The Efficient Market Hypothesis, the Financial Instability Hypothesis, and Speculative Bubbles

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The Efficient Markets Hypothesis, the Financial Instability Hypothesis, & Speculative Bubbles

Boston College Senior Thesis 2014

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Anyone taken as an individual is tolerably sensible and reasonable—as a member of a crowd, he at once becomes a blockhead.

—Friedrich von Schiller, as quoted by Bernard Baruch

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I would like to express my sincerest thanks to Professor Petersen, for all his time and patience in helping me develop these ideas and write this thesis. Everything I know about financial markets I learned from Professor Petersen, and I am extremely grateful for his generosity towards me and his enthusiasm for proving the existence of speculative bubbles. I couldn’t ask for a greater mentor.

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As Charles Kindleberger so astutely points out, there is a deep-seated proclivity in human behavior to make invidious comparisons between one’s neighbors’ wealth and one’s own. It does seem very difficult to sit around and do nothing while those around us are getting rich. This behavioral tendency seems easily observable in what we might identify as speculative bubbles, whether it be the Tulip Mania of the 1630s, the South Sea Bubble of the 18th century, 1 or the tech stocks of the late 1990s. Perhaps the most readily observable instance of this tendency was in the subprime bubble of the last decade, in which “everyone and their mother” was speculating on houses.

There is an old fable, the origins of which I am not entirely sure, that quite wonderfully illustrates this behavioral tendency. I’ll do my best to recount the story here:

There once was a genie who granted a man three wishes on one condition—whatever the man wished for, his neighbor would receive twice the amount. First, the man wished for a great estate. The wish was granted. The man had a great estate with everything he needed to satisfy all his needs and desires—except for one: his desire to have more than his neighbor. Observing the new estate of his neighbor, which was now twice the size of his, the man covetously called in his second wish: an unparalleled stock of cattle. So his wish was granted, and indeed he had more cattle than everyone else in the land, except for his neighbor who now had cattle equivalent to unparalleled x2. Upset with his relative lack of wealth, the man thought, calculated, and thought some more. Then he called upon the genie to grant him his final wish.

This is what the man said: “Genie, undoubtedly, you have made my first two wishes come true and they are indeed great. But my neighbor has been granted twice what I have received, and I just can’t stand it anymore! For my third and final wish I want you to make me blind in one eye!”

We have a subconscious proclivity for comparing our wealth with those around us, and this proclivity is always coupled with an insatiable desire to have relatively more. This behavioral phenomenon is of interest generally as it offers insights into the desires that motivate all of us; however, it is also of interest specifically to this paper, as it provides a psychological insight into how and why investors engage in speculative trading even when asset prices have skyrocketed beyond any sort of fundamental valuation. When securities markets are surging upward, it is easy to get rich and it is difficult to watch others do so without jumping on the bandwagon.

Rather than assuming an unrealistic, reductionist view of humans as utility maximizing hedonists, why not assume a rich and complex array of motivations, sometimes contradictory, deeply embedded in our psychological propensities, that recognizes the intricacy (and dare I say beauty) of human behavior?

1 Even the master of the mint, Sir Isaac Newton himself, lost a fortune speculating on shares of the South Sea Company. Newton perceptively acknowledged the difficulties faced by the social scientist—namely, the irrationality of human beings: “I can calculate the motion of heavenly bodies but not the madness of people.”
I. Abstract

According to the Efficient Market Hypothesis (EMH), speculative bubbles do not exist and are impossible. We disagree. If prices are the only observable component of an asset’s value, and they themselves are an aggregated consensus of perceived value, then what about the Efficient Market Hypothesis (EMH) is testable? Rather than assume that prices always reflect value (i.e. perfect market efficiency), we maintain that markets are efficient to the extent that one can be confident that tomorrow’s prices will not diverge dramatically or arbitrarily from today’s prices, absent significant new information. Speculative bubbles are not materializing every day, every month, or even every year. But they do have the potential and indeed a tendency to occur from time to time.

If markets are efficient, what explains all the trading? Rather than assume rational expectations and a homogenous investor class, we assume four investor classes that diverge in their perception of value (i.e. in their expectation of future returns) and thus trade with each other. Using insights from Hyman Minsky’s Financial Instability Hypothesis (FIH), we develop a theoretical framework for how a speculative bubble might materialize within a modern capitalist economy with securities markets’ that follow a random walk.

Obviously, there is no “bubble” variable. We use Tobin’s Q, the ratio of the price of an asset to its replacement cost, and Shiller’s cyclically adjusted P/E ratio as proxy variables for bubbles. We find statistically significant, negative relationships between both of these proxy variables and our dependent variable, Ten Year Cumulative Returns, thereby providing evidence against the EMH and suggesting the possibility of speculative bubbles.

I. Introduction

The Efficient Markets Hypothesis (EMH) yields a paradox: if securities markets are efficient then profitable trading strategies do not exist and rational investors would hold an index fund that reflects the performance of the market overall, adjusting their weights in stocks and bonds in response to price shocks only to rebalance their respective Sharpe ratios, rather than engaging in speculative trades. If trading is rendered unprofitable then what is the mechanism by which prices adjust to “fully reflect” new information? It is only through buy and sell offers that prices adjust to equal value. The EMH cannot

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2 That is, value itself is not observed. Prices thus serve as the market’s best approximation of value; I think they can be thought of as our best proxy for the underlying value of an asset.

3 Of course, markets must be relatively efficient. Perfect inefficiency implies that prices are perfectly arbitrary. This would make it very difficult for any economy to function. We take this to be intuitively and empirically consistent (and self-evident) I think most of us our pretty sure that we can afford to buy eggs, milk, bread, and the like at reasonable prices in the foreseeable future.

4 In fact, in the U.S. we have only experienced two episodes that can truly be identified as bubbles: The Stock market frenzy of the 1920s that led to the Great Depression, and the subprime mortgage crisis of the mid 2000s that led to the 2nd Great Contraction. The so-called DotCom bubble is also a good candidate, though it did not
explain why trading occurs (let alone why it would occur at the volume at which it does) because it assumes that people develop rational expectations about value. In order to explain why trading occurs we assume that investors can also develop irrational expectations. To model this, we assume four investor classes: (1) Rational Investors (RI), (2) Over Reactors (OR), (3) Slow Learners (SL), and (4) Crowd Investors (CI).

Because we assume that investors can (and do) develop irrational expectations, we imagine market price fluctuations as a consequence of a seesaw or pendulum-like mechanism, by which prices “orbit” around value, such that \( P_0 \approx V_0 \), most of the time. In the absence of a bubble, ORs will buy from SLs in response to a positive price shock, and SLs will buy from ORs in response to a negative price shock. Because SLs and ORs are trading more than RIs, they are incurring transaction costs and RIs show superior performance to other investor types most of the time. Therefore the CIs gravitate towards the RIs most of the time and price very closely approximates value. In this situation, markets are efficient as the majority of investors follow the RI class. This is the theoretical foundation for market efficiency, which explains how efficiency happens rather than erroneously assuming that prices adjust to new information automatically.

This reasoning also provides a theoretical foundation for how speculative bubbles might manifest. Assume a series of positive random shocks. Initially, there will not be much of a divergence in price from value. But, as these positive shocks continue, just by chance, investors start to believe that there is something new about the market (whatever this “new paradigm” is, the fundamental implication is that estimates of future returns become biased upward and/or risk measurements become biased downwards). Now, ORs become heavily weighted in stocks and are also trading on margin (i.e. are highly leveraged) because of their higher risk tolerance. If these positive shocks continue for some time, these levered ORs are making a lot of money; indeed, they will be showing superior performance to the other investor classes. As this happens, the CIs move their money to the ORs (or equivalently, emulate the ORs), further bidding up asset prices. At some point all this good news has become the new reality and even RIs and SLs get caught up in the frenzy, lest they be left in the dust by their “neighbors.”

The better the news, the bigger the bubble; however, the bigger the bubble, the greater the chance that the next news story will not be as good as expected! As reality hits, as it always does, the bubble deflates. Thus, speculative bubbles sow the seeds of their own destruction.

The theory is guided by Hyman Minsky’s Financial Instability Hypothesis, which helps explain how a series of random positive shocks can snowball into a speculative bubble. Ultimately, we believe that securities markets are efficient to the extent that one can be confident that today’s price will not diverge dramatically from tomorrow’s price.

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6 As opposed to the one, paradoxical one implied by EMH.
7 Since any positive shock over more than one instant is a sum of largely positive shocks over shorter periods, (i.e. a positive shock over the course of one day is the sum of the hourly shocks, which is a sum of shocks per minute, etc.) the ORs will on balance be accumulating stock as its price rises and thus having superior returns.

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In this paper, we critically examine the assumptions of the EMH and present some arguments for altered assumptions. Once these assumptions are relaxed, it becomes easier to see why markets might not always be efficient and how bubbles might materialize.

II. Background

Prices imply buyers, sellers, and a market. More importantly, prices imply an agreement between two parties with respect to the underlying value of the entity being exchanged. The development of simple financial instruments such as equity and debt that can be traded implies the existence of a financial market and what seems to be an implicit agreement between buyers and sellers with respect to the value of said securities.

Over the last fifty years, economics and finance departments around the world have witnessed the development and ascendance of the Efficient Markets Hypothesis (EMH), which simply states that securities’ prices at any point in time fully reflect all publicly available information at that time. Equivalently, \( P_0 = V_0 \). Price changes are random as they are a function only of new information, which is random. The fundamental implication of the EMH, is that there are no long-term trading strategies that can outperform the market.

