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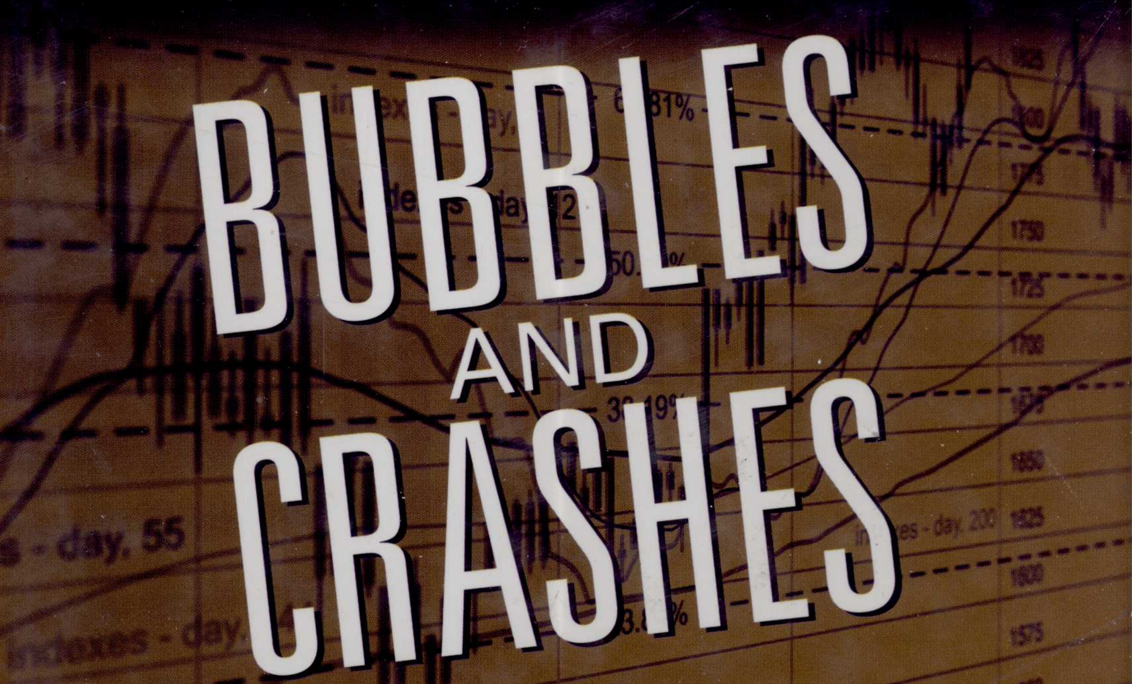

BUBBLES AND CRASHES

HAROLD L. VOGEL

Financial Market Bubbles and Crashes

Harold L. Vogel

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Prologue

Bubbles are wonders to behold. They take your breath away and make your pulse race. They make fortunes and – just as fast or faster, in the inevitable stomach-churning crash aftermath – destroy them too. But more broadly, bubbles create important distortions in the wealth (e.g., pensions), psychology, aspirations, policies, and strategies of society as a whole. Bubbles, in other words, have significant social effects and aftereffects.

One would think, given the importance of the subject, that economists would by now have already developed a solid grip on how bubbles form and how to measure and compare them. No way! Despite the thousands of articles in the professional literature and the millions of times that the word "bubble" has been used in the business press, there still does not appear to be a cohesive theory or persuasive empirical approach with which to study bubble and crash conditions.

This book, adapted from my recent Ph.D. dissertation at the University of London, presents what is meant to be a plausible and accessible descriptive theory and empirical approach to the analysis of such financial market conditions. It surely will not be the last word on the subject of bubble characteristics and theory, but it is offered as an early step forward in a new direction.

Development in this new direction, however, requires an approach that appreciates the thinking behind the standard efficient market, random walk, and Capital Asset Pricing Models, but that also recognizes the total uselessness of these concepts when describing the extreme behavior seen in the events that are loosely referred to as bubbles or crashes. The body of work that is known as behavioral finance, it seems, ends up being much closer to what is needed. And along these lines, the notion of a behavioral risk premium is introduced.

Yet none of this gets to the heart of the matter: When it comes to asset price bubbles and crashes, the most visibly striking and mathematically important feature is their exponentiality – a term that describes the idea that growth accelerates over time.

