The flying arrow is at rest.
The all is one.

-- Zeno of Elea (about 490 BC – 425 BC)

The way gave birth to unity, Unity gave birth to duality, Duality gave birth to trinity, Trinity gave birth to the myriad creatures.

-- Lao Tzu (about 600 BC – 500 BC)

Equilibrium Illusion and Evolutionary Foundation in Economic Theory

Ping Chen

China Center for Economic Research at Peking University in Beijing, China
http://bbs.auto.sohu.com/r-car-603050-0-12-0.html
pchen@ccer.edu.cn
http://pchen.ccer.edu.cn/

And

Center for New Political Economy at Fudan University in Shanghai, China


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Abstract

It is widely believed that equilibrium framework based on optimization and representative agent model provides a consistent framework in micro, macro, finance, and institutional economics. However, new discoveries based on non-linear non-equilibrium methodology revealed unrealistic theories and weak evidence of equilibrium economics. The self-stabilizing market and institutional convergence are far from industrial economy with nonlinear interaction and social behavior. The new science of complexity offers powerful tools for developing quantitative framework of
evolutionary economics. Both computational and natural experiments shed new lights on future development of evolutionary dynamics.

Key Words: equilibrium, evolution, linear, nonlinear, representative agent, social behavior.

I. Introduction

During the turn of millennium, I had an exchange with late Herbert Simon, a Nobel Laureate in economics and a critic of neoclassical economics, on what was the unsolved issue in economics. Simon thought that mainstream economics used too much mathematics and my response was that economics used too narrow mathematics. By “narrow mathematics,” I was thinking about the lesson from Einstein. Before relativity theory developed, scientists widely believed that Euclid geometry was the only choice for geometry in real world. But Einstein enlightened us that there were infinite possibilities of geometric system. Which geometry is relevant to our world should be an empirical question, which should be free from constraints in ideology or aesthetics.

Today, economics faces a similar situation like classical physics, or more exactly, the astronomy before Copernicus. It is widely believed among many economists that equilibrium economics provides a consistent framework in economics, which is capable in explaining almost everything from demand and supply in micro, money and unemployment in macro, corporate finance and asset pricing in finance, even firm and law in institutional economics. There are only two clouds in the sky: the persistence of business cycles and the recurrence of conflicts and wars. But mainstream economists have good reason to ignore the minority camp on one ground that heterodox economics is underdeveloped, simply because they do not use elegant math models as their main language.

Things have been changed since the emergence of new science of complexity. The beautiful mirage in equilibrium economics is built on only three pillars: the linear curves of demand and supply, the representative agent model, and the Frisch model of noise-driven cycles. The major testing ground is regression analysis in econometrics. Since 1980s, better tools are developed in empirical analysis: nonlinear dynamics and non-stationary time series analysis in dealing with complex systems such as biological and economic dynamics. Newly discoveries have shocked the very foundation of neoclassical economics. Many widely believed equilibrium theories are purely theoretical illusions, with little empirical evidence. Some most influential theories are essentially new kinds of perpetual motion machine against the basic laws in physics. In this short article, we will briefly discuss two beliefs and some illusions in equilibrium economics: the believes in self-stabilizing market and institutional convergence; and math illusions including the unique stable equilibrium in demand-supply curves and the Arrow-Debreu model, the Frisch model of noise-driven cycles, the Lucas model of microfoundations and rational expectations, the Coase world of zero-transaction costs and symmetric bargaining, and the geometric Brownian motion in option pricing.

By equilibrium economics, we mean the simplest version of neo-classical economics, including the assumption of Robinson Crusoe economy, the optimal condition of convexity or non-increasing return to scale, the concept of perfect information and zero transaction costs, the first-differencing (whitening) filter in econometrics.
Many economists did realize limits of neoclassical economics and made many modifications such as asymmetric information, nonlinear demand and supply curve, sticky price, business cycles, psychological frame, irrational behavior, path-dependence, etc. Our approach is developing a unified framework of general economic theory, so that useful observations in current economic theory can be understood as special cases of economic complexity. The good news is: now we do have new math tools in dealing with economic complexity. Nonlinear dynamics is capable of describing history in the forms of chaos, bifurcation, and irreversible process in economic modeling.

Because of time limit, I only discuss basic ideas in major discoveries in past 20 years. We will discuss two basic believes in equilibrium economics: the self-stabilizing market and the conflicts-free society and related illusions in micro, macro, finance, and institution economics in equilibrium approach. Basic references are also given for further studies in empirical and theoretical analysis.