One of the enduring ironies of the EMH, is that market efficiency itself is dependent upon practitioners’ belief that markets are inefficient. Why? Because it is through the trading mechanism that prices are pushed to value and are adjusted to reflect new information. Trading occurs presumably because investors believe they can capture excess risk-adjusted returns. If there are indeed no long-term profitable trading strategies, what explains the persistent and increasing volume of trading? Furthermore, the EMH is built on the assumption that investors develop rational expectations about both the present and future value of securities. If people do in fact develop rational expectations, they would not engage in trading, but just hold an index fund that reflects the overall performance of the stock market. Both of these conditions cannot hold simultaneously.

Reality demonstrates that a tremendous amount of trading occurs everyday. In 2008, for example, annual turnover on the NYSE exceeded 135%, implying that each share of each stock was traded 1.35 times on average! This intensity of trading has been increasing substantially since the 1970s. Though the volume of trading has fallen somewhat in the wake of the 2nd Great Contraction, it is still significantly higher than its historical average.

Another apparent difficulty with the EMH, is that it can only be tested against another equilibrium model of asset pricing. Why? Because only prices are observable, value is not. Thus, tests of efficiency will only be valid if we have an asset-pricing model that is accurate. This is the famous joint hypothesis problem. All asset-pricing models depend on an accurate assessment of risk to determine value. The more we learn about financial markets, the more it seems that we are unable to accurately determine the inherent risk of various financial securities.

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8 Jonathan Berk and Peter DeMarzo, *Corporate Finance, 2nd Ed.*
In other words, according to the EMH, securities of equivalent risk should have the same expected return. However, “equivalent risk” is not defined, rendering the EMH impossible to test. A measure of risk is defined under the Capital Asset Pricing Model (CAPM) assumptions, and thus we can test the idea that no profitable trading strategies exist in the CAPM by testing whether the market portfolio is efficient and all trading strategies have a zero “alpha” (i.e. trading strategies are on or below the Security Market line).

Empirical tests of the EMH, therefore, typically rely on the CAPM’s measure of risk. Ironically, the empirical evidence is not conclusive—while individual investors and professional fund managers on average perform no better than the market, there are profitable trading strategies that exist. This inconclusiveness is a consequence of the joint hypothesis problem: perhaps the CAPM is not accurately measuring risk. This is no easy task, and there is perhaps no quest more important in finance than correctly measuring risk.

There is a growing literature today that is concerned with the impact of rare, “fat-tail” events and our inability to calculate the probability of their occurrence. The epistemologist, statistician, and trader, Nassim Nicholas Taleb, has developed some of these ideas into what is now loosely referred to as Black Swan Theory:

What we call here a Black Swan (and capitalize it) is an event with the following three attributes. First, it is an outlier, as it lies outside the realm of regular expectations, because nothing in the past can convincingly point to its possibility. Second, it carries an extreme ‘impact.’ Third, in spite of its outlier status, human nature makes us concoct explanations for its occurrence after the fact, making it explainable and predictable.

Ironically, this third characteristic of hindsight rationalization has been used by Eugene Fama as a criticism of those who believe asset bubbles exist (see below), but this criticism could be levied with equal if not greater validity against those who retrospectively “correct” their equilibrium model of asset pricing to confirm the EMH when confronted with negative results.

If Taleb, et. al are correct about the difficulty in accurately assessing risk, then how can we be sure that our tests of the EMH are accurate? Might it not be the case that our equilibrium asset-pricing models are wanting? The issue is apparently (very) unresolved.

This year the Nobel Prize in Economics was awarded jointly to Fama and Robert Shiller, for their empirical analysis of asset prices. Fama is largely responsible for the theoretical development of the EMH beginning in the 1960s with his PhD dissertation at the University of Chicago where he has remained since. Shiller is the Sterling

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9 To the extent that CAPM does not include securities from global markets, it is clearly mispricing risk.
11 Lars Hansen also shared the prize.
Professor of Economics at Yale and is well known for his book *Irrational Exuberance* as well as his meticulous collection of historical real estate and stock price data.\(^\text{13}\)

Amusingly, the two economists’ analyses bring them to diametrically opposed conclusions about how assets are priced and how prices change. Fama outright denies the existence of speculative “bubbles” on the grounds that there are no econometric tests that allow us to predict when a bubble is forming or when it might burst. According to Fama, all bubbles are only recognized as such retrospectively. Furthermore, he criticizes the use of the term as being inconsistent and misleading.

Shiller, on the other hand, consistently refers to the EMH as a “half-truth,” and that financial markets are repeatedly subject to fads or social epidemics that cause prices to fluctuate around value. Shiller believes that economics must rely on and integrate theories from other disciplines within the social sciences to develop a more accurate model of human behavior (i.e. a model of human behavior that has more explanatory power than the rational expectations model). Shiller asserts that speculative bubbles do indeed occur and are the result of feedback mechanisms between investors and the media that cause asset prices to be bid up beyond fundamental value.

Financial markets since the late 1980s have witnessed some extreme turbulence (relatively speaking)—from the Market Crash of 1987, to the rise and fall of Japanese stocks and real estate in the 1990s, to the NASDAQ boom and bust in the early 2000s, to the subprime mortgage crisis in the U.S. at the end of the last decade that has led to our current global recession—that seem inconsistent with the EMH. Much of the revolution in behavioral economics and behavioral finance over the last twenty years are indicative of this apparent incongruity.

Despite all this, Fama and his followers maintain that markets are efficient. We think there are bubbles.

a. The Role of Financial Markets: Connecting Lenders & Borrowers

The Amsterdam Stock Exchange was established in 1602 to finance the trading ventures of the Dutch East India Company (*Vereenigde Oostindische Compagnie, VOC, ”United East India Company”*).\(^\text{14}\) After successfully raising money by selling shares in what can only be described as the world’s first IPO, it was not long before a securities market emerged where investors and speculators could trade shares and speculate on short-term share prices. Thus it was in 17\(^{th}\) century Amsterdam that “the global securities market began to take on its modern form.”\(^\text{15}\)

Since the beginning of the 17\(^{th}\) century, financial markets have become both increasingly complex and important to the development of what might be described as a “modern

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\(^{13}\) Shiller was instrumentally in developing the Case-Shiller Index for U.S. Housing Prices as well as the Shiller P/E ratio.

\(^{14}\) Initial expeditions were financed to capture profits from the Malukan spice trade. And capture profits they certainly did! The VOC provided approximately 18% annual returns, on average for nearly 200 years!

economy.” In fact, there are few who would argue that a modern economy is possible without the development of sophisticated financial markets.

By financial markets we mean those institutional arrangements that facilitate the allocation of an economy’s capital stock by connecting lenders with borrowers through the issuance of stocks (equity) and bonds (debt). In a very real sense, financial markets facilitate the manifestation of innovative ideas by connecting those keen on investing their savings with those who have ideas but lack the capital necessary to implement them. Financial markets unleash this creative potentiality through this capacity of intermediation. It is difficult to imagine how an idea or venture could come to fruition without this crucial function.

Within securities markets, a distinction between primary markets and secondary markets must be made.

a.1 Primary Markets
Primary markets are markets through which firms raise new money from the public through the issuance of stocks or bonds (or instruments which combine features of both). It is through these primary markets that good ideas are launched by the issuance of securities intended to finance future growth.

a.2 Secondary Markets
Once securities are issued they are negotiable—they can be bought or sold or given away. This trading of securities is done primarily through securities exchanges. Secondary markets play two important functions: (1) they add liquidity to the market thereby freeing up capital for new, profitable ideas and (2) they facilitate economic efficiency by providing a means by which prices can adjust to reflect the supply and demand for different securities (price discovery). However, this trading of securities has become so pervasive, especially with the rise of the internet and the consequent decline in trading costs, that it is unclear whether their social benefits outweigh their social costs. The line between trading and gambling is a fine one indeed, if it exists at all.

John Maynard Keynes expressed this concern nearly ninety years ago:

When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done. The measure of success attained by Wall Street, regarded as an institution of which the proper social purpose is to direct new investment into the most profitable channels in terms of future yield, cannot be claimed as one of the outstanding triumphs of laissez-faire capitalism—which is not surprising, if I am right in thinking that the best brains of Wall Street have been in fact directed towards a different object.

These tendencies are a scarcely avoidable outcome of our having successfully organized “liquid” investment markets. It is usually agreed that casinos should, in the public interest, be inaccessible and expensive. And perhaps the same is true of Stock Exchanges.
Keynes wrote *The General Theory* in the wake of the Great Depression. As we slowly emerge from the 2nd Great Contraction (so-called by Reinhart and Rogoff), perhaps it is wise to consider Keynes’ words regarding the imposition of greater transactions costs on speculative trading.

a.3 The Importance of Financial Markets: Prices as Signals

The prices set in financial markets are extremely important not only to those actively engaged in trading, but to the rest of the economy as well. In fact, they are arguably more important for the latter as the aggregated consequences to the entire population seem greater than the gains or losses of speculative traders. Regardless, financial markets price everything from financial securities to commodities, which include everything from the price of real estate to coffee.

Prices are like signals or signposts that allow individuals to make informed decisions about how to allocate their resources. We use prices to determine how much money we can generate through the expenditure of our labor over a given period of time, how much to save in preparation for the future, whether or not to invest in a particular asset, etc. Thus, if prices were arbitrary or subject to capricious fluctuation, much of the economy would be unable to accurately form expectations about the future and consequently unable to make decisions in the present. Because this is apparently not the case, we tend to think that prices reflect some underlying quality of the asset, namely value. Ironically, we can never observe the actual value of an asset. As mentioned, the only thing we observe is price.

