Market Uncertainty, Information Complexity, and Feasible Regulation: An Outside View of Inside Study of Financial Market

Prepared for
Emiliano Ippoliti Ed.
Methods and Finance, A View from Inside
Springer (2019)

May 8, 2019

Abstract

The view from inside improves our understanding on market failure and regulation failure in financial market. The EMH fails to understand the causes of financial bubbles and crashes. Behavioral finance introduces insight from psychology. The heuristic and biases (H&B) approach studied behavioral asymmetry in static environment that leads to market irrationality and information distortion. The fast and frugal (F&F) thinking in decision-making further explore more complex situation under changing environment. They argue that soft-paternalistic regulation is needed under information overload. The most critical issue is information uncertainty and complexity. Lacking information in frequency domain is the main barrier in managing business cycles. Data form inside reveals current limitations of financial data mainly in the short-term price changes. Microstructure studies show that pricing process is shaped by trading rules. Quantitative analysis reveals severe instability in high frequency trading (HFT) and derivative market. Feasible regulation should aim to encourage new technology and sustainable growth, rather than protect obsolete technology and short-term speculation. The most fundamental challenge to sustainable economic order is the excessive size of the derivative markets that crowding out investment in real economy. This is a more severe issue than the climate change.

Key Words: market uncertainty, information complexity, feasible regulation, financial crisis, regime switch.

* * * * * * * * *

A man from a foreign land was crossing a river. When his boat was shaken in the middle of the river, his sword fell into

the water. Immediately he made a mark on the side of the boat where the sword was dropped. When the boat reached the bank and stopped moving, he went into the water to look for his sword at the place where he had marked the boat. Certainly, he got nothing, since the boat had moved but the sword had not. What a foolish measure without attention to the changes in circumstances!

- - A Chinese Fable, Mark the Boat Where the Sword Dropped in the River

Introduction

In the previous volume (Ippoliti, Chen 2016), we study finance theory mainly from a view from outside, where mathematical modeling of financial indexes plays a central role in financial economics. In this volume, a view from inside including behavioral analysis and institutional studies provide useful inside in financial market dynamics. In this article, we will discuss the central issue in the outside view of financial market and what can we learn from the inside view of financial economics.

We should point out that the new classical school of microfoundations made one significant mistake. Lucas assumed that the Great Depression could be understood from micro behavior and the mass unemployment can be explained by rational choice between leisure and work (Lucas 1972). This is impossible since business cycles observed the macro level cannot be reduced to the sum of micro fluctuations of many particles (Chen 2002, 2010). Mathematically speaking, fluctuations among many micro agents would cancel out each other, so that large macro movements are hard to explain by simple micro behavior. Philosophically speaking, the whole is more than the sum of the parts. This is especially true for living and social systems. In physics, quantum mechanics at the micro (atom and molecule) level is different from classical mechanics at macro level. Therefore, studies in micro behavior by behavioral psychology and management economics may not capable in understanding macro movements in financial markets because of economic complexity. However, institutional study of financial market does shed new lights on the roots on market instability. We will carefully examine the relation between inside and outside view of financial market.

There are three critical issues in studying the view from inside: the theoretical gap between the dynamic nature of financial market and the static feature in financial economics and behavioral economics; the empirical difficulty in measuring information uncertainty and ambiguity in changing economies; the guarding principle in feasible regulation in face of economic complexity and market instability in

financial market. We will address these issues in the dialogue between inside and outside view of financial market.

I. The Changing Nature of Financial Market and the Static Framework in Economics and Psychology

As we discussed before, empirical and theoretical studies of financial market show strong evidence of nonlinear dynamic mechanism and non-stationary nature of financial and macro indexes (Chen 2010). From empirical analysis, we observed two regimes co-exist in financial market: the calm regime that looks like an equilibrium market and the turbulent regime that was far from equilibrium (Tang, Chen 2014). The emergence of turbulent regime occurred within the period of financial liberalization (Tang, Chen 2015). This new outside view of financial market sheds lights on fundamental debate within competing thoughts from inside view, such as behavioral psychology, decision-making theory, and micro-structure studies. We should take an in-depth analysis of hidden assumptions behind these equilibrium theories.

We should point out that the mainstream theory in microeconomics and behavioral economics are static in nature. Their difference is that neoclassical theory of EMH assumes that financial market is always in equilibrium with little chance of large deviation, while behavioral economics argues disequilibrium exists because of irrational behavior. Both of them do not realize the evolutionary nature of market movements, so that there is no clear line to distinguish rational and irrational behavior in a changing market.

(1) The Hidden Assumption of EMH in Financial Economics

Let us begin with the question why equilibrium theory of EMH fails to understand the complex feature of financial market. The EMH theory had three hidden assumptions that are not valid in a dynamic market with nonlinearity and complexity.

(1.1) Financial Market is More Complex than a Scalar-Field Theory

EMH claim market prices have full information that is impossible in financial market. There are many market indicators in addition to stock price, such as trading volume, interest rate, market share, macro trend, and geopolitical news, which play important roles in portfolio management and asset allocation. Mathematically speaking, EMH is a scalar field like gravity. But economic dynamics is more complex than gravity field with only one independent variable (the distance between interacting particles). A vector or tensor theory is needed to characterize financial market (Chen 2016).

(1.2) Financial Time Series Are Not Linear and Stationary

There is no operational definition of the basic value of market prices. Neoclassical economics simply assumes that financial time series is stationary with stable mean and finite variance. In reality, most economic data have changing trend and irregular fluctuations. Even behavioral economics can only define "bias" in lab experiments, but not from real time observations (Chen 1996b, 2010). Asset pricing theory has two assumptions: one is market arbitrage mechanism could ensure price equilibrium; another is linear pricing (Ross 1976). Both assumptions are challenged by studies of economic complexity and historical lessons. The 2008 Financial Crisis was originated in the derivative market. Arbitrage with herd behavior is a source of market dis-equilibrium rather than equilibrium.