However, although exponentiality is the essence of any and all bubbles, it is merely a manifestation of short-rationed quantities. In plain English, this means that people make trading decisions based mainly on the amount that, for whatever reasons – fundamental, psychological, or emotional – they need to buy or sell *now*. Considerations of current prices thus begin to take a backseat to considerations of quantities: In bubbles you can never own enough of the relevant asset classes, and in crashes you cannot own too little of them.

The problem is, though, that all this flies in the face of the neoclassical economist's empirically unproven approach in which the market participant is always a "rational," calculating automaton tuned into a world with perfect, symmetrically available, instantly digested, and analyzable information that causes the market to quickly arrive at neoclassical Walrasian "equilibrium." As will, it is hoped, be convincingly shown, the market is never at, nor will ever reach, this stage, because if it did, it would cease to exist; it would disappear, as there would be no further need for it.

In extreme market events, as ever more investors stop denying and fighting the tide and join the herd, the rising urgency to adjust quantities is reflected by visible acceleration of trading volume and price changes noticeably biased to one side or the other. And this is where the magical constant e, which equals 2.718, enters as a way to describe the exponential price change trajectory that distinguishes bubbles (and crashes).

What a number this e is. It suggests steady growth upon growth, which leads to acceleration. Keep the pedal to the metal in your car or rocket ship and you go faster and faster with each additional moment of elapsed time. It is the mechanism of compound interest. In the calculus, it is its own derivative – no other function has this characteristic. And, best of all, even a nonmathematician such as I can figure it out using only basic arithmetic.

A brief example suffices to demonstrate the power of compounding (i.e., geometric progression). I sometimes ask MBA students in finance, whom I occasionally have the privilege of addressing, "Quick, if I give you one penny today and double the resulting amount every day for the next 30 days after, what will the total then be? Remember, we're talking here about only one single penny, one measly little hundredth of a dollar, and only a months' time. Most guesses of even these bright students, helpless without their pocket calculators and laptop computers, are, as most of ours would be, far off the mark. The correct answer is $10,737,417. That's – starting from a penny – nearly $11 million in a short month! And that's the ultimate bubble.

This work should first of all be of interest to financial economists of all stripes. Yet the potential audience ought to extend also to MBA- and Ph.D.-level students; central, commercial, and investment bank researchers; and investors and speculators. In this pursuit I have aimed for comprehensibility and comprehensiveness to appeal to as many types of readers as possible. Although not structured as a breezy popular book, with all academic and technical references tucked neatly out of the way in footnotes, this work for the most part requires for assimilation only a background that might include college-level finance and economics courses. A brief glossary of terms has also been appended to ease the journey for general readers.

Some of the material, specifically on bubble histories and on the random walk and related theories, has been around for a long time and has appeared in much greater detail in many other books and articles. Fast-trackers might thus prefer to skim over those sections and to scan the extensive literature review in Chapter 4, the details of which are apt to be of greatest importance only to serious researchers in this area. Also, readers initially unfamiliar with technical aspects of the subject should not be turned off by the somewhat challenging start of the Preface. Stick with it, as the ride should become increasingly comfortable as you proceed through the text. Indeed, I anticipate that at a minimum most people will greatly enjoy the opening chapters.

This project could never have been completed without the many great works that came before and the many kind people who provided encouragement, help, and good cheer during its production. The following works stand out for particular relevancy, clarity of exposition, and stimulative effects: *Asset Pricing*, rev. ed., by John H. Cochran; *Quantitative Financial Economics*, 2nd ed., by Keith Cuthbertson and Dirk Nitzsche; *Applied Econometric Time Series*, 2nd ed., by Walter Enders; *Options, Futures, and Other Derivatives*, 5th ed., by John C. Hull; *Behavioural Finance: Insights into Irrational Minds and Markets*, by James Montier; *An Introduction to the Mathematics of Financial Derivatives*, 2nd ed., by Salih Neftci; and *Chaos Theory Tamed*, by Garnett Williams.

I am fortunate to have met at Birkbeck, University of London, Professor Zacharias Psaradakis, who encouraged my enrollment; Professor John Driffill, who supervised my academic endeavor there; Mr. Nigel Foster, who provided timely clues in programming; and Mr. Stephen Wright, who helped to focus my thinking. I'm also grateful to Professor Jerry Coakley of the University of Essex, who provided valuable advice in review of an early draft.