But financial markets appear to be subject to asset bubbles, in which traders and lenders get carried away in waves of euphoria in which they overestimate returns and underestimate risk. During these euphoric waves, traders take on excessive amounts of debt and bid asset prices to unsustainable levels. Then at some point reality hits and asset prices begin to fall. Loans are called in or not renewed, and the traders are forced to sell at any price. Asset prices collapse and lenders either fail or are bailed out by governments. Credit dries up and a recession ensues. It has happened over and over and no doubt will happen again.

a.4 Hyman Minsky’s Financial Instability Hypothesis (FIH)

In economies where borrowing and lending exist, ingenuity goes into developing and introducing financial innovations, just as into production and marketing innovations. Financing is often based upon an assumption “that the existing state of affairs will continue indefinitely” (GT, p. 152), but of course this assumption proves false. During a boom the existing state is the boom with its accompanying capital gains and asset revaluations. During both a debt-deflation and a stagnant recession the same conventional assumption of the present always ruling is made; the guiding wisdom is that debts are to be avoided, for debts lead to disaster. As a recovery approaches full employment the current generation of economic soothsayers will proclaim that the business cycle has been banished from the land and a new era of permanent prosperity has been
inaugurated. Debts can be taken on because the new policy instruments—be it the Federal Reserve System or fiscal policy—together with the greater sophistication of the economic scientists advising on policy assure that crises and debt-deflations are now things of the past. But in truth neither the boom, nor the debt deflation, nor the stagnation, and certainly not a recovery or full-employment growth can continue indefinitely. Each state nurtures forces that lead to its own destruction.16

The late economist Hyman P. Minsky17 was acutely aware of the systematic tendency of modern capitalist economies to misallocate resources. Disagreeing with many of his contemporaries who advocated financial deregulation in response to what many thought to be a new macroeconomic paradigm whereby the business cycle could be managed scientifically with monetary and fiscal policy, he argued that modern financial markets sow the seeds of their own destruction by encouraging speculation and the build up of increasingly risky credit structures and thus require significant regulatory oversight. Though many dismissed Minsky as a cynic, he certainly seems to have been vindicated in the aftermath of the 2nd Great Contraction.

Today Minsky is perhaps best known for his Financial Instability Hypothesis (FIH), which he summed up best in three words: “Stability is destabilizing.” At first glance, this may seem to be a paradoxical or even absurd statement, but further consideration yields an interesting logical foundation for the claim. The basic idea is that an economic boom can lull investors and other market participants into a false sense of security. As investors become over confident in their valuation of the market, they lever up and take on more risk. Implicit in Minsky’s thinking is a conception of human memory that puts more weight on the most recent past. People make judgments and form expectations about the future based on what they have experienced most recently. Evidently, human beings don’t have a very robust memory when it comes to financial history, as speculative manias have occurred over and over again. Is it a coincidence that the implosion of the subprime mortgage market and the ensuing 2nd Great Contraction occurred about seventy years after the Great Depression? (this seems like roughly enough time for anyone who was old enough to remember the Great Depression firsthand to have passed away).

As the subjective repercussions of the debt-deflation wear off, as disinvestment occurs, and as financial positions are rebuilt during the stagnant phase, a recovery and expansion begins. Such a recovery starts with strong memories of the penalty extracted because of exposed liability positions during the debt-deflation and with liability structures that have been purged of debt. However, success breeds daring and over time, the memory of the past disaster is eroded. Stability—even of an expansion—is destabilizing in that more adventuresome financing of investment pays off to the leaders, and others follow. Thus an expansion will, at an accelerating rate, feed into the boom.18

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17 I have had the unique pleasure of studying under Hyman Minsky’s student, Dr. Harold Petersen!
Observing the recurring cycle of boom and bust within financial markets, Minsky was deeply impressed by what he perceived to be their inherent fragility. While other contemporary economists worked to explain away anomalies to market efficiency individually, attributing each one to “exogenous shocks”, Minsky suspected that qualities of the economy itself were a contributing factor to the development of speculative manias.

Minsky identified five stages of a typical speculative bubble: (1) Displacement, (2) Boom, (3) Euphoria, (4) Profit Taking, and (5) Panic.

(1) Displacement

A displacement is any event or series of events that changes the way in which investors think financial markets work. In his book (blank), John Kenneth Galbraith aptly describes this phase:

The more obvious features of the speculative episode are manifestly clear to anyone open to understanding. Some artifact or some development, seemingly new and desirable—tulips in Holland, gold in Louisiana, real estate in Florida, the superb economic designs of Ronald Reagan—captures the financial mind or perhaps, more accurately, what so passes.

A key feature of a displacement is that some (seemingly) new financial paradigm enamors investors. Other examples include the development of the Internet for commercial use or the historically low interest rates ushered in by Alan Greenspan after the implosion of the Dotcom bubble and the terrorist attacks of 9/11. These events signaled to investors that something new and unprecedented was afoot within financial markets. Ironically, there is plenty of precedent for the seeming unprecedented to be anything but.

(2) Boom

Following a displacement, prices slowly begin to rise as investors are awakened to the “new” opportunity. Again, no one wants to be left behind by his or her neighbor who has doubled her wealth. These price increases begin to gain momentum as more and more participants enter the market. Galbraith also eloquently describes this stage of the bubble:

The price of the object of speculation goes up. Securities, land, objets d’art, and other property, when bought today, are worth more tomorrow. This increase and the prospect attract new buyers; the new buyers assure a further increase. Yet more are attracted; yet more buy; the increase

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19 Whether or not Minsky explicitly developed and outlined these five stages is unclear. Charles Kindleberger in his book, *Manias, Panics, and Crashes*, attributes this five-stage framework to Minsky. Investopedia also lays out this framework and attributes it to Minsky.

continues. The speculation building on itself provides its own momentum.21

The Boom phase is usually characterized by widespread media coverage. Fear of missing out on what could potentially be a once-in-a-lifetime opportunity draws more traders into the speculative fold. Shiller refers to this mechanism of price increases leading to media coverage leading to further price increases and so on as a feedback loop:

A situation in which news of price increases spurs investor enthusiasm which spreads by psychological contagion from person to person, in the process amplifying stories that might justify the price increase and bringing in a larger and larger class of investors, who, despite doubts about the real value of the investment, are drawn to it partly through envy of others’ successes and partly through a gambler’s excitement.22

Shiller more explicitly lays out the framework for feedback loop theory in his book Irrational Exuberance:

In feedback loop theory, initial price increases…lead to more price increases as the effects of the initial price increases feed back into yet higher prices through increased investor demand. This second round of price increases feeds back again into a third round, and then into a fourth, and so on. Thus the initial impact of the precipitating factors is amplified into much larger price increases than the factors themselves would have suggested.23

The legendary investor, George Soros, similarly refers to this phenomenon as “reflexivity.”

[…] markets never reach the equilibrium postulated by economic theory. There is a two-way reflexive connection between perception and reality which can give rise to initially self-reinforcing but eventually self-defeating boom-bust processes, or bubbles. Every bubble consists of a trend and a misconception that interact in a reflexive manner.24

(3) Euphoria

During this phase, restraint is “thrown to the wind” as asset prices skyrocket. Valuations reach extreme, unprecedented levels during this phase.25 Furthermore, new valuation metrics emerge to rationalize the unremitting rise in prices.

25 For example, at the peak of the Japanese real estate bubble in 1989, land in Tokyo sold for as much as $139,000 per square foot, or more than 350-times the value of Manhattan property. After the bubble burst,
During this phase, any “dissenters” (i.e. those who recognize the speculative orgy and call it out as such) are harshly rebuked and censored: “The euphoric episode is protected and sustained by the will of those who are involved, in order to justify the circumstances that are making them rich. And it is equally protected by the will to ignore, exorcise, or condemn those who express doubts.”

The bearer of bad news is often condemned and reproached—this seems to be especially true in speculative bubbles. No one who is making easy money wants to be told that their success is unsustainable or unwarranted. Perhaps this “rebuke of dissenters” is an indicator of the Euphoria phase of a speculative bubble.

Another potential bubble indicator is the increased use of leverage in speculative wagers:

- During these euphoric periods an increasing number of investors seek short-term capital gains from the increases in the prices of real estate and stock rather than from the investment income based on the productive use of these assets. Individuals make down payments on condo apartments in the preconstruction phase of the developments in the anticipation that they will be able to sell these apartments at handsome profits when the buildings have been completed.

The build up of leverage during bull markets is not explained by the EMH.

(4) Profit Taking

By this time, seasoned investors are selling out positions and taking hefty profits. But predicting the precise time when a bubble is due to implode and when to sell out one’s position is a difficult exercise and awfully hazardous to one's financial health, because, as John Maynard Keynes put it, "markets can stay irrational longer than you can stay solvent."