(1.3) Friedman Spirits Cannot Wipe Out Noise Traders

Third, the core belief behind the efficient market is the claim made by Friedman, that irrational arbitrager could copy winner's strategy so that no winner could survive in competitive market (Friedman 1953). I call this artificial mechanism as "Friedman Spirits", which was equivalent to Maxwell demon in thermodynamics (Chen 2005, 2010).

Why Friedman Spirits could not perfectly copy winner's strategy and drive down winner's profit? There are two fundamental reasons ignored by equilibrium economics. First, uncertainty principle in information theory sets severe limit to copy winner's market position. Second, small deviation in chaotic trajectory would quickly divergent. Therefore, imitators could not drive out market winners in a nonlinear dynamic market. Arbitrage opportunity is not capable of reaching market equilibrium.

(2) Complexity and Heterogeneity in Financial Market

Behavioral finance examines human behavior with bounded rationality (Shleifer 2000). The most important discovery by behavioral economics is behavioral asymmetry such as loss aversion (Kahneman, Tversky 1979). From physics perspective, equilibrium economics implies time symmetry, while behavioral economics observes time asymmetry in human behavior. In classical mechanics, time is symmetrical for reversible process, but time arrow exists in thermodynamics. From the perspective o evolutionary biology and non-equilibrium physics, living and social system do have time arrow in history. In this regard, behavioral economics is philosophically correct in comparison with neoclassical economics (Prigogine 1980).

There is strong empirical evidence that supports behavioral economics. One notable example is so-called equity premium puzzle that could be explained by myopic loss aversion (Benartzi, Thaler 1995).

However, there is an issue in observation reference. In behavioral studies, the bias is often measured with a static distribution or a long-term trend (Tversky, Kahneman 1973). In real financial market, there is no static distribution or stationary trend.

Therefore, it is hard to measure "bias" in a dynamic framework. We can only observe "orientation" or "strategy" in animal behavior where both risk aversion strategy or risk taking strategy compete and co-exist in animal behavior (Wilson 1975). That is why behavior diversity is widely observed in cultural anthropology (Harris 2006). The danger of the representative model is the assumption of homogeneity in social structure and human behavior. Complexity studies reveal the importance of heterogeneity in economic structure and behavior.

(2.1) Information Uncertainty and Information Complexity in Economic Dynamics

The theory of information asymmetry in behavioral economics assumes that one party has more information than the other party in market, such as the used car market (Akerlof 1970). But in financial market, information uncertainty may be more significant than information asymmetry when innovations and changing technology create information uncertainty in financial market. Strategic behavior is another source to create information distortion and information noise to fool competitors.

In the real world, there is no such possibility that asset prices reflect all available information (Fama 1970). On the contrary, all investors are seeking more information in addition to asset prices in order to understand past market and guess future development. Equilibrium economists are simply mistaken their utopian world with complex reality.

(2.2) Competing Strategies and Adaptive Behavior in Evolutionary Economics

For dealing with information complexity, decision-theory may not have "correct" or "optimal" strategy. Diversified behavior exists in market and path-dependence plays an important role in market mechanism (Paul 1985).

In dealing with dynamic behavior, the Fast and Frugal (F&F) approach is more pragmatic than the Heuristic and Bias (H&B) approach in empirical studies (Kahneman 2011), since bounded rationality defined the adaptive nature of human behavior.

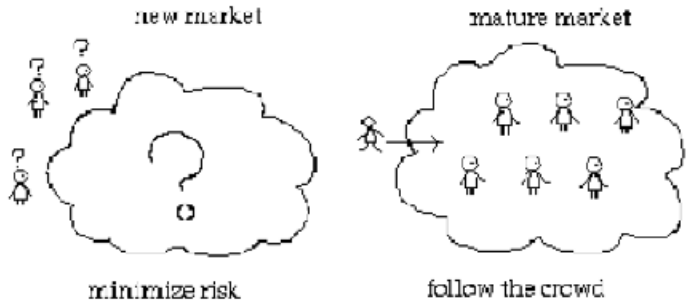
III. Outside Evidence of Inside Mechanism in Financial Market

We have new evidence that the outside view of financial market sheds new lights on inside mechanism in financial market. We provide two recent cases for our readers below.

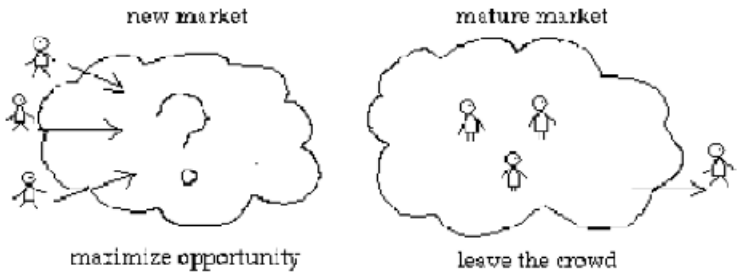
(3.1) Competing Strategies and Risk Cultures in Learning Competition

Neoclassical economics assumes homogeneous behavior for so-called rational economic man with same preference of risk attitude in static optimization model (Pratt 1964; Arrow 1965, 1971). In technology competition, we observe two types of

learning strategies co-exist, such as risk-taking and risk aversion culture that leads to varying resource utilization ratio in competing industries and nations (Chen 1987, 2010, 2014). Their different learning strategies can be seen in Fig. 1.



(1a) Risk-aversion behavior.



(1b) Risk-taking behavior.

Fig 1. Risk-aversion and risk-taking behavior in facing an unknown market or uncertain technology in market share competition.

In our model of metabolic growth, three features are introduced into growth theory that is missing in neoclassical economics. First, all technologies have life cycle under ecological constraints and technology competition. Second, the magnitude of environmental fluctuations play important role in evolution of complex economic system with many competing technologies. Third, heterogeneous behavior is characterized by varying culture attitude in risk learning factor. We found out that there is no optimal strategy in learning competition. Risk-taking culture has advantage in technology innovation that is observed in early history of colonialism, while risk-aversion culture has advantage in stability that is visible in rise and fall of civilizations through wars and climate changes.

