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What Is an Asset Price Bubble? An Operational Definition

Jeremy J. Siegel*
The Wharton School, University of Pennsylvania
e-mail: siegel@wharton.upenn.edu

Abstract

This paper reviews and analyses the current definitions of bubbles in asset prices. It makes the case that one cannot identify a bubble immediately, but one has to wait a sufficient amount of time to determine whether the previous prices can be justified by subsequent cash flows. The paper proposes an operational definition of a bubble as any time the realised *asset return over given future period is more than two standard deviations from its* expected *return. Using this framework, the paper shows how the great crash of 1929 and 1987—both periods generally characterised as bubbles—prove not to be bubbles but the low point in stock prices in 1932 is a 'negative bubble.' The paper then extends this analysis to the internet stocks and concludes that it is virtually certain that it is a bubble.*

Keywords: *asset prices*; *asset returns*; *bubbles*; *internet bubble*; *irrational exuberance*

JEL classification: *G*12, *G*14

1. Bubbles: Definitions

Current definitions

The word 'bubble' conjures up the image of an object growing steadily until it finally pops.[1] Charles Kindleberger, professor emeritus at the Massachusetts Institute of Technology and author of the enormously popular *Manias, Panics, and Crashes: a History of Financial Crises* defined a bubble as 'an upward price movement over an extended range that then implodes' (Kindelberger, 1978, p. 16).

In the New *Palgrave: a Dictionary of Economics*, Kindleberger is more specific:

> A bubble may be defined loosely as a sharp rise in the price of an asset or a range of assets in a continuous process, with the initial rise generating expectations of further

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[1] For an excellent review of the bubble and fads literature, see Camerer (1989).

> rises and attracting new buyers—generally speculators interested in profits from trading in the asset rather than its use or earnings capacity (Eatwell *et al.*, 1987, p. 281).

This definition implies that a high and growing price is unjustified (not related to 'earnings capacity') and is fed by 'momentum' investors who buy with the sole purpose of selling quickly to other investors at a higher price. Economists have tried to give additional substance to the definition of a bubble by linking asset price movements to 'fundamentals'. Fundamentals refer to those economic factors such as cash flows and discount rates that together determine the price of any asset. Peter Garber, in his book *Famous First Bubbles* indicates:

> The definition of *bubble* most often used in Economic research is that part of asset price movement that is unexplainable based on what we call fundamentals (Garber, 2000, p. 4).

Professor J. Barley Rosser of the Department of Economics of James Madison University suggests taking a more specific view of 'fundamentals' when defining a bubble:

> A speculative bubble exists when the price of something does not equal its market fundamentals for some period of time for reasons other than random shocks. [Fundamental] is usually argued to be a long-run equilibrium consistent with a general equilibrium (Rosser, 2000, p. 107).

Rosser indicates that fundamentals should reflect an expected value of the long run equilibrium but allows 'random shocks' to influence the price in the short-run. He admits that this equilibrium is frequently unobservable. As Rosser puts it, 'the most fundamental [problem] is determining what is ''fundamental'' ' (Rosser, 2000, p. 107).

Asset prices and future cash flows

We know that the price of any asset is the present value of all future *expected* cash flows. Ultimately this means that to define a bubble there must be an implication that either (1) the expectations of the cash flows, or (2) the rate used to discount these cash flow expectations is not rational, given a 'reasonable' range these variables could realise at the time the expectations are made.

Yet this definition pushes the problem back one step to the word 'reasonable'. Gerald Sirkin (1975) has written that given the rate of earnings growth that investors witnessed in the years leading up to the 1929 crash, the price-to-earnings ratio of stocks (in the upper teens) was not at all unreasonable. Even though the Great Depression proved those expectations to be wrong, it did not necessarily make them irrational.

A second problem is that current empirical work on financial bubbles fails to recognise that the price of an asset may be justified not only by cash flows in the next few years, but cash flows in the next few *decades*. For example, stock prices in 1929 were indeed not justified by the returns in the early 1930s, but, as will be shown, the cash flows 20 and 30 years later did in fact justify stock values in 1929. It is impossible to judge the 'rationality' of the price of a long-lived asset by looking at only the next few years.

Several years ago I examined the performance of the 'Nifty Fifty', a group of premier, large capitalisation growth stocks that rose rapidly in 1972 and then crashed in the following bear market (Siegel, 1995). There was unanimous agreement following the crash that these stocks had been grossly overvalued at the market peak.[2] Yet careful examination of their subsequent performance showed that these stocks, as a whole, were just slightly overvalued at the height of the bull market in December 1972 and that many stocks on the basis of their subsequent performance did deserve the lofty P-E ratios that investors had accorded them.

Importance of long-term cash flows

The following example emphasises the importance of long-term cash flows in determining the price of equity. Assume a firm earns 7% real return on its capital and pays a 4% dividend, using the remainder to buy back shares or reinvest for the future. Assume that investors also demand a 7% real rate of return on the stock. This will mean that the real dividend per share is expected to grow at 3% per year. These assumptions are very close to the long-run historical data on stocks (Siegel, 2002).