II. From Methodological Debate to Fundamental Thinking in Economic Complexity

The strong link between mathematical simplicity and equilibrium thinking is a major source in economics. I would like to share my own experience with fellow economists in understanding the nature of equilibrium economics.

I was trained as experimental and theoretical physicist. When I began searching empirical evidence of economic chaos in 1984, I had no idea about conflicting economic schools of thoughts. When I discovered the first empirical and theoretical evidence of monetary chaos and later color chaos from stock market indexes, our discoveries received warm response from physicists, biologists, Austrian and Keynesian economists, but cool reaction from mainstream economists and fierce opposition from leading econometricians.

At the surface, most of debates were concentrated on technical issues: noise vs. chaos, linear vs. nonlinear detrending, deterministic vs. stochastic models, etc. After more technical progress, the central issue shifted to basic issues in economic order. We found that equilibrium economists share fundamentally different view of world order. For physicists and biologists, life is better described by cycles, essentially major physics models from planet motion, crystal to atom, from classical mechanics to quantum mechanics is based on the simple model of harmonic oscillation, and so-called chaos model is simply a more general model of nonlinear oscillator. Brownian motion only plays a minor role in ideal gas without interactions. But for economists believing in laissez-fair policy, the normal economic order is an equilibrium state plus some random noise.

We should point out that poor theoretical modeling may often be defended by philosophical arguments. For example, equilibrium economists used to pay lip service to individual freedom and diversified choices in market economy. However, if you examine the degree of freedom in idealized model of rational expectations, you are stunned by a simple fact that the most sophisticated equilibrium model in economics is even simpler than the simplest physics model—the ideal gas. We should be careful in evaluating economic theories, not by their claim and beauty, but by their structure and methodology.

III. The Economic Believes and Equilibrium Illusions in Economics

Now, we will piercing layer by layer how this mirage was build up and eventually become policy guidance in deal real world with unexpected disaster.
3.1. The Belief in Self-Stabilizing Market

The central argument for laissez fair economics is the belief in self-stabilizing market.

There are two lines of models arguing for self-stability of market. The static models are supply-demand curves and the optimization model based on convex utility and production functions. The dynamic models are random walk model and the geometric Brownian motion.

Methodologically speaking, the essential difference is between single equilibrium state in linear models and multiple equilibrium states in nonlinear models. The implications for single stable equilibrium is: there is no chance for existence of economic complexity and economic instability, such as persistent business cycles, including excess capacity, unemployment, unsold inventory, financial crisis, etc.

There are several illusions of equilibrium order in equilibrium economics. We will discuss them in turn.

3.1.1. The Unique Equilibrium in Linear Demand and Supply Curves

The most influential illusion among economic students is the self-stabilizer characterized by negative-sloped demand curve and positive-sloped supply curve, which has unique equilibrium. It was first standardized by Marshall by simple geometric diagram, and then it was theoretically derived from utility theory under the condition of non-increasing economy of scale (Marshall 1920, Varian 1984). If unique equilibrium exists in market economy, there is no possibility for persistent cycles and economic chaos.

It was realized even among neo-classical economists that nonlinear demand and supply curves may exist as well as multiple equilibriums. Two economic mechanisms may lead to nonlinear demand or supply curves. Social interactions such as fashion and collective behavior among economic agents will introduce S-shaped demand curve (Becker 1990). Nonlinear limitations will also generate nonlinear demand and supply curves. For example, the subsistence threshold in minimum income and backward tilted curve in high wage will generate Z-shaped labor supply curve. Therefore, multiple equilibriums may occur under nonlinear demand or supply curves, which imply the possibility of cycles and sudden changes in price or output.

3.1.2. The Unique and Stable Equilibrium in Arrow-Debreu Model without Non-convexity, Social interactions, and Product Innovations

The unique stable equilibrium can be further derived from the Arrow-Debreu model based on maximization of utility and production function (Arrow and Debreu 1953, Debreu 1959). Advanced technique such as the fixed point theorem in topology was used to justify the existence and stability of unique equilibrium in the Arrow-Debreu model of general equilibrium.

We should point out that the Arrow-Debreu model has main features in primitive economy and commanding economy, but essentially irrelevant to industrial economy. There are three problems in the Arrow-Debreu model. First, it only permit non-increasing economy of scale, while increasing return to scale and scope is the driving force of division of labor and industrial revolution. Second, no information diffusion occurs among economic agents, so that no space exists for social interactions, such as advertising and strategic behavior. Third, the dimension of commodity space is fixed. In other words, no product innovations are allowed in the Arrow-Debreu model. Forth,
resource limits and market extent have no impacts to economic behavior. All the four missing dimensions are fundamental sources of economic instability and complexity in the form of Schumpeter's “creative destruction.”