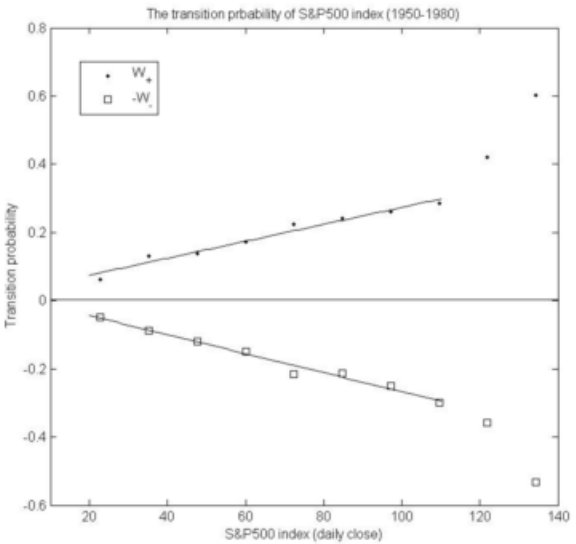
In this model, the picture of varying risk cultures is closer to F&F approach, since there is no absolute "right" or "bias" in changing technologies. F&F

approach may be embedded in historical and cultural experience during social evolution.

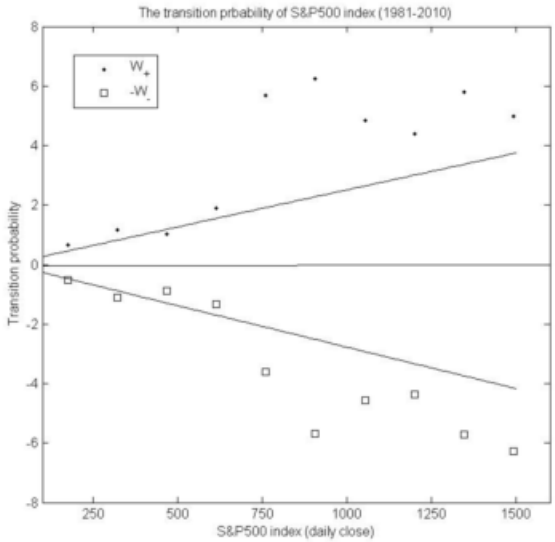
Clearly, homogeneous assumption in equilibrium models of neoclassical mechanics is only an approximation in short-term time-windows when birth of death of firms and technologies are ignored. In a modern world with rapidly changing technology, evolution of complex market implies a trend of divergence rather than convergence in dynamic behavior.

(3.2) Multiple Regimes and Institutional Switch in Financial Market

The cause of 2008 financial crisis is a theoretical challenge to financial economics. EMH simply rules out the possibility of financial crisis. We developed new tools of the birth-death process that is capable of analyzing collective movements in financial market based on empirical financial indexes (Tang, Chen 2014). We discovered two regimes of financial market exist in different periods (Tang, Chen 2015) (see Fig.2).



(2a) The calm regime observed in 1950-1980.



(2b) The turbulent regime observed in 1981-2010.

Fig. 2. The transition probabilities W_+ and W_- of the S&P 500 daily close in1950-2010. The horizontal axis is the price level of the S&P 500 daily index. Here, W_+ is the transition probability of stock price moves up and W_- is the transition probability of stock price moves down. They are changed at different price level.

From Fig. 2, W+ can be understood as the strength of the "bull camp", while W- as the strength of the "bear camp". Stock movements are resulted from the two competing camps.

We can see the two curves of transition probability in Fig. 2a are rather smooth and close to linear except at the end of large stock price movements. Accordingly, financial market in this period of 1950-1980 was rather "calm" that looks normal in financial history.

In contrast, the transition probability curves in Fig. 2b have large deviations from linear pattern. Financial market in the period of 1981-2010 was "turbulent" in history. This was a period when liberalization policy was dominating in government policy.

As a natural experiment, we solved the nonlinear master equation of the birth and death process, and calculated the critical point of the regime switch. The date was found at Sept. 25, 2008, when OTS (Office of Thrift Supervision) seized the Washington Mutual and sold its assets to JP Morgan for $1.9 billion dollars. This

event triggered a chain reaction that led to market panic and caused 2008 Financial Crisis.

From this analysis, we can see the outside observation provides useful information between market failure and regulation regime. This correlation is valuable for inside view of market failure and institutional change.

(3.3) Information Disclosure and Regulation Flexibility in Changing Market

From our observation, current regulation based on static theory of information asymmetry did not pay enough attention to information uncertainty so that regulation rigidity leaves little flexibility for firms to adapt a changing market. For example, there is increasing demand for information disclosure from firms for the purpose of protecting shareholders. The real issue is the short-term motivation of shareholders and the long-term operation of firms in a changing market. If firms have no flexibility in dealing with market changes, market instability would increase rather than decrease.

In this regards, we believe that we need a new thinking in market regulation. The real cause of 2008 financial crisis was the excess speculation in derivative market at the cost of crowding out real economy (Johnson 2009). It would be more effective if we simplify regulation for firms but increasing regulation for financial market. We learn this lesson from China's reform and rapid growth when China made great effort in infrastructure investment and simplifying regulation for firms. The world is not flat, so should be for market regulation.

In regulation design, the goal is not relax short-term regulation in the name of reducing transaction costs but to increase market stability for encouraging long-term investment and growth. The selection rule is the key for a healthy and stable market (Chen 2007, 2010).

IV. Data Representation and Feasible Regulation for Moving Market

Behavioral economists raise important question on data form. They hope their studies may help improve financial regulation. Based on our experience, current knowledge on financial behavior paid more attention to information asymmetry in static setting, but made limited progress to study financial behavior in dynamic situation, which is essential for financial regulation.