In the above situation, it takes investors nearly 20 years to receive just one-half of the present value of future dividends. The duration of this asset, which is the time-weighted average of all future cash payouts, is nearly 27 years. Even over the entire duration of 27 years, less than two-thirds of the total present value is realised from cash flows.[3]

It is easy to see how events many decades hence can have a significant impact on future cash flows and thus the price of equity today. How, therefore, is it possible in the 1930s to know with any degree of certainty that the price in 1929 is wrong? It is not.[4]

Operational definition of bubble

Of course, one cannot wait forever to determine whether a price is eventually justified by subsequent cash flows. It is theoretically possible for cash flows in the next 100 or 1000 years to be of such magnitude that almost any price, *ex post*, could be rational. To make the definition of a bubble operational, some time limit must be placed on the period over which future cash flows are measured and some criteria must be used to determine whether it is 'reasonable' to assume such cash flows in the future.

I propose the following operational definition of an asset market bubble. It is based on whether the future *realised* return of the asset justifies the original price over a time period long enough so that the present value of cash flows received by investors during

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[2] See Siegel, 2002, Chapter 9 for detailed references.

[3] As firms reduce the payout ratio and the dividend yield falls, the duration of the equities becomes even greater. At the current dividend yield of $1\frac{1}{2}\%$ and an implied $5\frac{1}{2}\%$ dividend growth, the duration rises to 71 years. Even if future dividend growth is only 4% (and assuming required return remains 7%), duration is 36 years.

[4] Alan Greenspan, Chairman of the Federal Reserve, was right when he responded to a question about the rising market in the late 1990s, 'We never know a bubble until after the event'. But even he might not be aware of how long it may take to confirm such a phenomenon (Testimony on 23 February 1999).

this period constitute at least one-half of that price. A simple measure of this length of this time is the *duration* of the asset, or time-weighted average of all future expected cash flows. If the realised return is more than two standard deviations from the *expected* return, given the risk and return conditions present up to the time when the price is being examined, then a bubble has been confirmed.

More specifically,

a period of rising (or falling) prices in an asset market can be described as a *bubble* (or *negative bubble*) at time ***t*** if it can be shown that the *realised* return of the asset over a given future time period, that time period defined by the *duration* of the asset, can be shown to be inconsistent, i.e., more than two standard deviations from the *expected* return, given the historical risk and return characteristics of that asset at time ***t***.

In other words, one must wait a sufficient period of time to see how the future plays out before anyone can identify a bubble. If, after this time period has been reached, the *realised* asset return is more than two standard deviations from the *expected* return, then one can call the asset price movement a bubble. This definition indicates it is virtually impossible to know immediately after a price falls whether there was a bubble or not.[5]

2. Empirical Analysis

The data for stock returns are taken from the Cowles Foundation data from 1871 through 1926 and the CRSP value-weighted data from 1926 to the end of 2001. Figure 1 displays real price index for equities from 1871 through 2001. Prominent peaks and troughs are indicated.

For the determination of bubbles, I chose a time period of 30 years to measure the realised returns on equities. For equities, historical data for dividends and historical return leads to a duration of about 30 years for stocks. Although the dividend yield is lower today, implying a longer duration, it is reasonable to use a 30-year planning horizon for investors.[6]

In order to determine whether a given price is a bubble or not, some assumption must be made about the mean real stock return, or the return investors expect from equities. Historically, the mean real return on equities has been 7% per year. But there is substantial economic theory, initiated by the work of Mehra and Prescott (1985), that claims a significantly smaller return for stocks is warranted based on the risks found in the overall economy.

Therefore two assumptions are made: one that takes the historical 7% real return as the estimate of the future mean stock return and the other that allows for a $4\frac{1}{2}\%$ real return on equities, a return derived from a 1% risk premium (suggested by the Mehra and Prescott work) added to a $3\frac{1}{2}\%$ real risk-free return available on long-term inflation-indexed bonds at the end of 2001.

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[5] It would be theoretically possible to call a price *irrationally low* almost immediately if the immediate discounted dividends exceed the price. However, it is not possible to call a price *irrationally high* within a short period.

[6] Thirty years corresponds to the maturity of the longest US regularly issued government bond and, approximately, to the length of a human 'generation'. This supports its use as a planning period.