3.1.3. The Frisch Utopia of Noise-Driven Persistent Cycles: a Perpetual Motion Machine of the Second Kind

During the Great Depression, Frisch invented a great dynamical fantasy to save the collapsed confidence in stability of market economy. He suggested that persistent cycles could be maintained by a stream of random shocks. This scenario has two attracting features: First, it is inherently stable when there were no external shocks, just like the pendulum with friction, whose oscillation would be damped by friction and reach equilibrium state; second, it attributes persistent business cycles to external shocks, which blames economic fluctuations to external factor, not internal instability.

Frisch made his claim in an informal conference paper on propagation and impulse problem in dynamic economics (Frisch 1933). Equilibrium economists quickly embraced the Frisch model and became a dominating model in business cycle theory, financial modeling, and macro econometrics. However, physicists knew before Frisch that the Frisch Utopia could not be true, since the harmonic Brownian motion had only damped oscillation (Uhlenbeck and Ornstein 1930). In other words, a stream of random shocks is not capable of generating persistent cycles.

The author estimated the possible length of cycles based on US real GDP data. If the US business cycles could be described by the Frisch model, which was called the harmonic Brownian motion in physics literature, American business cycles would only last about 4 to 10 years, which was against the history of American economy. The Frisch utopia implies a perpetual motion machine of the second kind, i.e. an energy generator by random thermal fluctuations or an engine with only one thermal source without release any waste heat at a lower temperature. This engine could not exist since it would violate the second law of thermodynamics (Chen 1999).

More surprisingly, Frisch quietly abandoned his model as early as 1934 but never open admitted his grand mistake in dynamical modeling. Frisch claimed his paper, "Changing harmonics studied from the point of view of linear operators and erratic shocks," already solved the analytical problem and would be soon published. The paper was advertised three times under the category "papers to appear in early issues" in Econometrica, in April, July, and October issue in 1933 respectively. However, the promised paper was never published in Econometrica where Frisch himself was the editor of the newly established flagship journal for the Econometric Society. Frisch never mentioned a word about his prize-winning model in his Nobel speech in 1969 (Frisch 1981). The puzzle is how mainstream economic community embraced a false belief without even checking its formal publication standard for the whole period of mathematical economics and until NOW!

We should emphasize that the Frisch utopia is the VERY FOUNDATION of equilibrium illusion in all dynamical models in macro, finance, and econometrics.

3.1.4. The Friedman Spirits of Risk-Free Arbitrager for Efficient Market Argument

A thought experiment for basic belief in stable and efficient market was created by Friedman in discussing the self-stability of flexible exchange rate regime. The central idea could be characterized by Friedman spirits, which were rational arbitrageurs capable in driving out any irrational (destabilizing) speculators (Friedman 1953). The
implication is that no cyclic patterns or unstable structures could exist in a competitive market. This is the main argument for the efficient market hypothesis in macro and finance dynamical theory.

Friedman spirits behave much like the Maxwell demon in equilibrium thermodynamics. The Maxwell demon is an imaginary gatekeeper trying to create a non-equilibrium order from an equilibrium state by operating a frictionless sliding door between two chambers that are filled with moving molecules. Maxwell assumed that his demon had perfect information about the speed and position of all molecules such that he could only allow a fast molecule into a designated chamber by opening or closing the mass-less valve in perfect timing. In economic language, under the condition of perfect dynamical information, the Maxwell demon could create a temperature difference without doing work, that outcome is contrary to the second law of thermodynamics. The meaning of perfect information is a Coasian world with zero information costs (we will return to the issue in the section 3.2.3).

Friedman spirits face a similar problem as the Maxwell demon but with an opposite task. To eliminate any market instability, Friedman spirits had three troubles in achieving their goal.

First, resource limitation is a severe barrier for market arbitragers in defending speculative winds with positive feedback strategy, i.e. the recurrent market fads by following the crowd (De Long et al 1990). This job is hopeless since foreign reserve in any central bank is limited and quite small comparing to speculative capital in the global financial market.