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I wish to thank Scott Parris, editor at Cambridge University Press, who has been greatly supportive through the processing of several editions of my earlier works and who offered early confidence for this one. And much appreciation is also owed the anonymous readers who vetted the text and provided numerous suggestions that have made it far better than it would have otherwise been. For any errors and deficiencies that may inadvertently remain, the responsibility is, of course, mine alone.

Bubbles and crashes have long been of immense interest not only to trained economists but also to the investing public at large. Great stories of massive wins and losses pertaining to bubbles and crashes have been published over many years, and these tales still fascinate us. It is my hope and expectation that by the end of this book readers not only will have a deeper understanding of such dramatic events, but will see them also from an entirely new perspective.

Harold L. Vogel New York City
October 2009

Preface

Jonathan Swift, the Irish-born English author of *Gulliver's Travels*, wrote a poem in December 1720 that probably made the first reference to a "bubble" as being a stock price that far exceeded its economic value.[1] Since then asset price bubbles have been extensively reported and studied, with many detailed accounts already extant on the presumed causes, settings, and general characteristics of bubbles.[2]

A review of the literature nevertheless indicates that, although economists constantly talk about bubbles and have conducted numerous studies of them, there has thus far been little progress toward a commonly accepted (or standardized) mathematical and statistical definition or method of categorization and measurement that comes close to describing how investors actually behave in the midst of such extreme episodes.

In fact, most studies outside of the behavioral finance literature take rationality as a starting point and a given, even though this axiomatic assumption – itself an outgrowth of neoclassical economics – remains unproven and debatable.[3] It is the intent of this study to conduct an exploration and analysis that might eventually lead to a robust, unified general theory applicable to all types and sizes of financial-market, and, more broadly, asset-price bubbles (and also crashes). At a minimum, a comprehensive theory of asset-price bubbles would appear to require that the descriptive elements be consistent with the ways in which people actually behave.[4]

An understanding of bubbles is also enhanced through introduction of fractal and exponential features. Many natural phenomena, such as galactic spirals of stars and even snowflake patterns, are fractal (i.e., self-similar across different time or distance scales). And these patterns are all intrinsically governed by power law (i.e., exponential) distributions that also appear in the markets for securities.[5]

These features were introduced into the stock market literature by Mandelbrot (1964) and are discussed in greater detail in Chapter 4.[6] Mandelbrot showed that stochastic processes describing financial time-series are much better modeled by stable Paretian (also called L-stable, Lévy, or Lévy–Mandelbrot) distributions than by the normal (i.e., bell-shaped or Gaussian) distributions that had been used previously to describe asset price return probabilities. Paretian distributions are of a discontinuous nature, contain a large number of abrupt changes, and suggest, in the words of Fama (1965, p. 94), "that such a market is inherently more risky than a Gaussian market... and the probability of large losses is greater."

Aside from their discontinuous nature, however, the most striking feature of all stable distributions is infinite variance, which contrasts with the finite variance of the Gaussian. The infinite-variance aspect of stable distributions is the one that best captures what happens to returns in the extreme events that are informally known as bubbles and crashes. These are the events that generate the fat-tailed (leptokurtic) distribution characteristics seen in empirical data for most if not all financial markets. But stability – meaning form-invariance under addition – is also important because it makes the distribution self-similar (i.e., fractal).[7]

This empirically well-established background then leads readily to the idea that the theories of nonlinear dynamics (chaos) might also be applicable to the study of bubbles and crashes. In nonlinear dynamics, a variable appears to be attracted to a time path or trajectory that may often look like random behavior but that is described by a deterministic equation. These types of equations show how complex, chaotic behavior can arise from the simplest of models, and also that there can be order behind disorder.

From visual inspection alone it would appear that all bubbles (and crashes) are attracted to an exponential-like price-change trajectory.[8] If such an attractor is indeed describable by a power law distribution, then the need to look to chaos-theoretical approaches in analyzing bubbles is inescapable, even though it has not been established as yet that chaos theory has contributed much to understanding of how markets work.[9]

Chaos theory is also important for another reason: The basic marker of nonlinear dynamic systems is what is known as sensitive dependence on initial conditions (SDIC). The implication of SDIC is that it becomes impossible to make long-range predictions. This notion, however, conflicts with the extensive work that followed the Poterba and Summers (1988) article suggesting that markets have a tendency to revert to the mean, that is, markets *are* somewhat predictable over the long run.[10]

These concepts will be tied together by the idea that in bubbles and crashes the elasticity of stock price–change variance with respect to an equity risk premium (ERP) measure tends to become infinite (as in a stable Paretian distribution). The empirical objective will then be to develop a method that finds instances in which this occurs. It is thus the *elasticity* – not the price-change (or returns) sequence itself – that is statistically fit to an exponential expression. Measurement of this elasticity of price variance with respect to ERP, ε_{vt}, has a conventional definition that allows the variance when the ERP is 6% to be evaluated in the same way as when, say, the ERP is 2%.