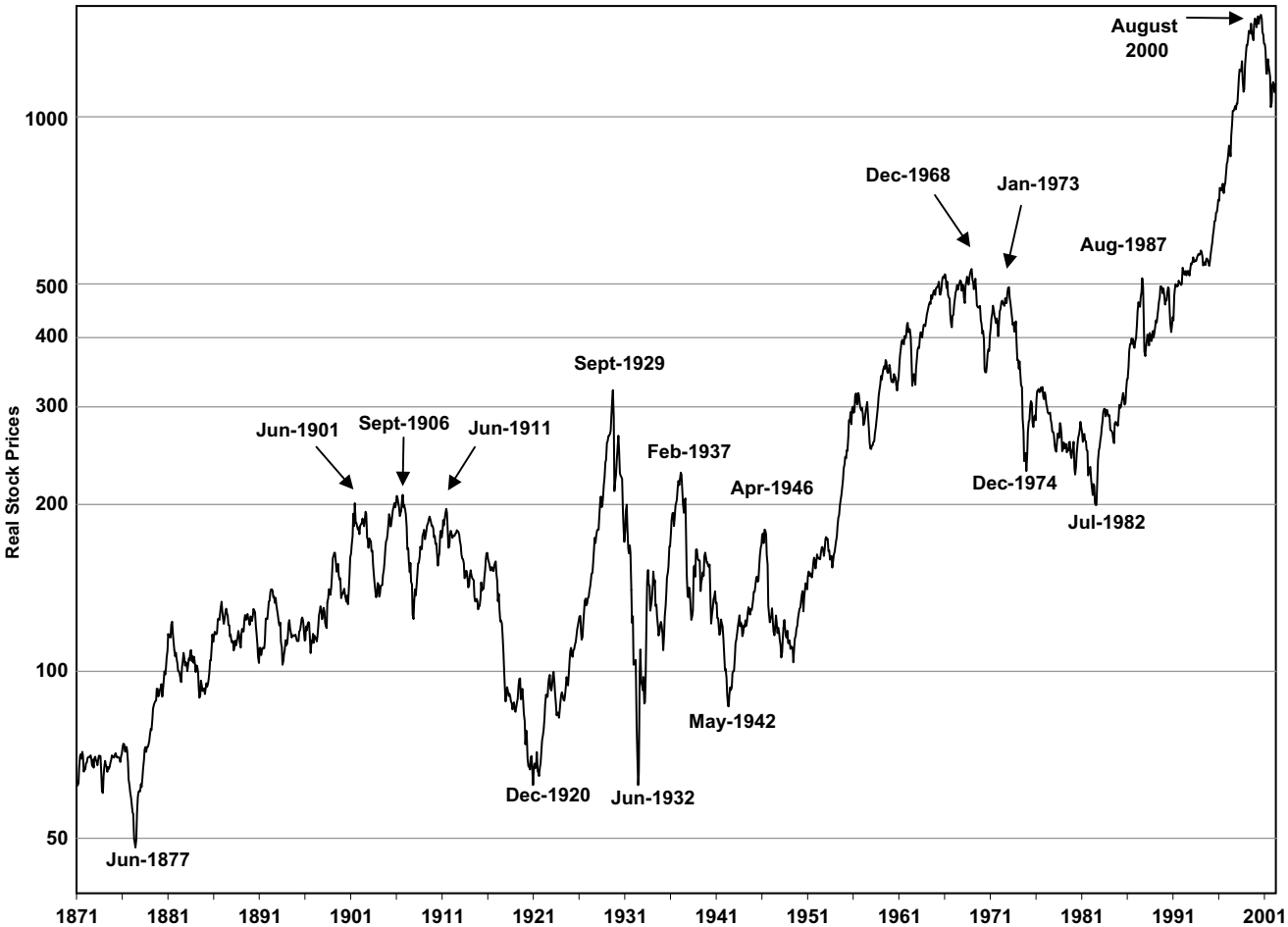

Fig. 1. Real stock price index, 1871–2001 (monthly).