(5) Panic

The final stage of the bubble is its implosion. In the panic stage, asset prices reverse course and descend as rapidly as they had risen. Investors and speculators, faced with margin calls and plunging values of their holdings, now want to liquidate them at any price. This is often referred to as an asset “fire-sale.” As supply overwhelms demand, asset prices slide sharply.

real estate lost approximately 80% of its inflated value, while stock prices declined by 70%. Similarly, at the height of the internet bubble in March, 2000, the combined value of all technology stocks on the Nasdaq was higher than the GDP of most nations. (investopedia.com)

28 “One of the most vivid examples of global panic in financial markets occurred in October 2008, weeks after Lehman Brothers declared bankruptcy and Fannie Mae, Freddie Mac and AIG almost collapsed. The S&P 500 plunged almost 17% that month, its ninth-worst monthly performance. In that single month, global equity markets lost a staggering $9.3 trillion of 22% of their combined market capitalization.” (investopedia.com)
Galbraith describes two additional characteristics of speculative bubbles that deserve mention—the brevity of financial memory and the unfounded association of money with intelligence:

Contributing to and supporting this euphoria are two further factors little noted in our time or in past times. The first is the extreme brevity of the financial memory. In consequence, financial disaster is quickly forgotten. In further consequence, when the same or closely similar circumstances occur again, sometimes in only a few years, they are hailed by a new, often youthful, and always supremely self-confident generation as a brilliantly innovative discovery in the financial and larger economic world. There can be few fields of human endeavor in which history counts for so little as in the world of finance. Past experience, to the extent that it is part of memory at all, is dismissed as the primitive refuge of those who do not have the insight to appreciate the incredible wonders of the present.

The second factor contributing to speculative euphoria and programmed collapse is the specious association of money and intelligence. Mention of this is not a formula for eliciting reputable applause, but, alas, it must be accepted, for acceptance is also highly useful, a major protection against personal or institutional disaster.

This idea of “financial amnesia” is a fascinating one and it is beyond the scope of classical economic theory to address, as it requires an understanding of how memory works. The assumption of rational behavior precludes the possibility of a subjective memory that places more weight on certain events and experiences while completely blotting out others.

The second factor mentioned by Galbraith is also intriguing as it uncovers a truth about human nature in the context of modern market economies. Within capitalist systems, money is the measure of achievement, success, and prowess. There is a deep fascination with those who are able to procure and command large sums of money. Much of this is attributable to the apparent difficulty in making money. Thus, possession of vast quantities of money is naturally associated with some special genius:

This view is then reinforced by the air of self-confidence and self-approval that is commonly assumed by the affluent. On no matter is the mental inferiority of the ordinary layman so rudely and abruptly stated: ‘I’m afraid that you simply don’t understand financial matters.’ In fact, such reverence for the possession of money again indicates the shortness of memory, the ignorance of history, and the consequent capacity for self- and popular delusion just mentioned. Having money may mean, as often in the past and frequently in the present, that the person is foolishly

indifferent to legal constraints and may, in modern times, be a potential resident of a minimum-security prison.\textsuperscript{30}

One need look no further than an undergraduate business program to witness the degree to which the brightest young minds are smitten by the allure of Wall Street. Or consider Martin Scorsese’s most recent film, \textit{The Wolf of Wall Street}, which simultaneously criticizes and glorifies the debauched lifestyle of the stock trader, Jordan Belfort. Whether or not Scorsese wrote the film as a critique or not is irrelevant. What’s important and alarming is the fact that many are enamored by Belfort’s lifestyle and, despite recognizing his complete lack of basic decency (let alone any recognizable ethical standards), still want to experience it!

This last September, Shiller wrote an article for \textit{Project Syndicate} called “The Best, Brightest, and Least Productive?”\textsuperscript{31} in which he seriously considers this problem: “Are too many of our most talented people choosing careers in finance—and, more specifically, in trading, speculating, and other allegedly ‘unproductive’ activities?” This question deserves the utmost consideration, in my opinion.

b. The Efficient Markets Hypothesis

Let’s take a closer look at the EMH.

As mentioned above, the Efficient Markets Hypothesis states that security prices fully reflect all available information. Prices change only in response to new information, which cannot be predicted since new information is a random variable. Thus, anything predictable is already reflected in the price: “News is good news only if it is better than had been expected and is bad news only if worse than had been expected.”\textsuperscript{32}

Equivalently:

\[
P_0 = V_0 = f(\text{information})
\]

\[
\Delta P = \Delta V = f(\text{new information})
\]

\[
P_t = P_{t-1} + \epsilon_t \quad \Delta P_t = \epsilon_t \quad E(\epsilon_t) = 0
\]

Thus, Price Changes are Random.

However, without an explanation of what it means to fully reflect this information, the equation is reduced to nothing more than a tautology. Hence the famous joint hypothesis problem: the EMH necessitates an equilibrium model of how security prices are set by which one can make predictions that can be observed and tested.

The joint hypothesis problem, however, creates an additional problem—that of choosing a security pricing model that works (i.e. actually reflects reality). If tests of market


\textsuperscript{31} http://www.project-syndicate.org/commentary/the-rent-seeking-problem-in-contemporary-finance-by-robert-j--shiller

efficiency produce negative results, it is difficult to determine whether it is the model that is deficient, or markets that are inefficient, or both. This issue still seems to be basically unresolved within the literature.

For the purposes of this paper, let us assume the following valuation model. Let

\[ \text{Val}_t = \frac{E_t}{k_t} \]

Where \( E_t \) is equal to earnings, defined as the amount that could be paid out to shareholders as a constant in perpetuity (in the absence of any future shocks) and \( k_t \) is the going rate of return on investments of similar risk. This is consistent with any pattern of future cash flows, since any pattern of future cash flows can be converted into perpetuity of equal value by either borrowing or lending. The discount factor \( k \) is the going rate of return on investments of similar risk, and it is composed of two parts: a risk-free rate and an equity premium:

\[ k = r_f + e \]

The risk free rate depends on both time preference and on the marginal productivity of capital. The equity premium depends on investors’ risk aversion and on the variability of future cash flows.

Assume that we have shocks that impact either \( E_t \) or \( k_t \) or both in any period of time. Thus we have

\[ \text{Val}_0 = \frac{E_0}{k_0}, \quad \text{Val}_1 = \frac{E_1}{k_1}, \quad \frac{\text{Val}_1}{\text{Val}_0} = \frac{E_1}{E_0}, \frac{k_0}{k_1} \]

Taking the log of the expression on the right, we have

\[ \Delta \ln(\text{Val}) = \Delta \ln(E) - \Delta \ln(k), \text{ or} \]

\[ \Delta V = \Delta \ln(E) - \Delta \ln(k) \]

Thus the random shock, \( e \), is the sum of a shock to earning power and the shock to the discount rate. Therefore, Value will increase either with a rise in earning power or with a decline in risk.

Now, back to the EMH.


(1) *Weak form efficiency*: Prices “fully reflect” all historical prices; the implication is that investors can’t earn excess risk-adjusted returns with a trading strategy based solely on historical data
(2) **Semi-strong form efficiency:** Prices fully reflect all current publicly available data as well as all historical data. The implication is that prices adjust rapidly to new public information so that investors cannot earn excess risk-adjusted returns trading on new public information or historical information.

(3) **Strong form efficiency:** Prices fully reflect all private and public information, as well as all historical data. The implication is that prices adjust rapidly to all new information so that investors cannot earn excess risk-adjusted returns trading on new or historical information.

“The basic market efficiency issue is the extent to which prices reflect historical information and adjust quickly to reflect new information (public or private), and whether investors can successfully implement trading strategies that earn an excess risk-adjusted return.”³³

The implication of EMH is of course that there are no long-term, profitable trading strategies, because the hyper vigilant activity of caffeine guzzling analysts are continuously and relentlessly trading in response to new information.

c. **Tobin’s Q and Long-Term Reversals**

One of the most fascinating anomalies in securities markets is that of long-term reversals—that a series of high returns tends to be followed by low returns and vice versa. To gain a bit more insight on this, consider Tobin’s Q.

Tobin’s Q was developed by Nobel Laureate James Tobin in 1968. It is the ratio between the market value and replacement value of a physical asset:

\[
Tobin's \, Q = \frac{\text{market value}}{\text{replacement cost}}
\]

One, the numerator, is the market valuation: the going price in the market for exchanging existing assets. The other, the denominator, is the replacement or reproduction cost: the price in the market for the newly produced commodities. We believe that this ratio has considerable macroeconomic significance and usefulness, as the nexus between financial markets and markets for goods and services.³⁴

Below is a graph of Tobin’s Q using Federal Flow of Funds data from 1945 through 2013. Notice that as of the end of 2013, Q is above 1.0, well above the historical average. A recent article by John Cassidy in *Fortune* expressed concerns about possible overvaluation in the stock market as the “Bernanke-Yellen bull market” enters its sixth year. Cassidy also suggests Q is a potential metric for evaluating bubble trends.³⁵

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³³ From the lectures of Professor Chris Maxwell (aka cMax) of Boston College.
As applied to the common stock of a corporation, we might think of Q as the ratio of the price of the stock to the replacement cost of the net assets.

Tobin’s Q is our key x-variable, and we will describe in further detail why Q is a good proxy variable for bubbles below.

d. A Critical Examination of the Assumptions of the EMH

“Your assumptions are your windows on the world. Scrub them off every once in a while, or the light won’t come in.” — Isaac Asimov

The EMH is built on three fundamental assumptions that do not reflect reality they claim to explain: (1) The Rational Expectations Model of Human Behavior (2) The Homogeneity of Investors (3) Price Changes follow a Random Walk (Brownian Motion).