Second, dynamical complexity sets fundamental limit in replicating strategy in competitive market. Friedman implicitly assumed that a winner's imitator could quickly drive down the profit margin to zero. This strategy could be operational only if the destabilizing pattern were replicable. The sources of dynamical complexity include imperfect information (having only finite data with significant noise and time delays), information ambivalence (in face of conflicting news and distorted information), unpredictable events (such as a financial crisis and changing structure), and limited predictability (non-periodic dynamics such as deterministic chaos or wavelet). The critical issue of information ambiguity is not only associated with bounded rationality but also rooted in dynamical complexity (Simon 1957, Chen 2005).

3.1.5. The Whitening Filter of First Differencing, the Unit-Root and Co-Integration in Econometrics

The Frisch model of noise-driven cycles is formulated in continuous-time differential equations. The discrete-time model and difference equation are widely used in econometrics because of mathematical convenience in regression analysis. The first-differencing (FD) filter is an essential device in creating equilibrium illusion in econometric modeling.

All scientific analysis has a common problem of noisy data resulted from measurement error or complex variables. The common solution is developing filter, which is capable of reducing noise and amplifying signal in the form of deterministic patterns. The only exception is econometrics. The FD filter is a whitening device, which reduce periodic signals in low-frequencies and amplifying noise in the form of high-frequency cycles. All illusionary evidence of efficient market in the form of white noise or Brownian motion, or the fashionable model of unit root and co-integration are all justified by the FD filter. However, counter evidence of persistent cycles and color chaos emerged when we apply the HP filter with nonlinear trends.
and WGQ filter of separating white noise with color cycles. We found out that about 70% of business fluctuations in stock market indexes were generated by color cycles while only about 30% of components were characterized by white noise. Majority of macro fluctuations are also dominated by persistent cycles rather than white noise (Chen 1996a, b).

The question is why econometricians are obsessed by the FD filter and the illusion of white noise. The strange approach of amplifying noise was also rooted in equilibrium perspective. Friedman clearly realized the poor result from the FD filter. He defended the FD filter on the ground that its result was independent of the choice of the period, i.e. independent from beginning and ending point in time history. History does not matter, which is the core message from equilibrium economics. In contrast, the Schumpeter’s picture of biological clock can only be observed from the detrending perspective, where history does matter in non-stationary time series analysis.

3.2. The Belief in Social Equilibrium by Methodological Individualism

The second belief in social equilibrium without conflicts is rooted in methodological individualism. So-called general equilibrium model is essentially based on homogeneous population, whose members have no individual degree of freedom at all. In another words, the Robinson Crusoe economy resembles a slave army like robots. The main methods are the representative agent and bilateral bargaining in equilibrium economics.

Methodologically speaking, the social nature of economic system cannot be described by one-body or two-body problem in economics, since the Principle of Large Numbers will change the qualitative picture in statistic analysis. One powerful indicator is the relative deviation, which is the ratio of the standard deviation and the mean. For positive variables with natural origin, such as population, energy, price, and output, the magnitude of the relative deviation is in the reverse proportion to the square root of the number of population (Schrödinger 1948, Chen 2000, 2005). This is the very foundation for insurance: the larger pool has less relative deviation since individual fluctuations would be cancel out each other. We will see that equilibrium illusions created by representative agent or bilateral bargaining would disappear under statistical picture with a large number of population.

3.2.1. The Lucas Fantasy of Microfoundations and Rational Expectations

The new classical school led by Lucas launched a counter Keynesian revolution in 1970s. Its most influential appeal is calling for microfoundations of macroeconomic fluctuations. Lucas suggested that independent fluctuations at the level of households (e.g., the inter-temporal substitution between work and leisure) would generate large fluctuations at the aggregate level. To achieve his claim, he used a magic device of so-called rational expectations, which could generate a mass consensus on equilibrium wage rate and other mean values of macro variables without any social interactions (Lucas 1972, 1981). We found out that there was weak evidence of microfoundations from American macro indexes. Theoretically speaking, Lucas made two serious mistakes: First, he forgot that relative prices must move in pairs. If many people choose leisure when wage declines, the leisure price would be up and create arbitrage opportunity. Therefore, rational expectations will subject to Lucas critique itself and turn into a self-defeating belief. Second, he did not understand the Principle of Large Numbers. There is an essential difference between the one-body and many-body problems. In fact, the Lucas island economy was a disguised model of representative
agent, even though it claimed to have a large number of agents (Chen 2002).

Based on American macro indexes, the magnitude of the relative deviation of macro indexes is in the range of 0.2 to 1 percent; its implied number (which is capable of generating such as relative deviation) is between 200,000 and 6,000. How can we associate these figures with the actual numbers in the US economy? According to the U.S. Bureau of Census, there were 81 million households, 3 million corporations with more than $100,000 in assets, and about 20 thousand public companies in 1980. We found that the observed implied numbers of the US macro indexes are several hundred times smaller than household or firm numbers. In another words, the observed relative fluctuations are at least 20 times larger than the magnitude predicted by the microfoundations models in labor or producer markets.