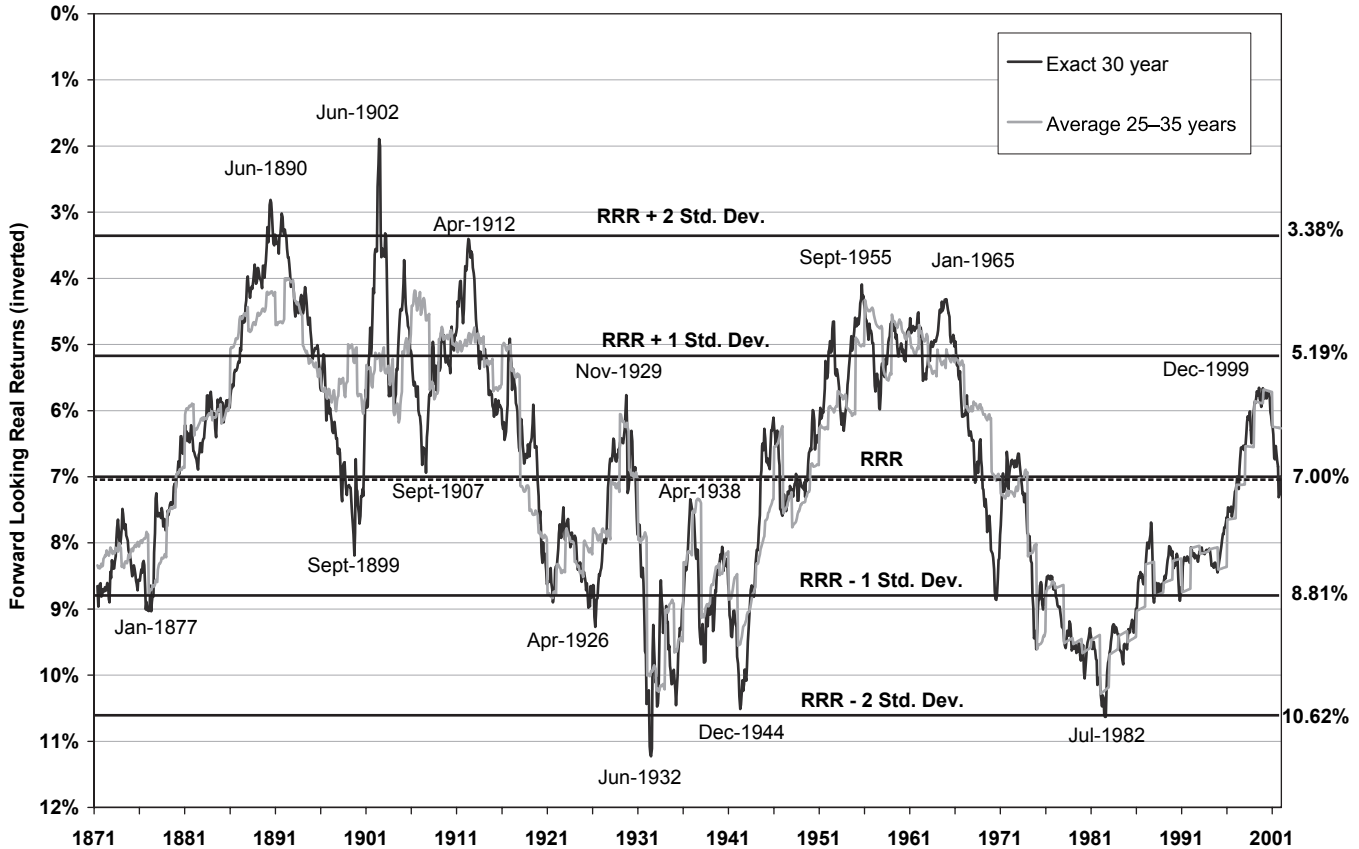

Fig. 2. Forward looking real stock returns assuming 7.0% required real return (RRR) after December 2001.

Figures 2 and 3 display the 30-year *forward-looking* annualised real return on stocks under the 7% and 4.5% return assumptions. The data represent the real return that investors would have earned by holding stocks for the next 30 years, reinvesting all dividends. Calculations were done for an exact 30-year period and an average of ten periods ranging from 25 to 35 years.

The reason for averaging different horizons is that about one-third of the present value comes from the price of stocks 30 years hence and about two-thirds from the intervening dividends. If the equity market were in a bubble 30 years hence, then the computation of the forward return would be significantly affected by this final price. Taking an average of the returns over 25–35-year horizons minimises the importance of the final year of data. Except for the late 1800s and very early 1900s, the exact 30-year and average 30-year forward-looking returns give almost identical results.

Figures 2 and 3 also display the 30-year real returns that are one and two standard deviations from the 7% and 4.5% mean real return, respectively.[7] The 1.8% standard deviation of average 30-year returns is derived from analysing the return over non-overlapping 30-year periods from 1802 through 2001.[8]

Figure 2 shows that there were virtually no years when the stock market was so overvalued that its subsequent 30 year real returns were two standard deviations below the mean. On an exact 30-year forward basis, the only significant over-valuations occurred in June 1890 and June 1902. This occurred because the severe drop in prices 30 years later (in June 1920 and June 1932) made the 30-year returns ending on that date unusually low. This significant overvaluation disappears when using the average of 25–35-year horizons. Note that the peak of the market in 1929 was not significantly overvalued since the 30-year forward return was only slightly below the 7% mean.

Figure 2 also shows that if an exact 30-year horizon is assumed, the bear market bottoms of June 1932 and July 1982 were significantly undervalued, but just barely. However, there was no period of significant *undervaluation* for the market if the average of 25–35-year horizons is assumed.

Figure 3 displays the real forward returns assuming an expected 4.5% mean real return on equities. It is not surprising that the market was never overvalued under this assumption. In fact, only occasionally did investors 'see the light' and send stock prices up to levels that are consistent with 4.5% expected real returns. On the other hand, stock prices were frequently so low that they yielded subsequent returns of more than two standard deviations above the 4.5% real return. Such undervaluation occurred throughout most of the period from 1920 to 1950 and also from 1971 to the mid 1980s.

An alternative to examining the forward-looking realised real returns for a defined period of time is to examine the internal rate of return (IRR) of equities. The IRR computes the real rate of return on stocks from the purchase price of the asset to the

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[7] In order to extend the calculated forward-looking returns beyond 1971 (and beyond 1966 when using a 35-year average), Figure 2 assumes that real returns are going to be identical to the historical average of 7.0% per year subsequent to 2001 and Figure 3 assumes future real returns will be 4.5% per year.

[8] See Siegel (2002, Chapter 2). This value is somewhat below the theoretical value of $0.182/\sqrt{30}$ that would hold if stock prices followed a random walk. This is because there is evidence of mean reversion in stock returns.