(1) Rational Expectations

Is “rational expectations” a rational assumption? The rational expectations model is a transmutation of the older rational, utility maximizing model and is not substantially different. In essence, the theory is that humans’ expectations equal true statistical expected values and that human agents make decisions so as to maximize their utility (i.e. their wealth).
Therefore, when presented with all appropriate information about a security, individuals will make the rational choice that leads to the greatest possible wealth. They will not overlook important information, or overpay for a stock they expect to fall. They will behave as rational, self-interested individuals. They will make the market work efficiently, with their well-reasoned actions driving prices quickly to the “correct” level. And their preferences can be expressed in straightforward formulas, (utility functions) which, for a given input, always yield the same output.

However, in reality people simply do not think in terms of some theoretical utility, and are not always rational and self-interested. The repudiation of this one assumption of modern economic/financial theory has in the past twenty-five years created a fertile new field of inquiry, called behavioral finance/economics. It studies specifically how human beings misinterpret information, how their emotions distort their decisions, and how they miscalculate statistical probabilities.

George Soros also feels quite strongly on this subject:

I contend that rational expectations theory totally misinterprets how financial markets operate. Although rational expectations theory is no longer taken seriously outside academic circles, the idea that financial markets are self-correcting and tend towards equilibrium remains the prevailing paradigm on which the various synthetic instruments and valuation models which have come to play such a dominant role in financial markets are based. I contend that the prevailing paradigm is false and urgently needs to be replaced.  

(2) Homogeneity of Investors

The EMH assumes that all investors are alike. They all have the same investment objectives and the same time-horizon. Given the same information, they would make the same decisions. While their level of capital (i.e. wealth) may vary, none of them can influence prices on their own. They are price-takers, not makers.

In reality, people are not alike. Some buy and hold stocks for thirty years; others trade stocks daily. There are fundamentalists and there are “technicians.” There are large institutional investors and small, hobbyists/speculators and everyone else in between.

Once we drop the assumption of homogeneity, new mathematical models must be constructed. How much more complicated and volatile is the real market, with almost as many different investor classes as individuals? Let’s try to deal with four.

(3) Asset Price Changes follow a Random Walk

At the beginning of the 20th century, the French mathematician, Louis Bachelier, published his PhD dissertation in which he argued that asset prices follow a Brownian...
motion, thereby becoming the first person to model asset price movements as a stochastic process. This idea that stock prices follow a “random walk” has become a foundational building block of modern financial theory and is a fundamental assumption of the EMH. What does a random walk look like algebraically?

\[ V_t = V_{t-1} + \varepsilon_t \]

Where \( V_t \) is the log of the value of an asset and \( \varepsilon_t \) is a random shock in value with the following properties:

\[ E(\varepsilon_t) = 0, \quad Var(\varepsilon_t) = \sigma^2, \quad Cov(\varepsilon_t, \varepsilon_{t-1}) = 0 \]

This means that the expected value of the shock, \( \varepsilon_t \), is 0. It is assumed that these shocks follow a normal distribution, which means that price changes follow the proportions of the bell curve (i.e. most changes are small while an exceptionally small number are large, in predictable and declining frequency).

Further, all price changes are independent of each other. Intuitively, this means that past, historical price changes do not influence prices today. The implication is that nothing can be learned by studying past prices, rendering the insights of technicians and “chartists” obsolete.

What might a random walk in asset prices look like graphically? Here are four random simulations with the following properties:

\[ V_t = V_{t-1} + \Phi_1 + \varepsilon_t, \text{ where } \Phi_1 \text{ is a trend equal to .06} \]

Footnote: Brownian motion is a term borrowed from physics for the motion of a molecule in a uniformly warm medium.
These graphs were all generated using a random value generator in Excel, with a mean of zero and a standard deviation of 0.20. A trend line of 0.06 was added to the random values in order to mimic the average returns generated by the S&P500 (approximately 6%) if all dividends had been retained and reinvested. The important point is that a random walk (plus trend) in prices can generate an infinite number of different patterns—the actual returns of the S&P500 is just one of these outcomes. If a technical analyst were shown any of the above graphs, they would have a difficult time distinguishing these from real stock price graphs; furthermore, there’s no doubt that they would look at these graphs and identify bull and bear markets and possibly even “bubbles”—trends that represent nothing more than a series of random, positive or negative shocks that coincidentally resemble the real stock market (though with considerably less variance).

The fundamental problem in valuation is that we don’t know the probability distribution of future shocks. All we can observe is the pattern of price changes. If we assume markets are efficient, this problem goes away, since prices have always adjusted to the point where the expected future return is equal to \( k \), and \( k \) depends on a risk-free rate (which is observable) the standard deviation of possible shocks (assumed constant) and a risk aversion parameter (assumed to change very little over time).

In reality, life is much more complex. In other words, the random walk might not be as random as we all thought. Benoit Mandelbrot, the mathematician famous for discovering fractals and developing fractal geometry, was also one of Eugene Fama’s thesis advisors in the 1960s. Here’s his take on the situation:

Alas, the theory is elegant but flaws, as anyone who lived through the booms and busts of the 1990s can now see. The old financial orthodoxy

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was founded on two critical assumptions in Bachelier’s key model: Price changes are statistically independent, and they are normally distributed. The facts, [...] show otherwise. [...] 

First, price changes are not independent of each other. Research over the past few decades [...] shows that many financial price series have a ‘memory,’ of sorts. Today does, in fact, influence tomorrow. If prices take a big leap up or down now, there is a measurably greater likelihood that they will move just as violently the next day. It is not a well-behaved, predictable pattern of the kind economists prefer—not, say, the periodic up-and-down procession from boom to bust with which textbooks trace the standard business cycle. Examples of such simple patterns, periodic correlations between prices past and present, have long been observed in markets—in, say, the seasonal fluctuations of wheat futures prices as the harvest matures, or the daily and weekly trends of foreign exchange volume as the trading day moves across the globe. [...] 

Second, contrary to orthodoxy, price changes are very far from following the bell curve. If they did, you should be able to run any market’s price records through a computer, analyze the changes, and watch them fall into the approximate ‘normality’ assumed by Bachelier’s random walk. They should cluster about the mean, or average, of no change. In fact, the bell curve fits reality very poorly. From 1916 to 2003, the daily index movements of the Dow Jones Industrial Average do not spread out on graph paper like a simple bell curve. The far edges flare too high: too many big changes. Theory suggests that over that time, there should be fifty-eight days when the Dow moved more than 3.4 percent; in fact, there were 1,001. Theory predicts six days of index swings beyond 4.5 percent; in fact, there were 366. And index swings of more than 7 percent should come once every 300,000 years; in fact, the twentieth century saw forty-eight such days. Truly, a calamitous era that insists on flaunting all prediction. Or, perhaps, our assumptions are wrong.38

III. Restructured Model with New Assumptions

By relaxing the rational expectations model to include the potential for investors to develop irrational expectations, we also create space for the development of a model with heterogeneous investor classes. We begin by assuming four classes of active investors: (1) Rational Investors, (2) Over Reactors, (3) Slow Learners, and (4) Crowd Investors. Each of these investor classes responds differently to new information, and at any given time either Rational Investors or Over Reactors may dominate the market and influence price changes disproportionately.39

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39 To make these assumptions even more realistic, we might assume five investor classes, rather than four. We might call this fifth investor class “Fama Investors,” or investors who believe that markets are efficient, and consequently hold an index fund. The implication, of course, is that these investors would not
(1) Rational Investors

RIs accurately interpret shocks and value. They buy stocks when \( P_0 < V_0 \) and sell when \( P_0 > V_0 \). However, they buy and sell stocks only up to the point that their greater weight in stocks (from buying) or a lesser weight in stocks (from selling) is consistent with a higher (or lower) Sharpe Ratio.\(^{40}\) When value goes up they anticipate price rising to value and thus see a higher Sharpe Ratio at any price below value. Thus they buy and sell, but only to the point that their increased weight in stocks is consistent with a higher Sharpe ratio at the new price.

(2) Over reactors

ORs observe a current shock and assume it is a portent of future shocks of like magnitude. Their perceived value rises by the current shock plus a weighted average of past shocks, which may be modeled by a Koyck average of past shocks. Their perceived value will be above \( V_0 \) following a series of positive shocks and below \( V_0 \) following a series of negative shocks. Following a large shock they will be buying so long as \( P < V \) and will be buying from both the rational investors and the SLs.

(3) Slow Learners

SLs absorb the impact of news only gradually. In response to a shock of epsilon, their perceived value rises by some fraction, \( \lambda \), of that shock, and by some lesser fraction of past shocks. The full shock is or may not be fully absorbed but to the extent it is it happens gradually over time. They will sell at any price above their perceived value. Thus in response to a large positive shock they are selling to other investors.

(4) Crowd Investors

CIs observe how portfolio managers are doing and put their money with the ones that have the best records. In effect they invest with a rearview mirror (this is something we can observe—the extent to which the managers with the best records have net inflows of funds, or at least a larger share of any new money coming into the market). CIs can be intuitively thought of as the “herd.”

Under the EMH, price changes (i.e. “shocks”) are a function of new information, which is a random variable.\(^{41}\) Thus, price changes are unpredictable and so we assume a random walk. A random walk implies that the probability of a subsequent shock being positive or negative is equal.\(^{42,43}\) Just by chance we may experience a series of positive shocks, possibly resembling what we might identify as a bull market (the inverse is also

\( \text{Sharpe Ratio: } (E_{r_m} - r_f)/\sigma_m, \) where the numerator represents the reward for bearing risk (the expected return from the market minus the risk-free return from a riskless security) and the denominator is the market risk.

\(^{40}\) This is self-evident, as one cannot predict the news.