Although the elasticity of variance (EOV) concept is the main innovation and focus, it is supplemented (in Chapter 5) by the different perspective offered through analysis of runs – sequences of up and down price changes. For instance, in extreme market events, it is proposed that high autoregressiveness (i.e., gains begetting more gains) causes the number of runs in a sample period (positive price-change sequences in bubbles and negative in crashes) to tend toward one and the variance of the length of a run to tend toward zero. But although such runs analysis has the potential to provide a new way to define bubbles and to understand their characteristics, it is ultimately highly arbitrary and dependent on Gaussian distribution assumptions, providing merely an interesting extension of the conventional approaches.

The factors that motivate investors and speculators to behave in the ways that they do are also explored with reference to theories of behavioral finance and of money and credit. Behavioral finance was developed early on by Kahneman and Tversky (1979, 2000) and then extended in works such as those by Camerer (1989), De Bondt (2003), and Thaler (1992, 2005). Based on these, a new concept of a "behavioral risk premium" is introduced.

Changes in credit availability and interest rates might be expected, *a priori*, to play a role in the development of bubbles and crashes. And this project provides some evidence that this might be so. The theory posited here is that extension of credit facilities beyond what can be absorbed readily by the real economy tends to spill over into asset price speculations that, if not early contained, restricted, or withdrawn, will inevitably evolve or metastasize into full-blown "bubbles."[11] Yet the whole subject is fraught with difficulties, beginning with frequent imprecision in usage of the term money – an accepted medium of exchange (based on faith) and unit of account – and the term credit, which is a transferable *right* to access money.[12]

Stiglitz and Greenwald (2003, pp. 26–7) say, for example, that "[C]redit can be created with almost no input of conventional factors, and can just as easily be destroyed. There is no easy way to represent the supply function for credit... The reason for this is simple: credit is based on *information*." And because information is asymmetrically derived, imperfect, and costly to gather, "[I]nterest rates are not like conventional prices and the capital market is not like an auction market." Hence, transactions-demand monetary theory (p. 12) is "badly flawed."[13]

All of this suggests that creation or destruction of credit may be the central component in the formation of bubble and crash processes and events respectively and, moreover, that markets exist only because the prevalent real-world state is one of asymmetric and imperfect information in which arbitrage is often difficult and costly to implement. This theoretical line, relating first to the works by Malinvaud (1985) and Bénassy (1986), in effect proposes that considerations of current prices might often take a backseat to those of desired quantities – an aspect of trading that appears to be particularly and acutely evident in bubbles and crashes.

Although the present project contains both deductive and inductive elements, wherever possible, the inductive approach is given preference and emphasis. This contrasts with the primarily deductivist neoclassical methods.[14] Indeed, the previously cited works by Mandelbrot, Fama, and many others on the stable Paretian (and fractal) nature of the fat-tailed returns distributions of stocks – and thus of the direct mathematical ties to power laws and exponentiality – provide not only the inspiration but also the inductive, empirically determined starting point for the current project.[15]

In financial economics, however, it is notable that the widely accepted random walk, efficient market hypothesis (EMH), and capital asset pricing models (CAPM) all follow only from the presumption (or axiom) that people behave rationally when it comes to money and investments, and that their utility functions are *independent* of each other. In the wake of an important early Blanchard and Watson (1982) article, the resulting standard approach has been to model bubbles as though they all intrinsically contained at their core a rational valuation component, above which all else is bubble froth.

The trouble is, though, that with asymmetric, imperfect information being an essential operating feature of all market exchanges, it is difficult to know even what such a rational valuation component is worth at any given point in time. Notable too is that with EMH/CAPM models, markets are assumed to be nearly always at or close to "equilibrium" and, therefore, bubbles and crashes are not possible.

