit conditions over the business cycle. During recoveries credit eases (Fig. 4 straightens out). The result should be that apparent risk-aversion declines, so that, e.g., $r_s - r_b$ declines toward zero, where r_s, r_b is the rate of return on stocks, bonds, respectively (thus a more-than-proportionate stock-market boom during recoveries). The pure risk-aversion approach could explain this only by a mysterious cyclical change in tastes.

<u>Liquidity Preference</u>

This is related to but distinct from the risk-aversion phenomenon, and refers to the fact that selling, like all other activities, takes time. In general, there is a trade-off between time and return (Fig. 5), which may take the form of active promotion (selling effort) or simply waiting. The problem is in principle no different than that with growing trees or aging wine.

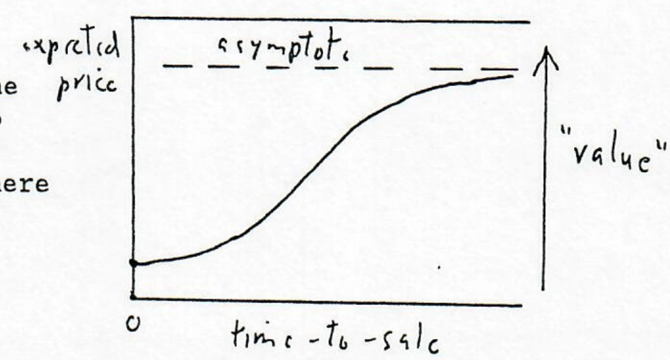

Figure 5

The expected price rises to asymptote $\bar{p}$, which is $\le$ "value" of the object. ($p <$ value indicates agent-specificity, as with installed machinery or old slippers.)

"Liquidity" refers to the speed with which the selling curve in Fig. 5 rises. Money is any asset that starts immediately at its full value.

Fig. 4 needs supplementing with a time dimension. Selling liabilities (e.g. bonds or promissory notes) has a selling curve as in Fig. 5: longer wait trades for higher price (= lower interest rate).

In general, more liquid assets will earn lower rates-of-return than less liquid, since the former provide an insurance buffer against forced sale of the latter. A liquidity crisis, which is also a credit crisis, raises the rate-of-return differential.

These differentials arise from the principle of maximizing expected future value. Thus both liquidity preferences and "risk aversion" come from the same source, and should be considered jointly.

There are two basic sources for the selling curve of Fig. 5. First, there are delays in the advent of potential buyers. Second, buyers need time to learn the value to themselves of what the seller is offering.

(This reflects a basic information-asymmetry between A selling a good or service to B in exchange for money: A knows what he is getting from B, but B is not sure of what he is getting from A. This is reflected in firm's sales departments being much more important than purchasing, countries' efforts in promoting exports, "job creation", etc. In centrally planned economies this asymmetry is reversed - " economics of shortage").

Note that unemployment--in the general sense of idle inventories of resources--is a consequence of the selling curves of Fig. 5.

<u>Imputed Values</u>

Perfect markets provide valuation information for the resources passing through them. Missing markets do not, but agents may still impute these values as a guide to action. There are two kinds of values: prices and rental values, corresponding to the p and w of equation (1). (Interest rates are a special case of rental values: set p ≡ 1 in equation (1)). These implicit values obey the basic equations of capital theory: first, equation (1), the present value formula; second, implicit rental value is the value of the marginal product. (The exact meaning of "marginal product" is by no means obvious, and requires the theory of action for its explication).

These imputed values are connected to actual market prices in the future insofar as the products of these resources eventually pass through actual markets, or in turn produce other things which pass through actual markets, etc.

X. Organization

The selection principle refers to the tendency for agents' traits to become correlated with wealth production, so that they tend to act as if "maximizing profits". But the content of this principle requires an answer to the question: what is an agent?

Economic theory usually identifies agents with individuals, though there are recent developments taking account explicitly of the composite nature of families, unions, firms and the state, with diverse interests and/or information.

Combining the selection principle with agents as isolated individuals runs into problems. For one thing, the principle operates as a long-run tendency (perhaps very long-run), while the individual soon dies. To operate successfully, the selection principle must operate well beyond the range of a single life, on traits that are passed along by inheritance, imitation or tradition. It must operate on organizations extending through time (e.g. family dynasties).

Consider a group of family lines, all equally adept at accumulating wealth within single lifetimes (all of equal length), and each line characterized by a different parameter f, the fraction of wealth handed down to the next generation ($o \leq f \leq 1$). After n generations, a line with parameter f will have relative wealth proportional to f^n. Thus there is selection toward high f. (cf. Theorem 1. If in addition "learning" to modify behavior toward higher f occurs, the selection process is accelerated.)