\(^{42}\) This seems like a reasonable assumption, though we may not be measuring the standard deviation accurately.
possible). When this happens the four investor classes diverge in their expectations of future value and thus in the price at which they are willing to buy and sell. We estimate this divergence in perception of value as a weighted average of past shocks, which can be modeled by a Koyck average of past shocks.

In response to a series of positive shocks, we contend that the ORs become over weighted in stocks, with expected returns that are biased upwards and risk estimates biased downwards. Assume that these positive shocks continue for some time. Prices continue to rise and the ORs show superior performance to the other investor classes. The CIs then begin to emulate the ORs. Following a large enough series of positive shocks the ORs (and their groupies) either invest or manage most of the money, and both the RIs and the SLs are left in the dust.

As the bubble grows it becomes more and more likely that the next shock will be less than expected. At some point we have disappointment (the shock is less than the average of past shocks) and perceived value as seen by ORs comes down. These investors now sell stocks, and price has to fall until the stocks find buyers, presumably from RIs and SLs. If the shock is positive it is bad news to ORs but still good news to RIs and SLs. If the shock is negative (and there is 50-50 chance it will be), then it is bad news to all investors and prices have to keep falling until all investors find they have a lower weight in stocks with a lower Sharpe ratio than before. If we have a series of negative shocks, then price continues to fall, and the rout is on. The ORs, with their overweight in stocks, underperform the RIs and the SLs. The CIs move away from the ORs to the SLs (who being underweight in stocks are outperforming the market) and to the RIs.

**Efficient Markets and Stock Trading**

Assume shareholder’s wealth grows as follows

\[ W_t = W_{t-1}e^{\alpha e_t} \]

Where \( \alpha \) is assumed constant and represents the rate at which wealth will grow as a function of time preference and acceptance of risk. We think of this as the going rate of return on investment in common stocks. It comes from investment of retained earnings so as to earn rate \( \alpha \) and from reinvestment of dividends at rate \( \alpha \). Alpha is assumed positive because we need to be rewarded for waiting (a risk-free interest rate) and for bearing risk (an equity premium).

The term \( e \) is a random shock with expected value of zero and a constant variance. Taking the natural log of \( W_t \), we have

\[ \ln W_t = \ln W_{t-1} + \alpha + e_t \]

Now model changes in log wealth due solely to the shocks, or apart from being able to reinvest changes in wealth (earnings as properly defined) at rate \( \alpha \). Thus, let

\[ 44 \text{ This can be conceptualized intuitively as Crowd Investors moving their money to portfolio managers of the Over reacting variety.} \]
\[ V_t = V_{t-1} + \epsilon_t \quad \Delta V_t = V_t - V_{t-1} = \epsilon_t \]

Where \( V = \log \text{of changes in wealth exclusively due to the shock, } \epsilon \). We do this so as to model changes in \( V \) under the EMH as a random walk, but we recognize that stock prices will rise over time due both to the firm’s retention of earnings and to the shareholder’s reinvestment of dividends. In looking at data we would estimate \( \alpha \) from the log trend of shareholder’s wealth.

It is understood that following a period when an investor starts at year zero with \( V_0 = \ln W_0 \), that \( \ln W_t \) will exceed \( V_t \) by the amount \( \alpha \) times \( t \).

\[
\ln W_t = \ln W_0 + t\alpha + \Sigma \epsilon_t \quad \text{and} \quad V_t = \ln W_0 + \Sigma \epsilon_t
\]

In looking at data we would estimate \( \alpha \) from the linear trend in the log of shareholder’s wealth. Under the EMH, P is always equal to V and thus the price change is equal to the value change.

\[
\Delta P_t = \Delta V_t = \epsilon_t \quad E\Delta P_t = E\epsilon_t = 0 \quad \text{Var}(\Delta P_t) = \sigma^2
\]

Thus prices follow a random walk. We will get bull markets occasionally with a series of largely positive shocks. Alternatively, we will get bear markets just by chance with a series of negative shocks, but from any point in time the expected value of the future price change will be zero.

**Rational Investors Dominate Trading**

We see through a glass darkly and thus in reaction to any shock, or series of shocks, we may overestimate \( V \) or underestimate \( V \). Assume we start with \( P = V \) but then over time experience a series of random shocks. Thus at any future point in time some investors overestimate \( V \) and some underestimate \( V \). Let \( V^* \) be the investor’s perceived or estimated value of \( V \) and \( V^* - V \) be thought of as bias upward or bias downward. Assume that RIIs buy if \( P < V^* \) and sell if \( P > V^* \) under the assumption that price will approach their perceived estimate of value and they will thus achieve abnormal gains from buying low or selling high. If all investors immediately and correctly perceive the shocks (\( \epsilon \)), and react immediately to any changes in value, then prices would change immediately and fully in response to any changes in value. Why? Because at any price below value all would want to buy but none would want to sell. And at any price above \( V \), all would want to sell and none would want to buy. Thus price changes in lockstep with value and we have the efficient market result above.

But we would have no trading, no buying or selling. Specialists or dealers would simply mark up the bid-ask spread to \( P = V \) and no one would buy or sell. This obviously is not the case. Thus we need to ask whether the EMH is consistent with buying and selling.

Define Rational Investors (RI) as a group whose individuals come to different values of \( V^* \) but who as a group have an unbiased estimate of \( V \). Those with high values of \( V^* \) buy from those with low value but do not affect the price. If the buying and selling is instantaneous, then the price adjusts instantaneously with trading and the EMH still holds.
Over Reactors (OR) Dominate Trading

But now suppose that following a series of positive shocks the CIs have moved their money to or emulate the ORs and this is the group that now dominates trading. Thus, price is equal to (or very close to) their estimate of Value, \( V^* \).

\[
P_t + V_t^* = V_t + \beta u_t, \quad \text{where} \]
\[
u_t = \lambda \varepsilon_t + (1 - \lambda) u_{t-1}
\]
\[
\Delta u_t = u_t - u_{t-1} = \lambda \varepsilon_t - \lambda u_{t-1}
\]
\[
\Delta P_t = \Delta V_t + \beta \Delta u_t = \varepsilon_t + \beta (\lambda \varepsilon_t - \lambda u_{t-1})
\]

This says that value perceived by ORs, \( V^* \), is equal to true value, \( V \), plus \( \beta \) times a Koyck\(^{45} \) weighted average of present and past shocks. To the ORs, the recent shocks become the new reality and they assume that future shocks will have an expected value equal to the average of recent past shocks. This may be thought of as the equivalent of a perpetually increasing rate of growth in earning power and the multiple \( \beta \) is like a P/E ratio.

At any point in time, starting from a given value of \( u_{t-1} \), the expected value of the price change is:

\[
E(\Delta P|u_{t-1}) = E(\varepsilon_t) + E(\beta \lambda \varepsilon_t - \beta \lambda u_{t-1})
\]

What this says is that if a bubble has been building up from a series of past shocks, then if the current shock is at its expected value of zero, then this is disappointing news and the price will fall by \( \beta \lambda \) times the past bubble. And we don’t need a negative value of epsilon for the price to fall. All we need is somewhat disappointing news.

Let’s explore this:

The variance of the price change will be

\[
Var(\Delta P|u_{t-1}) = (1 + \beta \lambda)^2 Var(\varepsilon_t) = (1 + \beta \lambda)^2 \sigma^2
\]

\[\text{with standard deviation} = (1 + \beta \lambda) \sigma\]

We can look at the probability of a price increase, or the probability that \( \Delta P > 1 \), as the probability that a standardized value of epsilon exceeds a multiple of \( u_{t-1} \) as follows.

---

\(^{45}\) A Koyck distributed lag takes the following form:

\[
v_t = \lambda u_t + \lambda (1 - \lambda) u_{t-1} + \lambda (1 - \lambda)^2 u_{t-2} + \cdots
\]

Where \( \lambda \) represents the weight attributed to the current year.

\[
v_{t+1} = \lambda u_{t+1} + \lambda (1 - \lambda) u_t + \lambda (1 - \lambda)^2 u_{t-1} + \cdots
\]

Factoring out a \( (1 - \lambda) \) from all but the first term and substitution with the first equation yields:

\[
v_{t+1} = \lambda u_{t+1} + (1 - \lambda) v_t
\]

And consequently:

\[
v_t = \lambda u_t + (1 - \lambda) v_{t-1}
\]

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Since $\Delta P > 0$ if

$$\varepsilon_t (1 + \beta \lambda) > \beta \lambda u_{t-1} \quad \text{or} \quad \varepsilon_t > \frac{\beta \lambda}{1 + \beta \lambda} u_{t-1}$$

And this will be the case if

$$\frac{\varepsilon_t}{\sigma} > \frac{1}{\sigma} \frac{\beta \lambda}{1 + \beta \lambda} u_{t-1}$$

The term on the left is the standardized value of epsilon

$$z = \frac{\varepsilon_t - E(\varepsilon_t)}{\sigma} = \frac{\varepsilon_t}{\sigma}$$

And thus the probability of a price increase is

$$P(z) > \frac{\beta \lambda}{\sigma(1 + \beta \lambda)} u_{t-1}$$

(This is so for any probability distribution of $\varepsilon$. If we assume that $\varepsilon$ is at least approximately normally distributed, then this is easy to find.)

We note that as the bubble $u_{t-1}$ becomes larger and larger, the probability of a price increase becomes smaller and smaller. Thus bubbles generate their own demise.