In the following discussion, we will discuss the main issues in financial regulation, and what kind of data form is need for feasible regulation.

(4.1) Misperceptions and Better Alternatives of Financial Dynamics

Misperceptions of financial dynamics in mainstream financial economics are the main source of data distortion and ineffective regulation. Neoclassical economics assumes that normal market is always in equilibrium and price level

could be determined by basic values with linear econometric models. They believed that all deviations in financial market were caused by external shocks that can be characterized by normal distribution. Therefore, financial analysis is mainly confined within the time domain with a false hope of "mean reversion" in market. In real market, no one knows if there was a stable mean of stock price, since stock price constantly move with a nonlinear growth trend. The dominating market measurement is the percentage change within a fixed time window, such as daily or yearly percentage change. Both investors and regulators lack essential information on market trend and internal business cycles for specific sector or company.

There is a significant conflicting perspectives between firms and investors, since all firms have to manage cash flow over a up-down business cycles that varying between 1 year to decades, while investors horizon last from minutes in high frequency trading (HFT) to long-term bonds up to 10 years or more. These analyses are conducted mainly in the frequency domain, which is known by engineers but foreign to economists.

A critical issue for regulator is what is the proper target of regulation time window? The regulator should protect short-term speculators or encourage long-term investors? Should we put crisis management on the top priority of financial regulation? We will discuss these questions before making any suggestions in refining current form of data presentation.

(4.1.1) Equilibrium Illusion Created by the FD Filter in Econometrics

We found out that random shocks are more complex than equilibrium models. The observed shocks from financial indexes are non-stationary with changing trend, changing distribution, and changing magnitude. Their analysis highly depends on analytical framework such as the case of Copernicus reference system in planet motion.

The utility maximization theory in neoclassical economics was based on the simple model of gambling when probability distribution was constant in time. The problem for economic data is changing trend that leads to changing probability distribution all the times. Econometric convention is applying the FD (first-differencing) filter to remove the trend (Chen 2008, 2010). Its result is amplifying high-frequency noise and suppressing low-frequency signal (see Fig. 3), so that the critical information of medium-term business cycles (in the range of 1-20 years) is ignored in econometric analysis.

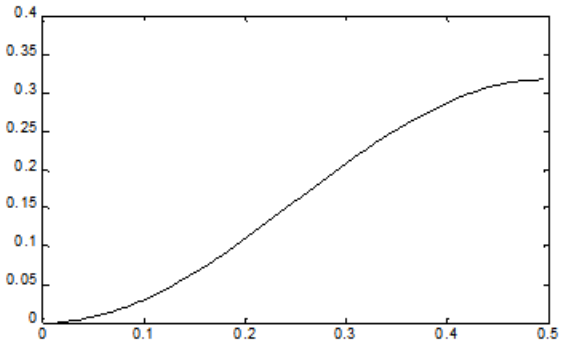


Fig. 3. Frequency response function for the FD filter. Here, X(t) = FD[S(t)]=S(t+1)-S(t) = log [Y(t+1)/Y(t)]. Here, Y(t) is the original time series of financial index, S(t) = log [Y(t)] that is used in econometric analysis.

The meaning of the FD filter is based on conventional concept of rate of changes in a time unit. Econometric analysis takes logarithmic form in order to changing the exponential growth trend into linear form. In Fig. 3, the horizontal axis is the normalized frequency range from zero to 0.5. This frequency response function is a typical high-frequency noise amplifier. The frequency response function for normal band-pass filter should be flat between minimum and maximum frequency.

The FD filter is the magic device in econometrics to transform a colorful world into a white picture, because the EMH assumes all market fluctuations are caused by white noise (random walk or Brownian motion). This equilibrium illusion is created by the short-term time window of one time unit (such as daily or yearly rate of return), which is equivalent to the Ptolemy's geocentric system in econometrics.

We should point out that the empirical evidence of the power law in financial market is also obtained through the FD filter. Their time window is extremely short, ranging from daily data to 15-minute data (Gabaix et al 2003). According to the Nyquist Theorem, the minimum period can be observed is only about 2 days or 30 minutes. The sampling rate is so short, that few information can be related to production process or business operation. Choosing a proper time window is the key to observe and regulate business activities.

(4.1.2) The HP Trend As the Observation Reference of Business Cycles

The HP filter used by REC (Real Business Cycle) school provides a better alternative in business cycle study (Hodrick, Prescott 1981, 1997). We found out that the HP filter plays a key role as the optimal observation reference in studying economic chaos. Its function is similar to Copernicus heliocentric system in planet

motion (Chen 1996b, 2010). The reason is simple. The geocentric system is useful in observing daily movement of sunrise and sunset, while the heliocentric system is better in observing annual movement of earth around sun. By the same token, the HP filter defines cycles around a smooth trend, so that the average cycle period is about the range of NBER business cycles. That is why choosing proper observation reference could simplify complex dynamics in financial market. This is the Copernicus problem in macro and financial economics.

The colorful world with multiple changing frequencies in financial market can be directly observed through the HP filter tuned to a proper time window. For example, we tested the S&P 500 monthly index from the period of 1947 to 1992 (FSPCOM is the name of the S&P index in the Citibase). The original time series can be decomposed into a nonlinear smooth trend with cycles around the trend. The average period of the HP cycle is 3.6 years (See Fig. 4).

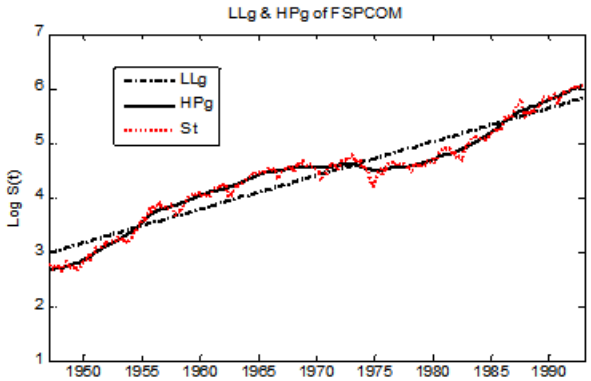


Fig. 4. The HP smooth trend of FSPCOM (S&P 500) logarithmic index. St=S (t) is the original index, HPg is the trend defined by the HP filter. For comparison, LLg is the log-linear trend that is used in econometric analysis for growth accounting.