There are several implications based on the analysis of relative deviations.

First, the representative model in business cycle theory is not valid, since the observed implied numbers are much larger than one.

Second, fluctuations in households or firms are not capable of explaining large relative deviations in aggregate output, consumption, business hours, or investment.

Third, fluctuations generated by financial intermediaries and industrial organizations are the only possibility of generating large business fluctuations since they have smallest number of agents comparing to households and firms. In other words, a market economy is better described by three layers: micro-meso-macro, not two layers of micro-macro. The roots of persistent business cycles lie in the intermediate structure. The financial Keynesian led by Minsky is right but new classical school led by Lucas is wrong (Minsky 1975).

The Lucas model of rational expectations in macro was based on the Becker model of inter-temporal substitution between goods and leisure in micro (Becker 197?). One lesson from the failure of the Lucas model is that macro behavior cannot be a simple extension from micro behavior. Why? According to basic principles in statistical mechanics, there must be a distribution of behavior among a population with large numbers. In the Lucas island economy, identical agents believe and act in perfect correlation under rational expectations like a robot army. If these agents have individual freedom of choice, arbitrage activity will eliminate correlations among individual fluctuations. Lucas claimed that government policy was effective only when it was unexpected. Similarly, rational expectations cannot last long if they mislead believers! Diversified choices are driven by conflicting interests rather than a common belief in a competitive but unequal society. Rational expectations and microfoundations theories did not provide a consistent framework for business cycle theory. Like Frisch, Lucas did create an equilibrium illusion in business cycle theory.

3.2.2. Failure of the Random Walk and the Geometric Brownian Motion Models, Because of the Limitation of the Representative Agent Model in Stock Market

One by-product of our studies in relative deviations was our discovery that the popular models in finance theory, such as random walk and the geometric Brownian motion model, was also representative agent model, which was not capable of generating stable relative deviations in the US economy (Chen 2005). This result paved a new way in financial modeling.

It is a long-time belief that stock market fluctuations could be described by linear stochastic process. Its peak is the option pricing model based on geometric Brownian motion, which serves the benchmark model in option market [Black and Scholes
It is known that the geometric Brownian motion has weak evidence from financial market, i.e. its variance is not constant. But most modifications are still based on the representative agent model with only one agent in random walk or Brownian motion. Few realized a better alternative of the population model of the birth-death process. We found out that both the random walk and the geometric Brownian motion cannot generate sustained fluctuations in time history. Fluctuations in the random walk model are damped while those of the Brownian motion are explosive. Only the birth-death process is capable of explaining the observed stability of relative deviations in the US macro indexes.

Now, we are developing better alternative models of option pricing based on the birth-death process, which would integrate the existing models as special cases of a general theory (Zeng and Chen 2007, Tang and Chen 2007). We will see that the applications of statistical mechanics in economic dynamics will be a better alternative of the representative agent model in equilibrium economics.

3.2.3. Monetary Neutrality and the Ricardo Device: A Fiction without Conflicting Interests

One critical issue in monetary economics is the existence of the neutrality of money. We found out empirical and theoretical evidence of monetary chaos, which was an evidence of endogenous money, but a challenge to the neutrality of money (Barnett and Chen 1988, Chen 1988). However, equilibrium theory still has a strong argument for neutrality of money. Its weapon is a simple thought experiment called the Ricardo device.

The Ricardo device is a thought experiment to justify the neutrality of money. Here, thought experiments are named by their authors. The Ricardo device is the hypothetical operation of doubling overnight the cash holdings of all business enterprises and households without changing relative prices. It means that all supply and demand functions are a homogeneous function of zero degree, which is the basic argument against Keynesian economics (Leontief 1936). Ricardo ignored the redistribution problem in an unequal society. The Ricardo operation implies a legislation of progressive subsidy or regressive taxation, which has no chance of winning in parliamentary politics. The Ricardo device can only work in a primitive economy with an even distribution of wealth.

In history of scientific thoughts, the Ricardo device in economics is very similar to the Loschmidt reversibility paradox in physics, which was designed for challenging Boltzmann's H theorem of thermodynamic irreversibility. Loschmidt argued that one should be able to return to any initial state by merely reversing all molecules velocity under Newton's law. The trouble here is the huge coordination costs. Boltzmann implied that the possibility of reversing all the initial conditions is very unlikely in dealing with a large system with many particles.