**Slow Investors Dominate Trading**

Slow Learners correctly see the current shock, epsilon, but only after a period of time. They see a part of it this year, a bit more the next year, and so on. We can model the difference between their perceived value $V^*$, and $V$ as a Koyck average of current and past shocks:

$$P_t = V_t^* = V_t - u_t, \text{ where,}$$

$$u_t = \lambda \varepsilon_t + \lambda (1 - \lambda) \varepsilon_{t-1} + \cdots = \lambda \varepsilon_t + (1 - \lambda) u_{t-1}$$

Thus,

$$\Delta u_t = u_t - u_{t-1} = \lambda \varepsilon_t - \lambda u_{t-1}$$

Thus,

$$\Delta V_t^* = \Delta V_t - \Delta u_t = \varepsilon_t - \lambda \varepsilon_t + \lambda u_{t-1} = \varepsilon_t (1 - \lambda) + \lambda u_{t-1}$$

Thus, if SL dominate the market, then $P$ will be very close to $V^*$ for the SLs, and the price change will be

$$\Delta P_t = \varepsilon_t (1 - \lambda) + \lambda u_{t-1}$$

And the expected value of the price change will be

$$E(\Delta P_t) = \lambda u_{t-1}$$

**IV. Empirical Results**
a. Data


Shiller’s dataset includes monthly data, however, we use annual returns for our key dependent variable: Ten Year Cumulative Returns. We use cumulative returns in order to explore the lagged or “persistence effect” of past price shocks. Ten years is a crude approximation of how long the effect of any past price shock may linger in the memory of an investor. Shiller’s stock data on the S&P500 goes back until 1871, giving us 124 observations.

Data for Tobin’s Q was calculated using the Federal Reserve Statistical Release Z.1 Financial Accounts of the United States and can be found at: [http://www.federalreserve.gov/releases/z1/current/z1.pdf](http://www.federalreserve.gov/releases/z1/current/z1.pdf). The Q ratio can be calculated from the most recent Federal Reserve Flow of Funds release. The ratio is calculated by dividing line 36 of table B.102 by line 33. We calculate Tobin’s Q through 2013. The Federal Reserve has data on Tobin’s Q beginning in 1945, leaving us with 69 observations; significantly fewer than we have with Shiller’s PE.

Interestingly, Tobin’s Q is calculated using data from nonfinancial firms (i.e. it excludes data from banks, insurance companies, etc.). High values of Tobin’s Q are presumably a consequence of high growth and/or high profits, which pushes asset prices far above their average replacement costs. If markets are efficient, high values of Q should be self-correcting or self-reversing, so we shouldn’t get very high values of Q for sustained periods. Why? Because profits attract entry. When profits are high, new firms enter the market and existing firms expand. As investment in plant and equipment grows, a corresponding increase in the aggregate capital-labor ratio will result. As basic microeconomic theory suggests, diminishing returns to capital set in and the profit rate will fall. Therefore, following high values of Q, we should expect lower returns in the following years. However, according to the EMH we should not expect lower returns following high prices. Because we do in fact find high values of Q to be followed by lower returns, we find evidence against rational expectations and for speculative bubbles.

Independent Variables

We constructed various cumulative return variables using Shiller’s S&P500 data in order to test whether investors’ expectations of future returns are consistent with the market efficiency. Specifically we use the following independent variables

a. Following Year Returns
b. Following 5 Year Cumulative Returns
c. Following 10 Year Cumulative Returns
d. Following 20 Year Cumulative Returns
The Following 5 Year Cumulative Returns takes the sum of real stock returns over the next five years. In other words, if we have an observation for our dependent variable in year \( x_t \), then we take the sum of the returns from \( x_{t+1} \) through \( x_{t+5} \). For example, we have data for Tobin’s Q beginning in 1945. Our Following 5 Year Cumulative Returns variable for the year 1945 would be the sum of real returns on the S&P500 from the year 1946 through 1950. The same was done for the other cumulative return variables.

**Dependent Variables**

a. Tobin’s Q  
b. Shiller’s CAPE (Cyclically Adjusted Price Earnings Ratio)\(^{46}\)

**b. Regression Results**

Two regressions are of particular interest.  
First Regression:  
\[
10YrCumRet = \alpha + \beta Tobin's \text{Q} + \epsilon
\]  
Here we regress Ten Year Cumulative Returns on Tobin’s Q.

---

\(^{46}\)“Price earnings ratio is based on average inflation-adjusted earnings from the previous 10 years, known as the Cyclically Adjusted PE Ratio (CAPE Ratio), Shiller PE Ratio, or PE 10” (http://www.multpl.com/shiller-pe/).
Looking at the scatter plot, we see a clear negative relationship between Tobin’s Q and the Following Ten Year Cumulative Returns. Intuitively, this means that we should expect to see lower returns in years following high values of Q. Specifically, we find a $\beta$ estimate for Q of -1.425804. This is a clear violation of the EMH and adds some explanatory power to our bubble hypothesis. With just 69 observations, we have an R-squared of approximately 0.54.

```
. reg Foll10YrCumRet tobinsq

                      Source |      SS      df    MS
----------------------|-----------|-------|--------
         Model        | 10.2669732  1   10.2669732
     Residual        |  8.79180179  67  0.131220922
        Total        |  19.058775  68   0.280276103

Number of obs = 69
F(  1,    67) = 78.24
Prob > F = 0.0000
R-squared = 0.5387
Adj R-squared = 0.5318
Root MSE = 0.36224

                      | Coef.    Std. Err.       t     P>|t|      [95% Conf. Interval]
-------------------------------|----------|-----------------|--------|---------|-------------------------|
Foll10YrCumRet          |  -1.425804   0.1611908    -8.85   0.000    -1.747542   -1.104066
            tobinsq  |         |                 |        |         |                          |
            _cons     |    1.609025   0.1174455    13.70   0.000     1.374603     1.843447
```

Sherman 31
We have a t-statistic for our parameter estimate equal to -8.85. However, because our dependent variable is cumulative returns (i.e. each year represents a sum of the next ten years’ returns), our observations are not independent. Therefore, our standard errors are biased downwards and, as a consequence, our t-statistic is biased upwards.

In order to correct our standard errors, we run a Newey-West estimator, which is commonly used to fix bias that arises from correlation between observations in a control variable as well as heteroskedasticity in the error terms. These results are presented below:

```
. newey Nxt10YrCumRet tobinsq, lag(9)
```

```
Regression with Newey-West standard errors
Number of obs = 69
maximum lag: 9
F( 1, 67) = 33.31
Prob > F = 0.0000

<table>
<thead>
<tr>
<th></th>
<th>Newey-West</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>Std. Err.</td>
<td>t</td>
<td>P&gt;</td>
<td>t</td>
</tr>
<tr>
<td>Nxt10YrCum-t</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tobinsq</td>
<td>-1.425804</td>
<td>0.2470603</td>
<td>-5.77</td>
<td>0.000</td>
<td>-1.916938</td>
</tr>
<tr>
<td>_cons</td>
<td>1.609025</td>
<td>0.1762927</td>
<td>9.13</td>
<td>0.000</td>
<td>1.257143</td>
</tr>
</tbody>
</table>
```

Our t-stat falls to -5.77, but is still statistically significant at the 5% level. There is no change in the parameter estimate.

Second Regression:

\[
10YrCumRet = \alpha + \beta \text{ ShillerPE} + \epsilon
\]

Here we regress Ten Year Cumulative Returns on Shiller’s CAPE (Cyclically Adjusted PE ratio).
We see a clear negative relationship here between Shiller’s PE and Ten Year Cumulative Returns. Our regression yields a $\beta$ estimate of $-0.0041349$, and $R$-squared of approximately $0.30$, and a $t$-statistic of $-7.29$. This test is a simple replication of many similar tests initiated by Shiller.

```
. reg foll10yrrret shillerpe
```

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 124</th>
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</thead>
<tbody>
<tr>
<td>Model</td>
<td>.089787083</td>
<td>1</td>
<td>.089787083</td>
<td>F( 1, 122) = 53.14</td>
</tr>
<tr>
<td>Residual</td>
<td>.206132271</td>
<td>122</td>
<td>.001689609</td>
<td>Prob &gt; F = 0.0000</td>
</tr>
<tr>
<td>Total</td>
<td>.295919354</td>
<td>123</td>
<td>.002405848</td>
<td>R-squared = 0.3034</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adj R-squared = 0.2977</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Root MSE = 0.0411</td>
</tr>
</tbody>
</table>

| foll10yrrret | Coef.    | Std. Err. | t      | F>|t| | [95% Conf. Interval] |
|--------------|----------|-----------|--------|------|---------------------|
| shillerpe    | -.0041349| .0005672  | -7.29 | 0.000| -.0052577            | -.003012 |
| _cons        | .1273319 | .0098441  | 12.93 | 0.000| .1078444             | .1468194 |

Again, in order to correct for the fact that the observations in our dependent variable are not independent, we run a Newey-West regression. These results are attached below.
Note, that while the t-statistic for our parameter estimate of Shiller’s PE falls from -7.29 to -4.93, it is still statistically significant at the 5% level.