(4.1.3) Biological Clock with Stable Frequency Band in Market Dynamics

Stable frequency pattern can be observed from the HP cycle series that are obtained through the original series deduct from the HP trend. Fig. 5 shows the HP cycles obtained from the HP filter.

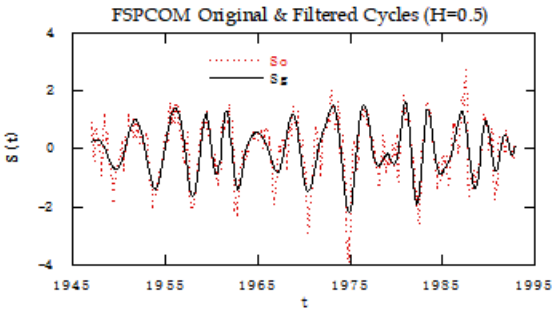


Fig. 5. The original and filtered HPc Cycles of the logarithmic FSPCOM (S&P 500) monthly series (1947-92). Here, So is the original HP cycle series, Sg is the filtered HP cycle series by means of time-frequency analysis. The ratio of their variance is v=69%, their correlation coefficient is CCgo=0.85. The fractal dimension of Sg is μ=2.5. De-correlation period is 3.3 years. H is the parameter for noise-cycle separation in time-frequency space.

The most significant discovery from HP cycles is that random shocks only play a minor role in financial market. The Sg cycles can be well explained by the color model, i.e. a nonlinear oscillator, its fractal dimension is 2.5. About 70 percent of market fluctuations could be explained by color chaos, i.e. nonlinear deterministic oscillation with stable period varying between 2 to 10 years with average period between 3 and 5 years that is typical range of business cycles (Chen 1996a, 2010).

This is the strong evidence that financial market is not linear, and market fluctuations cannot be attributed to random shocks or Brownian motion. The equilibrium assumption in financial economics has no empirical foundation. This finding also supports the research agenda of behavioral finance, i.e. the behavioral foundation of bounded rationality and market irregularity.

Contrary to the mechanic view of equilibrium order, Schumpeter called business cycles as biological clock. The biological view considers financial movements like organism that cannot be reduced to the sum of atomic agents (Schumpeter 1939). Both Schrödinger and Schumpeter realized that living systems have remarkable resilience and flexibility in adapting to environmental changes (Schrödinger 1948). Our model of soft-bouncing oscillator is similar to nonlinear dynamic model in biology since they are based on delay-differential equation. This is a mathematical feature that living dynamics is more complex

than fluid dynamics that based on partial differential equations. Econometric models based on difference equations are much simpler than physics and biology, since one-dimensional delay-differential equation can be approximated by N-dimensional differential equation, and one- dimensional differential equation can be approximated by N-dimensional difference equation. If the required solution demands accuracy to one present, N should be at least 100. Then the simplest solution of color chaos model needs a system of difference equations, its number is 100x100x100=100,000. How can we simplify this nonlinear dynamics with a dozen or so econometric equations? Financial economists must change their paradigm, for understanding a viable market with both dynamical instability and organic resilience.

Regulators need quantitative tools to separate the impact of business cycles at the macro level with noise shocks at the micro level, since macro policy-maker and long-term investors are mainly concern the former and financial traders are only care about the later. For example, the HPg trend is a good indicator of market expectation, while the de-correlation time is a measure of business cycle effect.

(4.1.4) Multiple Time-Scales Co-exist in Financial Market

Multiple time-scales are associated with varying life cycles in industrial process. We found out that China's transition to market economy was more successful than that of Eastern Europe because China adopted the dual track price system in dealing with long and short life cycles in different sectors (Chen 2006, 2010). For example, production cycle in farm market only about several months, but infrastructure would last several years or decades. China's rural market for vegetables and meats were liberalized first with remarkable success, but grain and energy prices were deregulated much slower for social stability. SEZ (Special Economic Zone) was selective open to foreign investment so that domestic firms could adopt new technology and new management for better competing with foreign companies. The gradual approach of decentralized experiments provided learning space and adjustment time for SOE (State Own Enterprise) reform and TVE (Village and Township Enterprise) growth. This disequilibrium approach developed a new development strategy in the globalization age.

In contrast, the so-called shock therapy simply demanded all sectors to adjust to equilibrium within a short-term time horizon. East European countries had much better human resource and technology base than China, but lost competition with multi-national corporations during the economic transition. From our observation, China's financial policy and banking regulation is more flexible in adapting the needs of various sectors during the transition period and market stress.

(4.1.5) Market Viability and Advance-Warning for Coming Crisis

Several models provide pessimistic arguments against government intervention of financial crisis. Notable examples are fat-tail distribution such as the Levy distribution, power law, fractal Brownian motion, sand-pile, self-criticality, and Black Swan. Our analysis provides more promising results, since viable market has remarkable property of self-recovery through recurrent cycles and crisis.

Fig. 6 gives dynamic information on market instability based on high moments within a moving time window of one quarter for Dow-Jones Industrial (DJI) index series; its time length was 110 years with 27724 daily closing prices (Tang, Chen 2014).