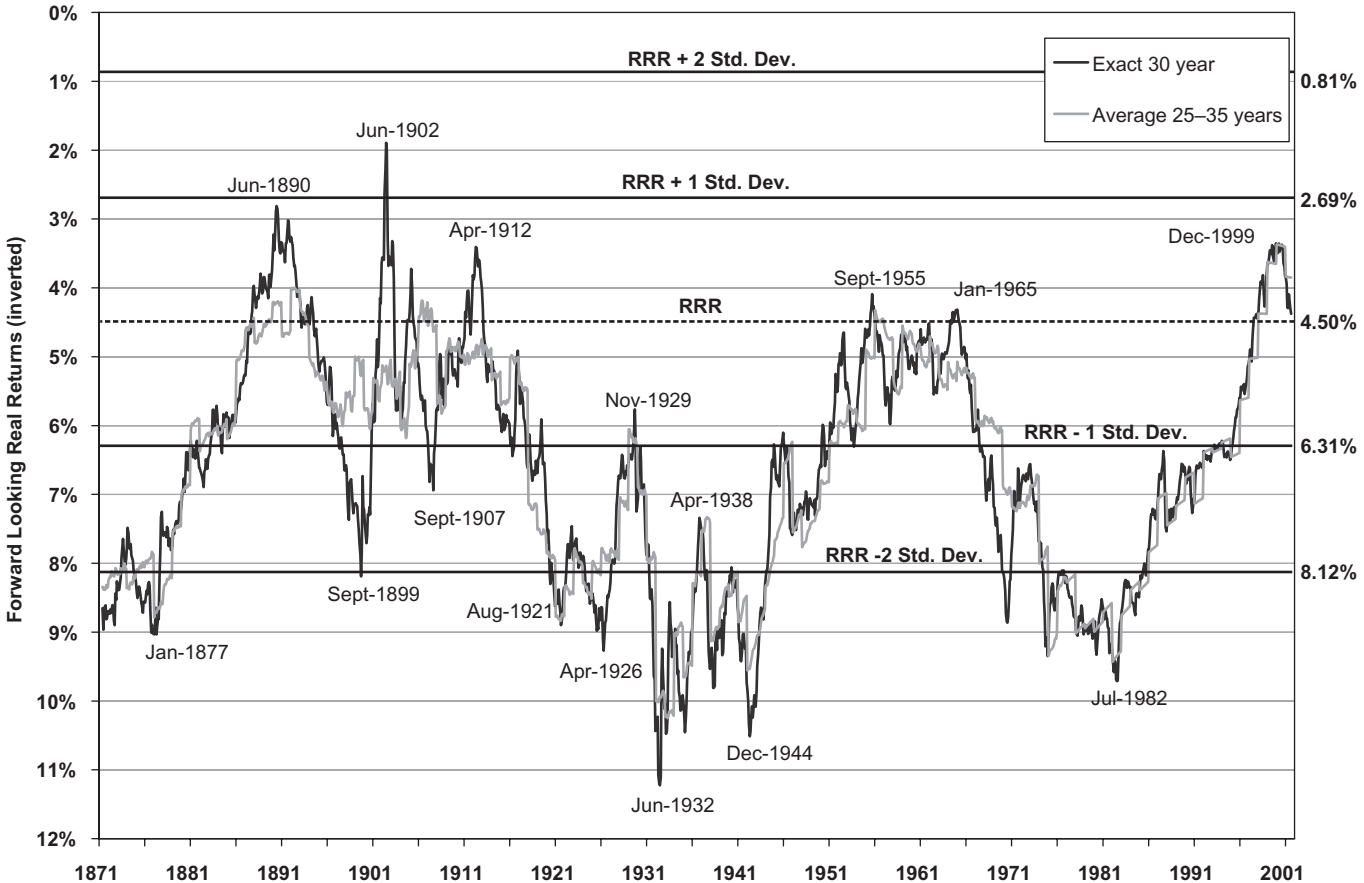


Fig. 3. Forward looking real stock returns assuming 4.5% required real return (RRR) after December 2001.