`. newey foll10yrrret shillerpe, lag (9)`

| foll10yrrret | C   | Std. Err. | t     | p>|t| | [95% Conf. Interval] |
|--------------|-----|-----------|-------|-----|----------------------|
| shillerpe    | -.0041349 | .0008392 | -4.93 | 0.000 | -.0057961 to -.0024736 |
| _cons        | .1273319   | .0168225 | 7.57  | 0.000 | .09403 to .1606338   |

**Additional Regression Results**

**Following Year Returns & Q**
Despite the fact that we don’t have statistically significant results at the 5% level, the coefficient estimate on Tobin’s Q is still negative, which still violates the expectations implied by the EMH.

```
. reg follyyrret tobinsq

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
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</thead>
<tbody>
<tr>
<td>Model</td>
<td>.078296007</td>
<td>1</td>
<td>.078296007</td>
</tr>
<tr>
<td>Residual</td>
<td>1.89715634</td>
<td>66</td>
<td>.028744793</td>
</tr>
<tr>
<td>Total</td>
<td>1.97545235</td>
<td>67</td>
<td>.029484363</td>
</tr>
</tbody>
</table>

Number of obs = 68
F( 1, 66) = 2.72
Prob > F = 0.1036
R-squared = 0.0396
Adj R-squared = 0.0251
Root MSE = .16954

| follyyrret | Coef.  | Std. Err. | t     | P>|t|  | [95% Conf. Interval] |
|------------|--------|-----------|-------|------|---------------------|
| tobinsq    | -.1264156 | .0765967 | -1.65 | 0.104 | -.2793459 , .0265148 |
| _cons      | .1494621 | .0553248 | 2.70  | 0.009 | .0390025 , .2599217  |
```

Following 5 Year Cumulative Returns & Q
In this model with Following 5 Year Cumulative Returns, the negative relationship between high values of Tobin’s Q and cumulative subsequent returns is apparent and is both statistically and economically significant.

```
. newey foll5yrret tobinsq, lag(4)
```

Regression with Newey-West standard errors

<table>
<thead>
<tr>
<th></th>
<th>Newey-West</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conf.</td>
<td>Std. Err.</td>
<td>t</td>
<td>P&gt;</td>
<td>t</td>
</tr>
<tr>
<td>foll5yrret</td>
<td>tobinsq</td>
<td>-.5821896</td>
<td>.2154864</td>
<td>-3.17</td>
<td>0.002</td>
</tr>
<tr>
<td>_cons</td>
<td></td>
<td>.7812904</td>
<td>.1379983</td>
<td>5.66</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Following 20 Year Cumulative Returns & Q
. newey foll20yrret tobinsq, lag(19)

Regression with Newey-West standard errors
Number of obs = 49
F( 1, 47) = 42.14
Prob > F = 0.0000

<table>
<thead>
<tr>
<th>foll20yrret</th>
<th>Newey-West</th>
<th></th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.   Std. Err.</td>
<td>t</td>
<td>P&gt;</td>
<td>t</td>
<td></td>
</tr>
<tr>
<td>tobinsq</td>
<td>-2.588881 .928797</td>
<td>-6.49</td>
<td>0.000</td>
<td>-3.391157</td>
<td>-1.786605</td>
</tr>
<tr>
<td>_cons</td>
<td>2.725149 .2013566</td>
<td>13.53</td>
<td>0.000</td>
<td>2.320072</td>
<td>3.130227</td>
</tr>
</tbody>
</table>

Following Year Returns & Shiller’s P/E
Following 5 Year Cumulative Returns & Shiller’s P/E
Conclusion & Topics for Further Study

The EMH is a powerful theory that provides a foundation and starting point for understanding securities markets. The purpose of this paper was to provide insight into
how market efficiency might be achieved, but more importantly, to provide a framework for thinking about how an efficient market can be “derailed” and snowball into a speculative bubble. Looking back at history, it seems difficult (indeed, foolish) to deny the recurrence of speculative episodes. Given their tendency to occur, it is imperative to gain deeper insights into how asset prices are reached.

To this end, we reach some interesting results by considering Tobin’s Q as a proxy measure for overvaluation in securities markets. Over the last 69 years, high values of Tobin’s Q have been highly correlated with much lower real returns over the following ten years. The EMH simply does not account for this relationship. However, we are still far from proving speculative bubbles definitively. Much more work remains to be done!

Some interesting topics for further study include but are not limited to the following:

1. The growing volume of trading securities. Why is everyone incurring all these trading costs if they cannot beat the market? Is the thrill of high volume trading itself enough to compensate for these losses? This seems irreconcilable with basic economic theory, and is not explained by the EMH.

2. Why does money move away from managers with poor performance to those with superior performance? Common sense provides an answer, but the EMH does not!

3. Why does leverage increase during bull markets and fall in bear markets? While Minsky’s FIH provides some theoretical explanations for this phenomenon, it is a clear violation of the EMH.
Other Regression Results

Model: \( Real\text{StockRet} = \alpha + \beta Tobin'sQ + \varepsilon \)

```
. reg realstockret tobinsq

Source | SS | df | MS          | Number of obs = 69
Model   | 0.066162677 | 1 | 0.066162677 | F( 1, 67) = 2.27
        | 1.95625692 | 67 | 0.029197864 | Prob > F = 0.1369
Residual| 2.0224196  | 68 | 0.029741465 | R-squared = 0.0327
        |            |    |             | Adj R-squared = 0.0183
        |            |    |             | Root MSE = 0.17087

realstockret | Cof. | Std. Err. | t    | P>|t|     | [95% Conf. Interval]
--- | --- | --- | --- | --- | --- --- --- --- --- --- ---
tobinsq | .1144577 | .0760351 | 1.51 | 0.137 | -.037309 | .2662244
_cons   | -.0095763 | .0554001 | -0.17 | 0.863 | -.1201553 | .1010027
```
Model: $\text{FollYrCumRet} = \alpha + \beta \text{Tobin's} Q + \varepsilon$

```
reg FollYrCumRet tobinsq

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 69</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>.387785399</td>
<td>1</td>
<td>.387785399</td>
<td>$\text{F}(1, 67) = 7.34$</td>
</tr>
<tr>
<td>Residual</td>
<td>3.53780727</td>
<td>67</td>
<td>.052803094</td>
<td>Prob &gt; F = 0.0085</td>
</tr>
<tr>
<td>Total</td>
<td>3.9256267</td>
<td>68</td>
<td>.057729451</td>
<td>R-squared = 0.0988</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adj R-squared = 0.0053</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ROOT MSE = .22979</td>
</tr>
</tbody>
</table>

| FollYrCumRet | Coef.   | Std. Err. | t     | P>|t|     | [95% Conf. Interval] |
|--------------|---------|-----------|-------|---------|---------------------|
| tobinsq      | -.2771022 | .1022512  | -2.71 | 0.009   | -.4811964 to -.073008 |
| _cons        | .3185646  | .0745014  | 4.28  | 0.000   | .1698592 to .4672701 |
```
Model: \( \text{Foll5YrCumRet} = \alpha + \beta \text{Tobin'sQ} + \epsilon \)

```
. reg Foll5YrCumRet tobinsq
```

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>2.20105693</td>
<td>1</td>
<td>2.20105693</td>
<td>( F(1, 62) = 20.82 )</td>
</tr>
<tr>
<td>Residual</td>
<td>6.55430653</td>
<td>62</td>
<td>.105714621</td>
<td>( \text{Prob} &gt; F = 0.0000 )</td>
</tr>
<tr>
<td>Total</td>
<td>8.75536346</td>
<td>63</td>
<td>.138974023</td>
<td>( \text{R-squared} = 0.2514 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \text{Adj R-squared} = 0.2393 )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>( \text{Root MSE} = 0.32514 )</td>
</tr>
</tbody>
</table>

| Foll5YrCumRet | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|---------------|-------|-----------|-------|-------|----------------------|
| tobinsq       | -.6838846 | .1498769 | -4.56 | 0.000 | -.9834843 -.3842849 |
| _cons         | .7824822  | .1066177 | 7.34  | 0.000 | .5693564 .995608    |
Model: $Koyck\overline{AveExRet} = \alpha + \beta Tobin's\, Q + \varepsilon$

```
. reg koyckaveexret tobinsq

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Number of obs = 67</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>27.2412334</td>
<td>1</td>
<td>27.2412334</td>
<td>$F(1, 65) = 45.86$</td>
</tr>
<tr>
<td>Residual</td>
<td>38.6121157</td>
<td>65</td>
<td>.59403255</td>
<td>$\text{Prob } F = 0.0000$</td>
</tr>
<tr>
<td>Total</td>
<td>65.8533491</td>
<td>66</td>
<td>.997778017</td>
<td>$\text{R-squared} = 0.4137$</td>
</tr>
</tbody>
</table>

| koyckaveex-t | Coef. | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|--------------|-------|-----------|-------|------|----------------------|
| tobinsq      | 2.371321 | .3501725  | 6.77  | 0.000 | 1.671978 3.070664    |
| _cons        | 2.261827 | .2519812  | 8.98  | 0.000 | 1.758586 2.765068    |
```
Model: $\text{ExcessRet} = \alpha + \beta \text{Tobin's Q} + \epsilon$

```
. reg excessret tobinsq

Source | SS     | df | MS
-------|--------|----|--------
Model   | .030451301 | 1  | .030451301
Residual| 1.85265449  | 65 | .028502377
Total   | 1.88310579  | 66 | .028531906

Number of obs = 67
F( 1,  65) =  1.07
Prob > F    = 0.3051
R-squared   = 0.0162
Adj R-squared = 0.0010
Root MSE    = 0.16883

excessret | Coef.  | Std. Err. | t     | P>|t|  [95% Conf. Interval]
----------|--------|-----------|-------|-------|------------------------
tobinsq   | .079283| .0767039  | 1.03  | 0.305 | -.0739053 -.2324712
_cons     | -.0010998| .0551955 | -0.02 | 0.984 | -.1113328 .1091331
```