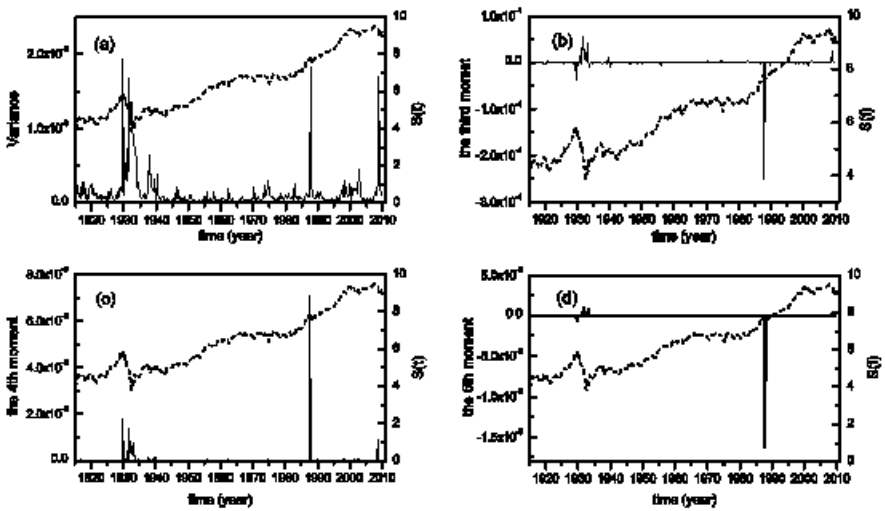


FIG. 6. The quarterly moments (solid lines) of the Dow-Jones Industrial Average (DJI) daily index, from Jan.2, 1900 to Sep.1, 2010 (N=27724). The original S(t) (dashed lines) is the natural logarithmic daily close price series. Each point in the solid line is calculated with a moving time window; its width is one quarter. Plots (a), (b), (c) and (d) correspond to 2^{nd}, 3^{rd}, 4^{th} and 5^{th} moment, respectively. The magnitudes of each moment representation are 10^{-5} for variance, 10^{-8} for 3^{rd} moment, 10^{-9} for 4^{th} moment, and 10^{-11} for 5^{th} moment.

Orthodox financial approach uses variance (the second moment) as the measurement of the market risk (Markowitz 1952). We discovered new patterns from high (2^{nd} to 5^{th}) moments representation.

For a calm market, the magnitude of high moments (3rd to 5th moment) is quite small (say, less than 0.1% to 0.001% of the magnitude of the variance) compared to the 2nd moment during the periods of a calm market.

For a turbulent market, the magnitudes of the higher moments typically increase 100 to 1000 times, which occurred in the quarters before and during the crisis period, so that the magnitudes of high moments are comparable or even larger than the usual magnitude of variance. If regulators keep monitoring the changes of high moments with a moving time window of one quarter, they could obtain warning signal from dramatically rising high moments, at least one quarter before market crash. Therefore, regulators may have time to calm down the market by imposing restrictions on market leverage.

(4.2) From Atomic Regulation to System Regulation

Recent progress in economic complexity shows that financial market is more complex than the atomic world in neoclassical economics. We do have new tools to manage economic complexity and market instability. So far, we do not have simple guidance for proper financial regulation, but we do have new clues to improve our regulation vigilance. One important step is changing perspective from equilibrium thinking to complexity thinking in macro management and financial regulation.

Both neoclassical and behavioral economics are based on atomic perspective on the assumption that the aggregated behavior can be understood from the micro foundation of individual behavior. Their main difference is between rational and irrational behavior when negative and positive feedback plays major role in specific market reaction. They do not realize that both negative and positive feedbacks often coexist and interact each other. The realistic issue is how to balance them in a dynamic situation. Different regulation environment may produce different market mechanisms that were observed in section 3.2.

From our observation, financial instability cannot be fully explained by micro behavior since the whole system is more than the some of parts. The discovery of economic chaos implies that financial movements are nonlinear in nature that sets a limit to reductionism in economics. Therefore, market regulation should pay more attention to system risk and social psychology, rather than individual irrationality and information asymmetry, since macro trend and collective behavior play strong role in market instability and financial crisis. After 2008 financial crisis, we should have a new thinking on financial regulation and institutional reform.

(4.2.1) Extending Time Horizon for Regulation Vigilance

Debate between H&B and F&F on market regulation did not pay enough attention on the proper choice of time scale in market indicators, since different time scale have different dynamics in viable market. In complex financial systems, information ambiguity and information uncertainty can be reduced by choosing a proper observation reference, which implies a regulation preference between short-term vs. medium-term economic goal.

From our observation, two aspects have strong influence in economic performance: one is the macro trend that defines the average period of business cycles; the other is firm dynamics in adapting business cycles. Financial structure plays an intermediate role between macro trend and micro behavior. For firm's decision making, quarterly and yearly data is essential for production, while monthly and daily data is useful for financial exchange. High frequency data is useful only for financial speculation with little concern for real economies.

Current data normally including three parts: the current level of stock prices or indexes, the absolute changes into points, and the daily or yearly percentage changes of rate of returns. All these data are short-term movements within a day or a year. Some financial economists try to predict market direction by term structure of interest rate with little information on the duration of business cycles. All these efforts are focus on price level rather than price frequency. Their net effects are increasing short-term price volatility. The only information in frequency domain is the NBER business cycle chronology that is determined by past events (NBER 2019). The last though was June 2009. Current expansion is already more than ten years. It is more essential for business community if future possibility of business cycles can be predicted.

We suggest future research should provide more information in frequency domain for market participants and regulators. A useful indicator is the average period for different countries and different sectors, which are slowly changing over time in comparison with price changes. Both producers and long-term investors need this information for their operation management and investment strategy; so does for policy makers and infrastructure planners.

For regulation purpose, how to measure a reasonable market value of a firm is critical for credit ranking through up and down business cycles. Using current price as a measure of company's market value is troubling both for company's survival and regulator's reaction, since stock price level is irregular and volatile. Stock prices may frequently crash caused by psychological panic rather than real contraction. A notable example is 1987 market collapse. We suggest that the regulation agency should set a time window for evaluation a fair value of company assets, such as five-year moving average for stable company with high credit ranking company, or three-year moving average for new company with medium credit ranking. Different sector may set different standard for the length

of the time window in calculating the fair value of a company. This measurement regulation is aimed to protect producer's stability rather than arbitrager's opportunity. From financial theory and historical lessons, we believe that arbitrage behavior by noise traders in financial market is mainly a destabilizing force (Shleifer, Summers 1990). According to the metabolic nature of technology competition, rule of law is not neutral in economic growth. Encouraging forward-looking investment in new technology and discouraging protection in obsolete technology is the key for economic growth (Chen 2016b).