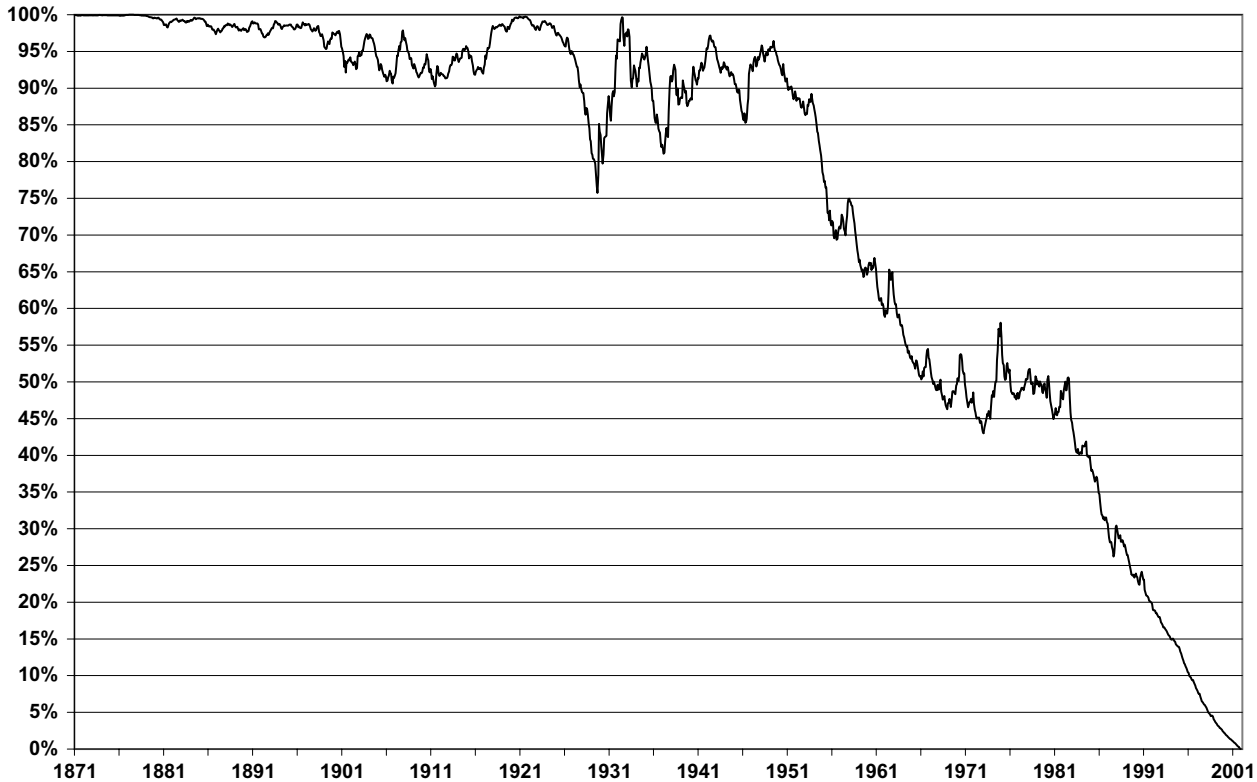


Fig. 4. Percentage of total present value received from dividend payments.

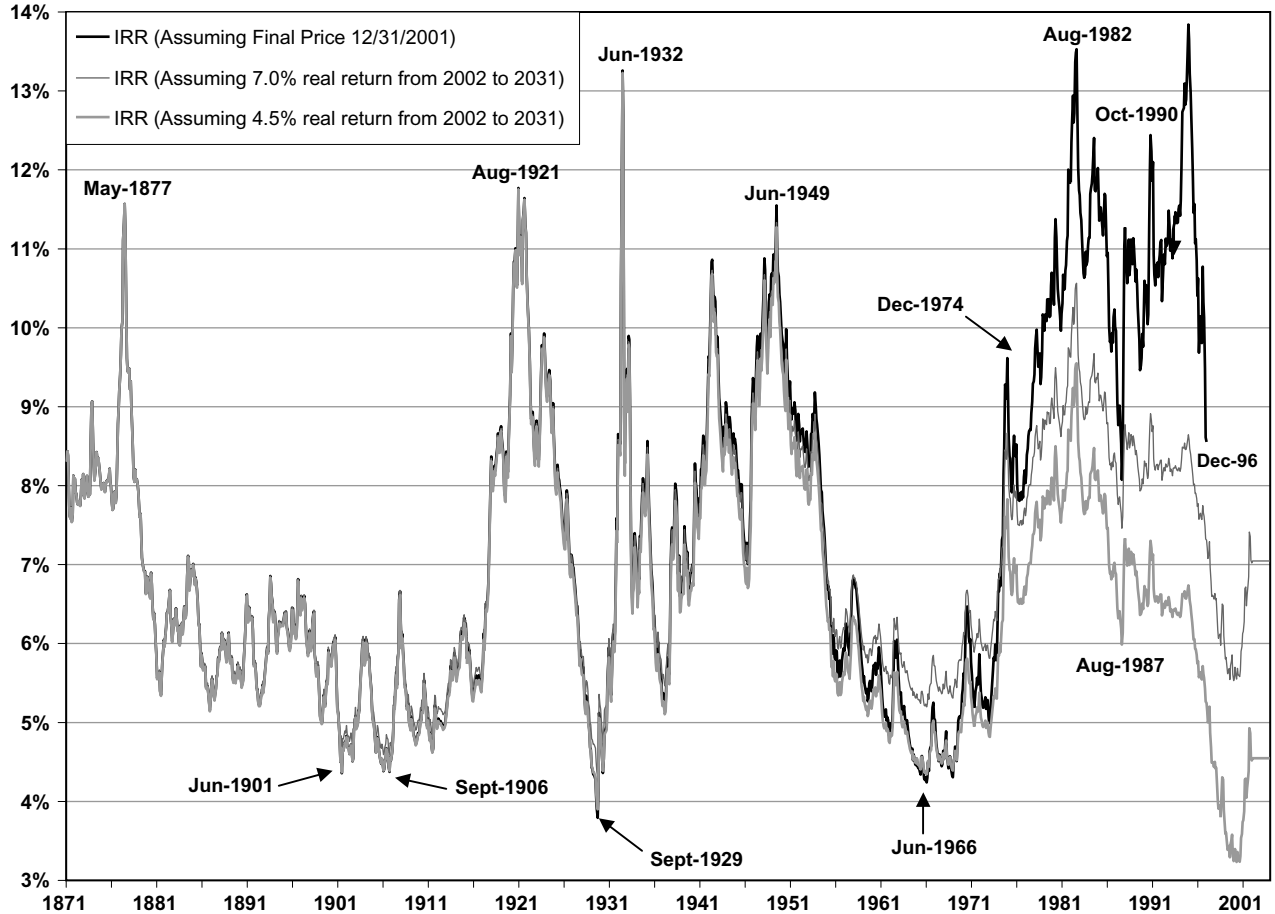


Fig. 5. Internal real rate of return on stocks given all cash flows.

final holding date, given the actual flow of *all* real dividends and the final price. The advantage of this IRR analysis is that it frees the calculations from a fixed horizon and the IRR can be computed with a high degree of accuracy for the first 100 years of the sample because the discounted future dividends comprise most of the total present value.