The argument of the preceding paragraph supports the following conclusion. Organizations through time are themselves selected for greater efficiency of the transmission mechanism (which in turn allows the selection principle in general to work).

<u>Parts and Wholes</u>

Consider a group of <u>pairs</u> of agents A, B having a distribution of traits x, y, respectively, such that the income of each is enhanced by higher values of the <u>other's</u> trait, and this symbiotic effect is enhanced by higher wealth. Then there is a selection toward higher x and y because of their indirect or feedback effect: each agent enhances its enhancer.

This phenomenon can extend to more than two agents. The limiting case is that of <u>perfect integration</u> into an organic unity (modeled by the organs of the body mutually supporting each others' existence). A perfectly-integrated organic unit has complete harmony of interest among its parts and may be thought of itself as a single (super-) agent in its own right. As such it may enter into connections with other (super-) agents, leading to the hierarchical organization characteristic of existing institutions and communities.

The selection principle operates on super-agents just as on ordinary agents, shaping then toward wealth-maximizing behavior. The parts of this unity may then behave in ways described by love, loyalty, charity and patriotism toward each other and toward the whole.

<u>Imperfect Integration and Bounded Rationality</u>

Perfect integration is an ideal limit not found in the world. Existing organizations are all imperfectly integrated, which gives rise to phenomena similar to that discussed above in VIII, imperfect adaptation.

In particular, ordinary people have an internal organization which is not perfectly integrated--as indicated by inconsistent preferences, emotional reactions, limited information-processing capacity, and bounded rationality in general.

Note that these phenomena (in principle) may be treated endogenously, as an outcome of "internal costs" within the human psyche.

XI. The Knowledge Industry, Methodology and Econometrics

Knowledge production is one industry among others. Economics is one of its branches. The industry is organized in terms of professions. The output consists of journals, books, papers, and, ultimately, of changes in people's cognitive states.

Most of the markets for this industry are missing, so that, as in all cases of this sort, a system of imputed valuations has arisen, involving some incomplete degree of consensus among the workers in each branch: the "seminality" of ideas, or, more crudely, the number of pages published. (A rough model of the knowledge industry would have its workers maximize publications, just as politicians are supposed to maximize votes, bureaucrats the size of their budgets, etc.)

Statistics is that branch of the knowledge industry which provides canons of acceptable treatment of empirical data for the other branches. (The other branches invariably modify these canons for their own purposes; econometrics is the modification of statistics adapted to economics).

As in any industry with imperfect markets, there are distorted incentives and inefficiencies in the knowledge industry in general, and in its economic branch in particular. We will concentrate on the econometric canon.

Non-econometricians, including journal editors, do not have the time or inclination to examine the foundations of inference critically. What they need is a "cookbook" of fairly simple procedures and conceptual tools for handling data -- e.g. ordinary significance tests at conventional significance levels.

If one does go more deeply into the foundations of statistics, one finds that almost everything is unsettled, up to and including the concept of probability itself. Standard statistical procedures have been subjected to withering criticism -- e.g. by Lindley, Savage, Berger, Jaynes, Leamer, et. al. All of these criticisms have been in terms of the internal coherence (or incoherence) of procedures, however. We propose to go beyond this and think of statistics in terms of the role it plays in the knowledge industry.

In effect, this approach endogenizes statistics (and its sub-branch, econometrics) into economic theory. The value of statistical procedures reflects the expected real social value of the "theses" they help produce.

This requires taking account not only of the internal coherence of procedures, but of the social and psychic context in which they operate -- the bounded rationality (limited informational capacity) of the human mind, and the behavior of writers, readers and editors in the knowledge industry.

Internal coherence alone leads to Bayesian inference. To grasp the issues it is necessary but not sufficient to understand Bayesian inference: other considerations, such as simplicity of models and the need for "objective" consensus, also enter.

XII. Bibliography

I will list just my own work. The full bibliography would be large: Just about all of the 101 innovations listed below fit somewhere into this framework.

"Natural selection, economics and probability," 579-607, Essays in Honor of Karl A. Fox (Elsevier, 1991).

"The foundations of probability," 195-213, Operations Research and Economic Theory: Essays in Honor of Martin J. Beckmann (Springer, 1984).

Economics of Space and Time (ISU Press, 1977).

(with G.C. Rausser) "Econometric policy model construction: the post-Bayesian approach," Ann. Econ Soc. Meas., 5:349-362 (1976).