V. Micro-Structures and Market Instability in High Frequency Trading (HFT)

Microstructure studies the process of market trading that is critical in the age of program trading (O'Hara 1995). After the Black Monday in 1987, it was found that market instability could be driven by program trading, such as portfolio insurance. New rules, such as trading curbs, were introduced into market regulation (Benhardt et al. 2014). Further studies on pros and cons of HFT are needed for financial regulation.

Power law distribution was observed by econophysics from financial data from 15-mimutes absolute returns (Gabaix et al. 2003). Power law distribution is highly unstable with large possibility of great deviations in market prices. This result is a strong evidence of market instability caused by HFT trading. This is a notable example of econophysics that the outside view can be useful for inside view of microstructure research.

VI. Conclusion

A dialogue between the inside-view and out-side view of financial market is helpful for understanding market instability and improving market regulation.

Mainstream financial economics developed quantitative analysis in financial economics, so that micro and macroeconomics also advancing in collecting empirical data. However, econometrics did not develop a consistent framework in discrete-time modeling. For example, microeconomics is a static framework with one representative agent that ignores economic heterogeneity and social interaction. Macroeconomic issues are mainly addressed in the medium-term for business cycles ranging from one to 20 years. Varying time scales exist in macro literature, such as static IS-LM model in short-term, DSGE (dynamic stochastic general equilibrium) model built on quarterly data, and over-lapping generation model in the range of 20 years. Time scale in financial economics varies from minutes in HFT, to daily trading, quarterly statements, annual report, and real estate bubble in decades. Mathematically speaking, the discrete-time modeling used in economics and econometrics is a primitive math in the pre-Newtonian era. All physics theory is based on continuous-time models, so that physical laws are independent from the choice of time scale. Economic math is obsolete in comparison wish physics, engineering, and medicine.

Economic complexity indicates that macro dynamics cannot be reduced to aggregation of micro fluctuations. That is why microfoundations approach failed to understand financial crisis and the Great Depression. There is no equilibrium theory in financial economics that could explain complex features of financial market with excess price deviations, recurrent crisis, and market resilience through shocks and crashes.

The concept of bounded rationality is the first step to break the limit of neoclassical framework based on perfect rationality, efficient market, and rational expectations (EMH), since finite capacity in economic computation sets the limit to computational economics. Behavioral economics made further progress in studies of psychological behavior. Heuristic and bias (H&B) is prevalent in lab experiment that is close to static situation in economic process. There are many applications in behavioral finance (BF) that is useful in policy design and market regulation. Fast and frugal (F&F) approach pays more attention to dynamic setting in economic decision-making and feasible regulation. Microstructure studies of financial market reveal the important role of market mechanism, such as program trading and arbitrage instability in high frequency trading (HFT). All these studies can be better understood from the outside view on economic complexity. The nonlinear and non-equilibrium nature of financial market is rooted in biological order of living system, since social system faces similar problem in understanding behavioral variability and structural stability.

All living systems have a common feature of life cycles, because changing time rhythm is the most effective mechanism in adapting to environmental changes. Business cycles in financial market have similar feature and function as biological clock. The static framework in efficient market hypothesis (EMH) narrowly focus on short-term speculation but lost the large picture of business cycles, so that it excludes the possibility of endogenous instability and financial crisis. The blind belief in laissez-fair policy in the liberalization era in 1980s to 2000s resulted to 2008 financial crisis that was clearly caused by internal instability rather than external shocks. A feasible regulation is needed for institutional reform in financial market. We can accomplish this goal because we have new tools in managing business cycles.

We suggest that disclosure of market information should be extended to frequency domain. Current forms of business information are mainly in time domain.

The most serious problem is the large size of the derivative market. According to BIS (Bank of International Settlement), the outstanding OTC derivative contract was $532 trillion; the gross market value of OTC derivatives was $11 trillions at the end of 2017 (BIS 2018a). Among them, the interest rate contract was $427 trillions, and foreign exchange contract was $87 trillions at the end of 2017. In addition, the size of exchange-traded futures and options was $34 trillions for futures and $47 trillions for options in Dec. 2017 (BIS 2018b). The combined size of the OTC and exchange-traded derivative market was $613 trillions in Dec. 2017.

In comparison, the world GDP was only 80 trillions in 2017 and the US GDP was $19 trillions in 2017 (CIA 2019). The size of the derivative market is 8 times of the world GDP and 32 times of the US GDP. Investment in fixed capital was only 26% of the US GDP or $21 trillions in 2017. Speculative financial capital was 25 times of the investment in fixed capital. This is the fundamental cause of increasing income disparity and social instability.

We need an international coordination to address this issue. The developed countries, especially the United States, bear the major responsibility in financial reform, in order to avoid the next crisis and the world recession. The abnormal size of unregulated derivative market is a time bomb, which is a more serious threat to human society than climate warming for a sustainable economic order.