Figure 4 displays the percentage of the price of the stock at time t that is accounted for by future dividends actually paid. One minus this number is the percentage of the price of stocks at time t that is dependent on price of stock in year 2001. In the earlier years of the sample, the terminal price makes up an insignificant percentage of the present value of stocks; in 1871 99.93% of the present value consists of actual dividends paid. The terminal price becomes more important as time progresses. By 1900 dividends still account for about 95% of the present value of stocks, by 1930 this is down to 87% and by 1960 dividends account for about 65%, about two-thirds the present value.

To mitigate the effect of the terminal price of 2001 on when IRR is computed for years closer to the terminal date, Figure 5 examines two additional cases (1) stocks yielding a 7% real yield after 2001 (consisting of a $1\frac{1}{2}$% dividend yield and $5\frac{1}{2}$% dividend growth rate for the next 30 years) and (2) stocks yielding a 4.5% real return (consisting of a $1\frac{1}{2}$% dividend yield and a 3% future dividend growth rate).

In the depths of the Depression, the IRR of the market was over 13%. Certainly by any measure the stock market was far more undervalued in 1932 than it was overvalued three years earlier. In August 1982 the subsequent annual real return was almost 14% based on the next 19.5 years of dividends and the December 2001 price.

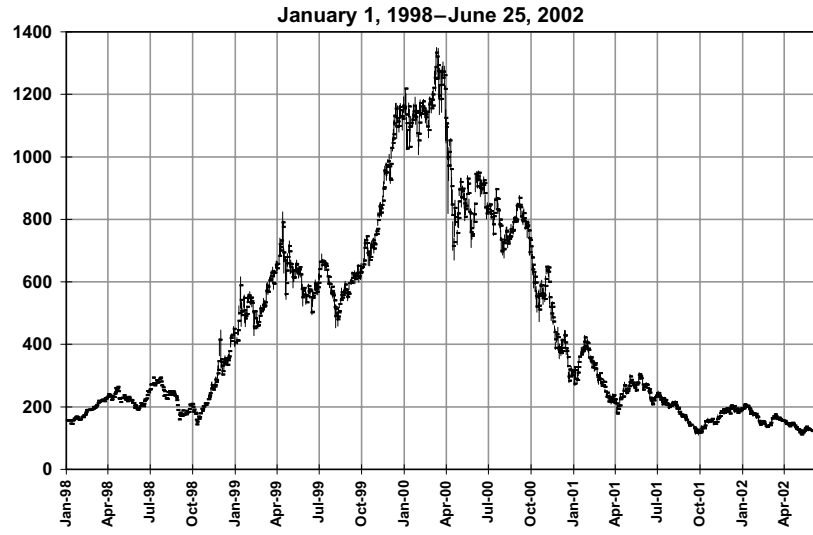
Figure 5 indicates that the forward real return on the market fluctuated between a low of just over 4% at the peak of September 1929 to a high of approximately 13.5% in June 1932 and August 1982. At the market peak in 1929, the forward return on stocks was just 3 percentage points lower than the 7% long run real return on equities, while at market bottoms it was nearly 7 percentage points higher. A history of the market shows that there is far more 'irrational despondency' at market bottoms than 'irrational exuberance' at market peaks.

3. Internet Stocks

The meteoric rise and then collapse in the prices of Internet stocks from 1998 through 2001 has often been described as a bubble. Figure 6 shows the behaviour of stocks that made up The Street.com index, an equally weighted index of 20 active Internet stocks. The index was set at 200 on its founding on 30 September 1998. It rose to 1350.16 on 10 March 2000 before plunging to 121.74 on 31 May 2002 and even lower subsequently.[9] The nearly seven fold rise and then more than 90% fall in the index is dramatic. The market value of these stocks exceeded $1 trillion at the market high. Over this time period, seven of the 20 stocks fell more than 99% from their peak price.

Can we be sure that this surge and then subsequent collapse was a bubble? The Dow Jones Industrial Average fell from 381.17 at the end of August 1929 to 41.22 in July 1932, or 89%, and this paper argues that based on future cash flows and the following 30 years of return one cannot call September 1929 a 'bubble'.

[9] As of this writing, the closing low of the dot.com index was 64/82 on October 3, 2002.