<u>101 Innovations in Economic Theory</u>

(* means: compatible with general equilibrium)

* Computable general equilibrium (Whalley, Scarf)
* Social accounting matrices (Pyatt)
Implicit contracting (Stiglitz)
Market signaling (Spence, Arrow)
* Rational expectations (Lucas, Sargent, Muth)
Lemons (Akerlof)
Bargaining (Rubinstein, Stahl)
Games in imperfect competition (Kreps, Tirole)
* Policy consistency (Kydland-Prescott)
Efficiency wages (Yellen, Shapiro-Stiglitz)
Price information (Stiglitz, Grossman)
* Insurance (Kihlstrom, Borch)
* Public debt neutrality (Barro)
Schelling prominences
* Coase equilibrium
* Human capital (Becker)
Firm structure (Coase, Williamson, Alchian-Demsetz, Simon)
Public choice (Buchanan-Tullock, Downs, Stigler, Becker, Olson)
Rent-seeking (Krueger, Tullock)
X-efficiency (Leibenstein, Simon)
Economics of law (Posner)
Scale economies in trade (Krugman)
Cash-in-advance (Lucas, Clower)
Capital rationing (Stiglitz-Weiss)
Internal labor markets (Doeringer-Piore, Snower, Lindbeck)
Sunspots (Azariadis)
* Lucas critique
Disequilibrium markets (Barro-Grossman)
* Options pricing (Black-Scholes)
* Division of labor (Rosen, Romer)
Turnpike theorems (Samuelson, McKenzie)
* Overlapping generations (Samuelson)
* Corporate structure neutrality (Modigliani-Miller)
* Flexible functional forms (Diewert)
Natural selection (Alchian)
* Selection bias (Heckman)
Crime (Becker, Peltzman)
* Martingale finance (Samuelson)
Fertility (Becker, Nerlove)
* Migration (Harris-Todaro)
* Family structure (Becker)
* Discrimination (Becker)
Non-equilibrium Von Neumann models (Sato, Samuelson)
Reputation (Kreps-Wilson, Milgrom, Roberts)
Bounded rationality (Simon)
Incentive compatibility (Groves, Clarke, Arrow, Laffont)
Induced innovations (Kennedy, Samuelson)
Real business cycles (King-Plosser, Kydland-Prescott)
* Common knowledge (Aumann)

* Correlated equilbria (Aumann)
* Bayesian games (Harsanyi)

Bubbles (Kindleberger)

* Scope economies (Baumol)
* Stochastic dominance (Allais, Stiglitz-Rothschild)

Search (Stigler, Mortensen, Rothschild)

Public investment criteria (Arrow-Lind)

Diffusion of technology (Griliches, Mansfield)

Learning-by-doing (Arrow)

* Irreversible actions (Fisher, Arrow)

Price adjustment (Arrow)

Price volatility (Shiller)

Institutional unplanned organization (Hayek, Schotter, Demsetz)

Biological economics (Hirshleifer, Boulding)

Staggered contracts (Fischer, Taylor)

Regulation (Stigler, Peltzman)

Communist economics (Kornai)

Learning rational expectations (Townsend, Bray)

* Adjustment costs (Lucas, Treadway)

Auctions (Milgrom, Vickrey, Maskin, Wilson)

* Inventories (Arrow, Marschak)
* Commodity storage (Newbery-Stiglitz)

Moral hazard (Pauly, Arrow)

Political business cycles (Nordhaus)

* Hedonic prices (Griliches, Rosen)
* Local public goods (Tiebout)
* Quantitative history (Fogel)
* Product variety (Dixit-Stiglitz, Lancaster)
* Welfare aggregation (Harsanyi)
* Economic rhetoric (McCloskey)
* CAPM (Sharpe, Lintner)

Constitutional design (Hayek, Buchanan)

Property rights (Demsetz, Coase)

* Resource economics (Clark, Dasgupta)

Second best (Lipsey-Lancaster)

Clubs (Buchanan)

Teams (Marschak-Radner)

Evolutionary stable strategies (Maynard Smith)

Ramsey taxes (Baumol-Bradford)

* Permanent income (Friedman)

Origin of money (Jones)

Agency (Jensen-Meckling, Fama)

Reciprocal altruism (Trivers)

* Entitlements (Sen)

Black-hole tariffs (Brock)

Neighborhood dynamics (Schelling)

Conflict and defense (Boulding)

Medical economics (Arrow)

Firm evolution (Nelson-Winter)

* Term structure (Meiselman)

New quantity theory (Friedman, Cagan)

Regulated monopoly (Averch-Johnson)