References

Akerlof GA (1970) The market for 'lemons': Quality uncertainty and the market mechanism. Quarterly journal of economics. 84 (3): 488-500

Arrow KJ (1965) Aspect of the theory of risk bearing. In Saatio YJ ed. (1971) The theory of risk aversion. Helsinki; Essays in the theory of risk bearing. 90–109, Markham Publ. Co., Chicago

Benartzi S, Thaler RH (1995) Myopic loss aversion and the equity premium puzzle. Quarterly journal of economics. 110 (1): 73–92

Bernhardt D, Eckblad M (2014) Black Monday: the stock market crash of 1987. Federal reserve history. Retrieved July 31

BIS (2019a) https://www.bis.org/publ/otc_hy1805.htm, Retrieved May 8

BIS (2019b) https://stats.bis.org/statx/srs/table/d1, Retrieved May 8

Chen P (1987) Origin of the division of labor and a stochastic mechanism of differentiation. European journal of operational research. 30, 246-250. In Chen P (2010) Chap. 8

Chen P (1996a) A random walk or color chaos on the stock market? - time-frequency analysis of S&P indexes. Studies in nonlinear dynamics & econometrics. 1(2), 87-103. In Chen P (2010), Chap. 6

Chen P (1996b) Trends, shocks, persistent cycles in evolving economy: business cycle measurement in time-frequency representation. In Barnett WA, Kirman AP, Salmon M eds. Nonlinear dynamics and economics. Chapter 13, pp. 307-331, Cambridge University Press. In Chen (2010) Chap. 7

Chen P (2002) Microfoundations of macroeconomic fluctuations and the laws of probability theory: the principle of large numbers vs. rational expectations arbitrage," Journal of economic behavior & organization. 49, 327-34. In Chen P (2010) Chap. 13

Chen P (2006) Market instability and economic complexity: theoretical lessons from transition experiments," In Yao Y, Yueh L eds. Globalisation and economic

growth in China, Chapter 3, pp.35-58, World Scientific, Singapore (2006). In Chen P (2010), Chap. 15

Chen P (2005) Evolutionary economic dynamics: persistent business cycles, disruptive technology, and the trade-off between stability and complexity. In Kurt Dopfer ed., The evolutionary foundations of economics, Chapter 15, pp.472-505, Cambridge University Press, Cambridge. In Chen P (2010), Chap. 3

Chen P (2007) Complexity of transaction costs and evolution of corporate governance. Kyoto economic review. 76(2), 139－153. In Chen P (2010), Chap.14

Chen P (2008) Equilibrium illusion, economic complexity, and evolutionary foundation of economic analysis. Evolutionary and institutional economics review. 5(1), 81-127. In Chen P (2010), Chap. 2

Chen P (2010) Economic complexity and equilibrium illusion: essays on market instability and macro vitality. London: Routledge

Chen P (2014) Metabolic growth theory: market-share competition, learning uncertainty, and technology wavelets. Journal of evolutionary economics, 24(2), 239-262

Chen P (2016a) Mathematical representation in economics and finance: philosophical preference, mathematical simplicity, and empirical relevance. In Ippoliti E, Chen P eds. Finance, mathematics and philosophy, in SAPERE Series (Studies in applied philosophy, epistemology and rational ethics). Springer, Berlin

Chen P (2016b). Alternative policies after the financial crisis: new thinking from complex evolutionary economics," in Gräbner C, Heinrich T, and Schwardt H eds. Policy implications of recent advances in evolutionary and institutional economics: essays in honor of Wolfram Elsner, Chapter 9, Routledge, London

CIA (2019) World factbook. See: Economy :: World; United States, https://www.cia.gov/library/publications/the-world-factbook/geos/xx.html Retrieved May 8

David P (1985) Clio and the economics of QWERTY. American economic review. 75 (2): 332–337

Fama EF (1970) Efficient capital markets: a review of theory and empirical work. Journal of finance 25(2), 384-433

Friedman M (1953) The case for flexible exchange rates. In Friedman M. Essays in positive economics, University of Chicago Press, Chicago

Gabaix X, Goplkrishnan P, Plerou V, Stanley HE (2003) A theory of power law in financial market fluctuations. Nature. 423, 267-270

Harris M (2006) Cultural anthropology, 7th edn. Allyn & Bacon

Hodrick RJ, Prescott, EC (1981) Post-war US. business cycles: an empirical investigation. Discussion paper No. 451, Carnegie-Mellon University; Hodrick RJ, Prescott EC (1997) Journal of money, credit, and banking, 29(1), 1-16

Ippoliti E, Chen P. eds (2016) Methods and finance, a unifying view on finance, mathematics and philosophy, in SAPERE Series (Studies in applied philosophy, epistemology and rational ethics), Springer, Berlin.
Johnson S (2009) The quiet coup. Atlantic. 303(4), 46-56
Kahneman D (2011) Think, fast and slow, Macmillan, London
Kahneman D, Tversky A (1979) Prospect theory, an analysis of decision under risk. Econometrica. 47(4), 263-291
Lucas RE Jr (1972) Expectations and the neutrality of money. Journal of economic theory, 4, 103-124
Markowitz HM (1952) Portfolio selection. Journal of finance. 7 (1): 77–91
O'Hara M (1995) Market microstructure theory, Blackwell, Oxford
NBER (2019) US Business cycle expansions and contractions: https://www.nber.org/cycles.html, Retrieved May 8
Pratt JW (1964) Risk aversion in the small and in the large. Econometrica. 32 (1–2): 122–136
Prigogine I (1980) From being to becoming: time and complexity in the physical sciences, Freeman, San Francisco
Ross SA (1976) Return, risk, and arbitrage. In Friend I, Bicksler J eds. Risk and return in finance, Ballinger, MA: Cambridge
Schrödinger E (1948) What is life? Cambridge University Press, Cambridge
Schumpeter JA (1939) Business cycles, a theoretical, historical, and statistical analysis of the capitalist process, McGraw-Hill, New York
Shleifer A (2000) Inefficient markets: an introduction to behavioral finance. Oxford University Press
Shleifer A, Summers LH (1990) The noise trader approach in finance. Journal of economic perspectives 4(2), 19-33
Tang Y, Chen P (2014) Time varying moments, regime switch, and crisis warning: the birth-death process with changing transition probability. Physica A 404, 56-64
Tang Y, Chen P (2015) Transition probability, dynamic regimes, and the critical point of financial crisis. Physica A 430, 11-20
Tversky A, Kahneman D (1973). Availability: a heuristic for judging frequency and probability. Cognitive psychology, 5 (2): 207–232
Wilson EO (1975) Sociobiology: the new synthesis, Harvard University Press