This project will instead attempt to show that such extreme events are real manifestations of collective behaviors that do not at all conform to the neoclassical Walrasian models of equilibrium – that is, models that start by assuming a complete market system and no uncertainty, and are "concerned with analyzing a dream world."[16] Especially during extreme events, there is no subtle matching of supply and demand of shares through a considered Walrasian process of *tâttonnement*.[17] That is because, in approaching the extremes, price changes are often brutally discontinuous and liquidity – which refers to a condition wherein assets are easily convertible into other assets or consumption without loss of value – is at a premium as there is, in such stages, so relatively little of it.[18]

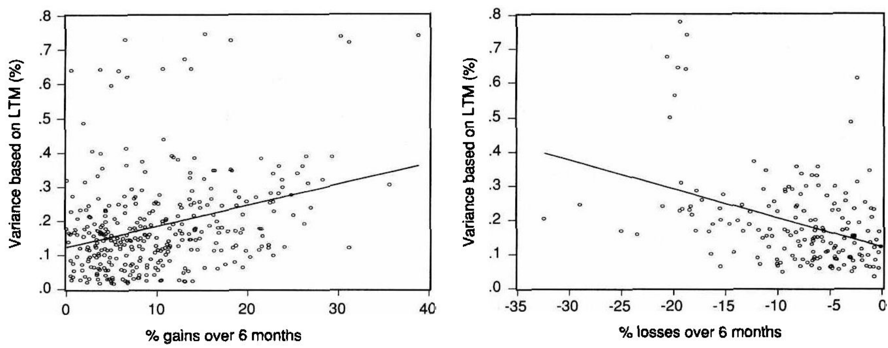

Figure P.1. Variance versus price change percentages: an example. Gains (left) and losses in percent, S&P 500 Index, 1960:01–2005:12, monthly rolling index percentage change measured over closing prices six months prior, with estimated variance in percent based on rolling last twelve months data.

In thus recognizing that the key assumptions – *independence* of each individual's utility function, availability of perfect (symmetrical) and instantly assimilated information, rationality at all times, and the presence of immediate arbitrage possibilities – are not realistic, the work ahead provides a clear break with previous methods and models.[19]

The theory presented here therefore does not at all depend on any such assumptions. It is, instead, inductively derived through the simple and empirically demonstrable observation (Figure P.1) that the variance of price changes will tend to rise along with the size of percentage changes in prices themselves. This is a pure function of the rules of arithmetic and of the statistical definition of variance and has nothing to do with the rationality of human behavior, the existence of equilibrium, or any other such idealized notions and constructs.

Indeed, in the theory that evolves from this relational aspect of variance and returns, it will later be seen that bubbles and crashes are formed by a *process* in which time becomes of the essence, urgency becomes the driver, and *quantity* held (instead of price paid or received) becomes the primary concern.[20]

The goals are thus to establish a viable definition of a financial asset "bubble," to devise a method that allows consistent and convenient comparisons of bubbles in the same or different asset classes (including foreign exchange), to understand why bubbles begin to inflate (and then often later collapse into crashes), and to present and test a theoretical approach that is in harmony with the behavior of investors and with the basic time discounting and risk-adjustment principles of financial economics.

In pursuit of these objectives, the four most important new theoretical notions to be introduced here for the first time are an elasticity-of-variance definition of bubbles, a concept of fractal microbubbles, derivation of behavioral risk premiums from transactions volume data, and development of bubble and crash strength indicators. Characteristics of price-change runs sequences in extreme market events are also explored. And the underlying theoretical basis for why bubbles emerge (credit creation is in excess of what is needed to finance non-GDP transactions) and why crashes occur (available cash is insufficient to service debt obligations) is explained.

All of this is developed from a viewpoint that is consonant with the notions of behavioral finance and nonlinearity and non-normal return distributions, and with the idea that bubbles and crashes are likely to be generated through changes in money and credit conditions. Although the role of money and credit in the fostering and support of bubbles is certainly not a new idea, it is one that is here extended and explored in a nontraditional way.