One important lesson is that macro changes are almost always an irreversible process. To reverse the macro movements imply infinite coordination costs. This lesson should be kept in mind when we address the next issue of transaction costs.

3.2.4. The Coase World with Zero Transaction Costs

Coase raised fundamental questions on the firm nature and market solution for social conflicts (Coase 1937, 1960, 1988). Clearly, both firms and organizations are macro phenomena shaped by long-term evolution. Surprisingly, Coase put transaction costs as the basic unit in analyzing economic organizations, which represents an extreme reductionism and a static view without history. Coase made a great effort to
push the boundary of equilibrium economics to the dangerous edges, so that we have a good chance to study the limits of neoclassical economics, whose nature is a static picture in short-time windows.

In fact, more confusion than inspiration was caused by the vaguely defined transaction costs, the ill-formulated Coase Theorem, and the false analogy of frictionless world in physics. There are fundamental problems with the transaction costs approach in economics, history, and even physics (Chen 2007).

First, the size of the firm cannot be determined solely by internal balance between transaction and coordination cost in the Coase theory. It is a common sense in biology and business that competitor’s scale and the size of the market niche are the basic constraints to the size of the firm (Schmidt-Nielsen 1984, Stigler 1951, Chen 2005). Vertical integration is defended on the ground of reducing transaction costs (Williamson 1979). However, the emergence of Dell Computer and the transition of IBM and Texas Instruments revealed a more important factor in organizational changes: innovation and uncertainty have more impact than transaction costs in shaping organizational structure and business strategy.

Second, Coase believed that market competition would drive down the transaction costs, which had no theoretical and empirical foundation at all. Cost competition plays a minor role comparing to innovation competition in an open economy. The essence of innovation is creative value in the form of creating new information. If the core component of transaction costs is information cost, then increasing transaction costs is a dominating trend in developing division of labor. Marketing competition is not confined in cost or price competition, which is the only concern in neoclassical economics. Innovation competition heavily counts on advertising as a strategic weapon in winning market share. In that case, increasing transaction costs in marketing is a business strategy, not a loss game. In the history of industrial revolution and division of labor, information costs as a whole increased more rapidly than production costs along with increasing complexity and uncertainty. There is solid evidence that transaction costs in the US GDP increased from about 25% in 1870 to more than 50% in 1970 [Wallis and North 1986].

Third, the Coasian world of zero-transaction costs cannot exist in real world since it violates several basic laws in physics. The analogy between frictionless world in physics and the Coasian world with zero transaction costs is wrong, since zero friction is a realistic abstraction for theory of planet motion in space, but zero information cost is impossible according to the uncertainty principle in quantum mechanics (Brillouin 1962). Any information collection or transmission requires some form of minimum energy. Transaction costs are essentially disorganized energy such as heat, which can be described as entropy in physics. The Coase belief of reducing transaction costs in social evolution is simply against the second law of thermodynamics, since entropy production increases in biological and social evolution. Technology progress may reduce unit cost of transportation and communication. However, technical changes cannot reverse the overall trend of increasing energy consumption and waste release during modernization. The Coasian world is another example of perpetual motion machine in equilibrium economics (Chen 2007).

Fourth, the Coase Theorem implied that institutional changes would converge to optimal system regardless initial conditions. This is a typical mechanic view of the world that has no evolution and history. Emergence of life and social organization is characterized by time arrow or symmetry-breaking in non-equilibrium process (Prigogine 1984). The rise and fall of powers and nations are tree-like bifurcation process, which results path-dependence and structural changes.
Fifth, the most controversial assertion in the Coase Theorem is that any social conflicts could be resolved by bilateral bargaining without the third party (law, government, or civic society) intermediation (Coase 1960, 1988). His argument was based on the symmetry between polluter and victim, and more generally, the symmetry between consumption and investment (Coase 1960, 1988, Cheung 1998). If the Coase Theorem is valid, there would be no war, no conflicts, no government, and no regulations. This may be true for primitive society without private property and wealth accumulation, but not true for a competitive but unequal market economy. Coase made the claim of observing the real world. After careful examination, we found out that no single case studied by Coase could support his claim. Bilateral bargaining could not converge to an optimal state when asymmetry exists in the form of non-convexity, such as scale economy in cattle ranch, upward-demand for pollution, and spill-over effect for broadcasting and commercial bribery.

IV. Computational and Natural Experiments in Testing Equilibrium and Evolutionary Economics

Mathematical modeling in current mainstream economics is mainly used as a language for debate in economic policy. Is there any hope for economics as an empirical science, which can be tested by computational experiment and lab experiment? The answer is YES if we consider the historical events as natural experiments.

We will use computational experiments and natural experiments for testing competing economic approaches. We will focus on two central issues in contemporary economics: the inherent market instability and the social nature of organizational changes.

4.1. Market Equilibrium vs. Persistent Cycles

Equilibrium economics believes that market economy is self-stabilizing, which should be characterized by equilibrium state plus some white noise, while Schumpeter economics considers biological clock in the form of persistent cycles and creative destruction is the normal order of market economy.

Mathematically speaking, how to characterize a moving phenomenon by stationary model is the essence of the Copernicus problem in economics. The critical choice is the proper time-window and a corresponding filter in separating trends and cycles. When we apply a short-time window such as the FD filter in econometrics, we may easily get the random image of market movements. If we apply the HP filter in terms of a time-window in the range of NBER business cycles, we found persistent cycles whose average period is about 4 years. Because economic data have significant component of noise, we need more advanced technique in non-stationary time series analysis. The raw data look like random, but the data filtered by WGQ transform in time-frequency space revealed clear picture of spiral pattern of color chaos, a typical form of biological clock with stable and narrow frequency band but irregular amplitude (Fig.1).
The phase portrait of filtered FSPCOM (Standard & Poor 500 Index) HP cycles shows a clear pattern of deterministic spirals, a typical feature of deterministic chaos (nonlinear oscillator) in continuous time. Color means a strong peak in Fourier spectrum in addition to a noisy background (Chen 1996). We found out that white noise component only counted about 30% in stock market fluctuations.

The existence of stable frequency or characteristic period in macro and stock market indexes is a more convincing evidence of Schumpeter’s concept of economic order as a biological clock. The history of market frequency or basic period during historical events is shown in Fig. 2.

The time history of basic period can be used as a tool of economic diagnostics, similar to medical diagnostics in terms of heart and breathe frequencies. We can easily distinguish external shocks from internal instability, like the cases of oil price shock in...
1973 and the stock market crash in 1987. Note, here we only use non-parametric computational experiments. Unlike regression analysis in econometrics, we simply project a complex time series onto a time-frequency space without regression. This is a common practice in physics and signal processing in information science. The frequency-domain analysis provides more useful information than time-domain analysis in econometrics.

In short, new empirical evidence through computational experiments in terms of nonlinear dynamics and non-stationary time series analysis provides strong support to Schumpeter’s view of persistent cycles but weak evidence to equilibrium economics. More rigorously speaking, market movements are better described by mixed picture with dominating component of persistent cycles and minor component of random noise. Then we may ask the source of persistent endogenous cycles. This is the subject of the next section.

4.2. Representative Agent vs. Collective Movements

As we said before that the relative deviation (RD) is capable in distinguishing one-body problem (representative agent model) from collective movements (population model). The stable and persistent pattern of relative deviation exists in major macro indexes (Fig.3).

![Graph showing RDs of gdpc1, gpdic1, and pcecc96 for US quarterly series (1947-2001). N=220. Moving time window is 10 years. Displayed patterns were observed through the HP filter.](image)

Fig. 3. The RDs of gdpc1 (US real GDP), gpdic1 (real investment), and pcecc96 (real consumption) for the US quarterly series (1947-2001). N=220. Moving time window is 10 years. Displayed patterns were observed through the HP filter.

We can see that there is no damping trend (for the random walk model) or explosive trend (for the geometric Brownian motion model). Among existing stochastic models, the population model of the birth-death process provides a simple and good explanation for the stable RD pattern in macro economy.

How can we understand the seemingly conflicting picture of persistent cycles in section 4.2 and persistent fluctuations in section 4.3? The answer lies in the relation between complexity in reality and complementary role of simpler math models. Deterministic model is better for describing predictable patterns such as trajectory and
periodic motion while stochastic model is better for statistical measurement of fluctuations. The real phenomena are often fall in between these two simplifying models. To have a unifying picture, we may use the concept of market resilience which includes both dynamic instability in the form of persistent cycles and structural stability in the form of persistent trend. In other words, stability only implies static stability in dynamical state, but resilience has both structural stability and dynamical flexibility in adapting a changing world.

4.3. Lessons from the Great Depression and Transition Experiments

Now, we consider historical events as natural experiments for testing equilibrium and evolutionary economics.