But, in addition, the basis for this whole approach is that – especially while they are caught up in extreme market events such as bubbles and crashes – behavior by both individuals and institutions is often not rational in the usual sense of the word; emotions and mass psychology (i.e., *zeitgeist*) instead become important concomitant factors.[21]

We humans, it seems from recent research in the emerging field of neurofinance, are apparently not wired to do otherwise, that is, to be rational at all times. For one, we tend to have a powerful and difficult-to-overcome urge to join crowds and emulate whatever the crowd is doing. As famed investor Warren Buffett has recently said, "the markets have not gotten more rational over the years . . . when people panic, when fear takes over, or when greed takes over, people react just as irrationally as they have in the past."[22]

Related to this, also, is the basic flaw in the underlying and almost universally accepted assumption that supply and demand in the financial markets can be modeled in the same way as in the markets for goods and services. If, for example, the price of beef or steel or gasoline or haircuts rises, we consumers tend to seek substitutes and demand fewer units of the affected products or services.

But if stocks or commodities or real estate prices rise, just the opposite usually seems to occur, as we are drawn to invest in such financial asset vehicles and tend to demand more rather than less of them. For whatever deep-seated reasons, we respond differently to price changes in financial markets than to price changes in goods and services markets. If so, and as a result, the traditional financial economics approaches to modeling bubbles and crashes are inevitably destined to fail.

The relevance of this research extends far beyond the usual intramural debates of academia or the direct interests of speculators and investors who would gain advantage if they were able to identify bubbles in their earliest stages – that is, the points at which the risk of missing the impending upswing or of experiencing a crash are the least.[23]

Keynes (1936, [1964], Ch. 12, VI), for example, has written that

"[S]peculators may do no harm as bubbles on a steady stream of enterprise. But the position is serious when enterprise becomes the bubble on a whirlpool of speculation. 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."[24]

And Shiller (2000 [2005]) says,

"If we exaggerate the present and future value of the stock market, then as a society we may invest too much in business startups and expansions, and too little in infrastructure, education, and other forms of human capital. If we think the market is worth more than it really is, we may become complacent in funding our pension plans, in maintaining our savings rate . . . and in providing other forms of social insurance" (p. xii)

"The valuation of the stock market is an important national – indeed international – issue. All of our plans for the future, as individuals and as a society, hinge on our perceived wealth . . . The tendency for speculative bubbles to grow and then contract can make for very uneven distribution of wealth." (p. 204)

Still, notwithstanding such views, while they are inflating, bubbles are often seen by investors – both individual and institutional – as relatively benign and favorable events. What's not to like? Shares rise easily and participants do not have to be especially skilled and selective when the tide tends to lift almost all boats, often even those of the lowest quality and with the flimsiest of finances.

Both Wall Street (bankers, lawyers, accountants, analysts, corporate managements, etc.) and Main Street (car dealers, travel agents, brokers, journalists, broadcast and cable networks, airlines, hotels, caterers, restaurants, retailers, limo drivers, dry cleaners, barbers, etc.) are beneficiaries. And sometimes, as perhaps in the 1990s (but not as for housing in the early 2000s), the bubble makes it much cheaper and easier for new companies developing and promoting important productivity-enhancing technologies to grow and prosper. For the numerous constituencies served well by a bubble's inflation – for instance, investment bankers and tech entrepreneurs in the 1990s and homebuilders, construction workers, mortgage servicers and packagers, and owners in the early 2000s – the attitude will always be (and has always been) dance while the music plays.[25] *"Laissez les bon temps rouler!"* (Let the good times roll!)[26]

Moreover, how can anyone in the government agencies and branches strenuously object? Unless the bubble is immediately accompanied by high inflation on goods and services, which normally happens only in the later stages, central banks do not have to focus too much on uncomfortable issues such as unemployment, falling exchange rates, capital account deficits, and market freeze-ups and bailouts of failing firms. Treasury coffers are filled from higher capital gains tax realizations and employee payroll tax collections, whereas budget deficits, including those of states and municipalities, shrink. And politicians everywhere will always welcome having more income to spend and having a richer platform on which to run for reelection.

It is therefore likely that, at least in the beginning and into the middle phases, there is usually a broad coalition in the body politic that has nothing particularly against – or that might even conceivably be tacitly in favor of – the formation of bubbles. It is only in the destructive aftermath that fingers are pointed, blame is affixed, retributions are sought, government institutions flail and bail, and nastiness and distrust pervade.

In sum, a financial asset bubble is perhaps best informally described as a market condition in which the prices of asset classes increase to what – especially in retrospect – are seen as absurd or unsustainable levels that no longer reflect purchasing power or utility of usage.[27] It is hoped that the present project, based as it is on readily available data, will prove practical in development of a more statistically rigorous approach to describing such bubbles and the crashes that typically ensue.

Notes

1. The poem, about the South Sea bubble of 1720, is quoted in Krueger (2005). Its last stanza reads,

> The Nation too too late will find,
> Computing all their Cost and Trouble,
> Directors Promises but Wind,
> South-Sea at best a mighty Bubble.

Balen (2003, p. 91) indicates that reference to bubbles "was effectively the creation of the South Sea period, although in fact it had been used earlier. Shakespeare, for example, describes a 'bubble reputation,' and in Thomas Shadwell's *The Volunteers*, written in 1692, men cheated or 'bubbled' each other for profit. Certainly, the use of the word became commonplace in 1720 and contemporary illustrations suggest that it was understood literally: like their counterparts in soap and air . . . financial bubbles were perfectly formed, and floated free of gravitational market forces. But the implication, of course, was that there would be a day of reckoning, a time when they would grow too large to hold their shape, leaving them to implode with spectacular, and messy, consequences."

2. Well-known incidents include the tulip and South Sea bubbles in the 1600s and 1700s, respectively, and the "roaring" 1920s experience. The Japanese stock market/real estate episode that ended in 1989 and the global technology/Internet stock mania of the late 1990s were notable for their persistence and strength. And more recently, price movements in housing and oil have often been referred to as "bubbles," although these situations are, for many complex reasons, not entirely comparable to those that occur in securities markets.

3. An axiom is an assumption that no reasonable person could reject.

4. Descriptive is how the world is, as opposed to normative, how it ought to be.

5. An early example of this was shown in the early 1900s by the Italian economist Vilfredo Pareto (1982), who found that in certain societies the number of individuals with an income larger than some value x_0 scaled as $x_0^{-\mu}$. Taleb (2007, p. 280) illustrates how the Gaussian is not self-similar.

6. See Mantegna and Stanley (2000), Voit (2002, pp. 95–115), and Mandelbrot and Hudson (2004). See also Vaga (1994, pp. 16–22), who emphasizes that it is during bubbles and crashes that the departure from a normal to a Paretian distribution occurs.

7. Campbell et al. (1997, pp. 19–21) show evidence of "extremely high sample excess leptokurtosis . . . a clear sign of fat tails." To fit the financial data better, the distributions are usually modified (e.g., truncated) because, in the extreme tails, financial asset returns decay faster than suggested by the unmodified Paretian. See also a related article on catastrophe insurance risk pricing by Lewis (2007).

8. Baumol and Benhabib (1989) describe an attractor as "a set of points toward which complicated paths starting off in its neighborhood are attracted."

9. Scheinkman and LeBaron (1989), for example, found evidence of nonlinear dependence on weekly returns for the value-weighted index of the Center for Research in Security Prices (CRSP), but as noted in Brooks (2002 [2008]) and in Alexander (2001), the issue is far from resolved. See also Vaga (1994, pp. 2–3) and Laing (1991).

10. A proposed resolution of these two opposing aspects, presented in Ch. 10, is that in bubbles (and crashes too) there is an exponential attractor and that SDIC is operative. In such extreme episodes, it is proposed that there is no long-term predictability. But in normal-trending markets the nonlinear dynamic aspects may be either faint or nonexistent, so that mean-reversion and long-run predictability are then possible.

11. Thus, the word "bubble" describes as much a process as a thing.

12. Hartcher (2006, p. vii) observes, "It is no coincidence that the word 'credit' stems from the Latin *credere* – to believe." A further important distinction is that self-liquidating credit, with loans repaid from sales of produced goods and services, adds value to an economy, whereas non-self-liquidating credit used for non-GDP transactions such as financial asset speculations generally does not.

13. In the post-1992 experience of Japan, Werner (2005, p. 62) observes that "high powered money, M1 + M2 + CD growth increased sharply. However, these increases in the money supply failed to be associated with commensurate increases in economic activity." Nor, it seems, did this increase in money lead to anything resembling a bubble. It was quite the contrary. Between September 1992 and December 1994, the Nikkei 225 index essentially traded sideways, in a range from approximately 17,000 to 21,000, but by June of 1995 it had fallen to just above 14,000, close to where it had been three years earlier. The two most recent lows were 7,607.88 on 28 April 2003 and 7,162.90 on 27 October 2008.