The inherent instability of market economy was clearly revealed by a series of events, from the Great Depression in 1929 to 1930s, the stock market crash in 1987, and recurrent financial crisis around the world.

The most enlightening experiments in recent events are the failure of the shock therapy in the East Europe and former Soviet Union (EEFSU) and the success of the dual-track price reform in China (Chen 2006).

Theoretically speaking, the shock therapy of price liberalization can be justified by the microfoundations theory in new classical macro economics and the Arrow-Debreu model, since market economy could be characterized by unique and stable equilibrium without cycles and instability. The bold policy of liberalization and privatization was also encouraged by the Coase belief of reducing transaction costs and institutional convergence under market competition. However, inflation spiral and rapid devaluation of currency simply wiped out domestic saving and destroyed existing network of international division of labor. We were surprised by the depth of the Transition Depression. US industrial output was down 47%, its real GDP declined by about 25% and the recovery to pre-Depression level took approximately 14 years. However, the Transition Depression in Romania, Bulgaria, and three other countries in the former Soviet Union lasted more than 16 years; their GDP levels now are still below those levels achieved before the transition. The decline in real GDP ranged from 43% in Russia, 60% in Ukraine, and even 73% in Georgia. The magnitudes of the Transition Depression were more severe than those in the Great Depression in US and most other European countries at that time. In contrast, China had sustained economic growth since 1979 at an average rate of 9%. More surprisingly, China’s open-door reformed succeeded in much poor initial condition with high population pressure, scarce resources, backward infrastructure, large regional disparity, low human capital, traditional culture, and underdeveloped institution (mixed property right and lack of rule of law).

Two observations shed lights on major policy differences based on different perspective of economic order. One is the depth of currency devaluation in former Soviet Union. From 1990 to 1998, Russia’s real GDP measured by 1990 US Dollar declined 43%, but its currency depreciated 13,860 times! This is a clear case of non-equilibrium process. Equilibrium theory such as the purchasing power parity has little power to understand the large currency depreciation during transition. On the other hand, China’s trial and error approach in economic reform led sustained growth of export and accumulation of foreign reserve (Fig.4). The difference is made between equilibrium strategy and learning strategy during economic reform and transition.
Another remarkable observation is the diversified patterns observed during China’s dual-track price reform. The most rapid price convergence and output growth was achieved in the market for farm products such as meat and vegetables. Foodstuff prices did increase initially; but several months later, the prices quickly stabilized or even fell after a rapid growth in farm supply. For basic goods such as grain and cotton, price controls was in place (on and off) for more than 10 years, and never fully liberalized. The prices of industrial products were rapidly liberalized and deflation for consumer goods and luxury products occurred in places, but market liberalization for basic consumption goods was much slowly. The prices for energy, utility, education, and health are still under tight control despite a persistent trend of price inflation, because their supply persistently falls behind social demand when income grows rapidly (see Figure 5). Price dynamics are complex with complicated interactions among changing micro behavior, varying product cycles, interdependent industrial structures, and cyclic macro environment.
One possible explanation for the varied pattern in price dynamics is the varied length of production cycles. The production cycle for vegetables and meat is several months, however, the investment cycle for power stations require several years. Additional complexity can be added as a result of roundabout production in division of labor (Hayek 1935).

From this observation, we could say the elegant Arrow-Debreu model is irrelevant to industrial economy and dangerous in price policy because it has no room for product cycles and market niches, two most important factors in business operation and policy decision.
V. Evolutionary Perspective as Better Alternative in Theoretical Foundation of Economics

From the above discussion, we can clearly see that nice simple models in equilibrium economics are not capable of characterizing main features of market economy, such as persistent cycles and creative destruction. The equilibrium illusion of stable market equilibrium and institutional convergence was created by linear model and representative agent without nonlinear interaction and collective behavior. The main pillars of equilibrium believes, such as the Frisch model of noise-driven cycles, the Lucas model of microfoundations, and the Coasian world of zero transaction costs are mathematical utopia that against the basic laws in physics and mathematics.

There was a wrong perception that evolutionary economics is not scientific since it mainly counts on historical interpretation and philosophical arguments. Now, we can see that the advancement of nonlinear dynamics and complexity science provide powerful tools not only in empirical analysis but also theoretical modeling. Especially, economic dynamics is better described by nonlinear and population models. The historical development of division of labor and Schumpeter dynamics of creative destruction can be better described by species competition in ecological dynamics (Chen 2005). Even the rocket science in finance, the option pricing model can be greatly improved by a more general framework of birth-death process (Zeng and Chen 2007). We will further present our progress in near future.

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