14. Werner (2005, p. 17) writes, "the neoclassical school of thought is based on the deductive approach. This methodology argues that knowledge is brought about by starting with axioms that are not derived from empirical evidence, to which theoretical assumptions are added." In contrast, the inductive approach "examines reality, identifies important facts and patterns, and then attempts to explain them, using logic, in the form of theories. These theories are then tested and modified as needed, in order to be most consistent with the facts of reality." Taleb (2007, 2005), however, provides coverage of problems of induction. See also Bezemer (2009, pp. 29–30).

15. The philosophical differences between the deductivist and inductivist approaches to economics are discussed in Keuzenkamp (2000, Ch. 1). And George (2007) observes that "Orthodox economics is increasingly dominated by sterile formalism, which refers only to itself."

16. The quotation is from Evans *et al.* (2007). As Kamarck (2001, pp. 5–7) has noted: "Walras, in trying to construct an economic theory on the analogy of Newtonian physics, confronted the problem of how there could be any regularity when manias have the richness of emotions, motives, expectations and uncertainties which affect all of us. Walras solved his problem by limiting human beings to a single drive, infinite selfishness ... A remarkable aspect of the fundamental assumption is that it lacks substantiation. There is no *a priori* guarantee that this assumption is true ... The rationality-optimization assumption depends on the belief that the individual's choices are his own: that preferences are not influenced by what others do. If people change their choices following on others' actions the demand curves dance around and become indeterminate. Beliefs and emotions drive actions as much as self-interest."

17. The present work nevertheless suggests that although securities markets are never in equilibrium in the classical sense, it is possible (in Ch. 6) to devise a practical statistical description of such an idyllic (absolute or perfect, as it is later called) equilibrium, were it ever to be attained.

18. Allen and Gale (2007, p. 52) define liquidity as a condition wherein assets "can be easily converted into consumption without loss of value." And Smick (2008, p. 22) writes, "[i]t may be that liquidity, when all is said and done, is not much more than confidence."

19. McCauley (2004, p. xi), indeed, explains: "There is no empirical evidence for stable equilibrium ... Standard economic theory and standard finance theory have entirely different origins and show very little, if any, theoretical overlap. The former, with no empirical basis for its postulates, is based on the idea of equilibrium ..."

20. "In all investment," as Mehrling (2005, p. 290) writes, "the biggest source of risk is time." In bubbles you don't want to delay lest you miss some of the anticipated gains (and thereby perhaps fail to match your peer group's performance), and in crashes you don't want to be the last to hold onto a rapidly vanishing asset.

21. Furnham and Argyle (1998, p. 5) write, "the psychological literature again and again shows people to act in ways quite different from the dispassionate, logical, utility and profit-maximisation model so long held by economists."

22. Burnham (2008) provides a popular treatment of the "new science" of irrationality and writes (p. 47) that "our lizard brains tend to make us greedy when we ought to be fearful, and fearful when we ought to be greedy." Burnham's behavioralist approach (p. 33) is that "irrationality is a fundamental part of human nature." See also Varchaver (2008).

23. Hunter *et al.* (2005 [2005], p. xiii) refer to bubbles as "costly, destabilizing episodes." De Bondt (2003, p. 207) observes that "Financial earthquakes undermine the public's trust in the integrity of the market system." Voth (2000) believes that "Higher volatility in asset prices can ... lead to instability in the rest of the economy." Cecchetti (2008) says that bubbles contort "economic activity ... – not to mention the balance sheets of commercial banks." And Werner (2005, p. 229) adds, "Instances of asset inflation are not welfare optimal."

24. A similar view encompassing both the tech and housing bubbles appears in Laperriere (2008).

25. This paraphrases the now-famous quote by Chuck Prince, former CEO of Citigroup, who said (in the *Financial Times*, 9 July 2007) with regard to subprime lending and the private equity buyout boom, "[W]hen the music stops, in terms of liquidity, things will be complicated. But as long as the music is playing, you've got to get up and dance. We're still dancing."

26. The expression was a New Orleans slogan that prevailed prior to the devastation of Hurricane Katrina in 2005.

27. Janszen (2008, note 1) writes that the familiar term "bubble" "confuses cause with effect. A better, if ungainly, descriptor would be 'asset-price hyperinflation' – the huge spike in asset prices that results from a perverse self-reinforcing belief system, a fog that clouds the judgment of all but the most aware participants in the market." He begins by saying that "A financial bubble is a market aberration manufactured by government, finance, and industry, a shared speculative hallucination and then a crash, followed by depression."