Index Components

Original Company Name	Current Ticker	Price as of 9/30/1998	Peak	Month of Peak	Price on 5/31/2002**	Decline from Peak	Change from 9/30/1998
US Web[1]	MRCHQ	$13.06	$58.50	Dec-99	$0.001	-99.999%	-99.995%
Eggshead[2]	EGGSQ	$7.25	$108.00	Dec-98	$0.003	-99.998%	-99.966%
At Home[3]	ATHMQ	$23.94	$99.00	Apr-99	$0.005	-99.99%	-99.979%
Open Market Inc[4]	DVIND	$11.25	$65.50	Mar-00	$0.15	-99.78%	-98.692%
CMG Info. Serv.	CMGI	$6.66	$163.50	Jan-00	$0.79	-99.52%	-88.13%
Inktomi	INKT	$18.81	$241.50	Mar-00	$1.77	-99.27%	-90.59%
Broadvision	BVSN	$1.17	$93.20	Mar-00	$0.81	-99.13%	-30.99%
Yahoo!	YHOO	$32.38	$250.06	Jan-00	$16.02	-92.60%	-50.52%
E-Trade Group	ET	$4.67	$72.25	Apr-99	$6.20	-91.42%	32.71%
Mindspring[5]	ELNK	$41.50	$66.50	Apr-99	$6.58	-90.11%	-84.14%
Real Networks	RNWK	$8.67	$96.00	Feb-00	$8.50	-89.18%	-1.98%
RSA Security	RSAS	$7.96	$62.04	Mar-00	$5.75	-88.87%	-27.76%
Go.Com[6]	DIS	---	$37.69	Nov-99	$4.30	-88.59%	---
Checkpoint Software	CHKP	$3.31	$118.58	Oct-00	$16.26	-86.29%	+390.87%
Lycos[7]	TRR SM	$16.91	$93.63	Dec-99	$14.31	-84.72%	-15.36%
Amazon	AMZN	$18.60	$113.00	Dec-99	$18.23	-83.87%	-2.01%
Macromedia	MACR	$20.00	$120.88	Jul-00	$22.20	-81.63%	+11.0%
AOL Time Warner	AOL	$15.92	$95.81	Dec-99	$18.70	-80.48%	+17.45%
McAfee Associates[8]	NET	$42.50	$67.69	Jan-99	$19.35	-71.41%	-54.47%
Ebay	EBAY	$7.51	$127.50	Mar-00	$55.21	-56.70%	+635.1%
Average		**$15.90**	**$107.54**	**Dec-99**	**$10.76**	**-89.18%**	**-54.13%**
Street.com Index[9]	**DOT**	**200**	**1350.16**	**Mar-00**	**121.74**	**-90.98%**	**-39.13%**

** Effective price after takeover

1 USWeb was acquired by MarchFirst in March 2000; MarchFirst filed for bankruptcy April 12, 2001

2 Eggshead filed for bankruptcy August 15, 2001

3 At Home filed for bankruptcy September 28, 2001

4 Open Market Inc. acquired by Divine Inc (Symbol DVIND), which announced at 25 for 1 reverse stock split on May 29, 2002

5 Mindspring merged with rival EarthLink on February 22, 2000.

6 GO.COM (symbol GO), Disney's Internet group, was issued November 18 1999 (the peak of the stock); the stock's symbol was changed to DIG and was re-acquired by Disney on 3/20/01 at the price $5.37. Since then, Disney stock has fallen 19.9%, so the effective price is $4.30

7 Lycos was acquired by Terra Networks SA, completed on 10/30/2000

8 McAfee Associates changed its name to Network Associates (NETA) on December 2, 1997

9 The Street.com Dot.com Index was developed with a base value of 200 on September 30, 1998

Fig. 6. The Street.com internet index.

Yet the great stock market crash of the early 1930s was not as severe as that of the Internet stocks. The price of consumer goods fell $21\frac{1}{2}$% between August 1929 and July 1932, mitigating the decline in real wealth. Furthermore investors received an average dividend of about 6% over that period. In contrast, the CPI edged upward during the dot.com crash and none of the Internet stocks paid *any* dividend.

It is theoretically possible for those Internet stocks to rise in price sufficiently in the future so that the peak of these stock prices in late 1999 or early 2000 will not be labelled a bubble. But this is highly unlikely. Even if we assume the stock market achieves a lower-than-average 7% per year *nominal* return over the 30-year period from March 2000 to March 2030, internet stocks would have to achieve an average return of over 17% per year over each of the next nearly 28 years to realize the same return as the rest of the market. No industry or group of stocks has achieved such an excess return over such a long period. Furthermore, a rate of return of these stocks that only matches the market would prove disappointing to investors given the much-higher-than normal risks facing internet investors.

4. Conclusion

There is a tendency to judge a bubble on the basis of immediate price action. This is quite inappropriate for a long-duration asset such as equity where the present value depends on cash flows many years in the future. The public and indeed most economists called the 1929 and the 1987 events bubbles on the basis of the price collapse that immediately followed.

However, in both cases analysis of the data indicate that subsequent returns justified the price paid at the market peak. In 1929 it took cash flows in the 1940s and 1950s to justify the prices stocks reached in 1929. In 1987, cash flows over a much shorter period of time confirmed that the peak reached in August 1987 was not only not overpriced, but probably underpriced on the basis of subsequent cash flows.

Has the stock market ever been 'overpriced' using the criteria of looking at the next 30 years of returns and comparing these returns with the historical mean return achieved by equities? It is almost certain that the Internet stocks were overvalued at their market peak in March 2000. But the US market was overvalued on just a very few occasions in the late nineteenth and very early twentieth century. And even these overvaluations may have been a statistical fluke based on the stock price collapses that took place 30 years later, in 1920 and 1932. Using the average of 10-year returns around a 30-year horizon shows no significant overvaluation.

The real return on the market fell below 4.5% on the basis of all realised dividend flows in less than 1% of the time during the last 130 years. Assuming a small equity risk premium of about 1%, the stock market has been chronically undervalued during most of its history. Only occasionally, during periods most often described as 'manic' or 'speculative' did the market emerge from an undervalued state. Bubbles, instead of being periods of irrationality, were periods where investors bid stock prices up to levels where the margin over bond returns has shrunk to levels consist with the risk and return profile of these assets.

References

Camerer, C., 'Bubbles and fads in asset prices', *Journal of Economic Surveys*, Vol. 3, 1, 1989, pp. 3–41.

Garber, P., *Famous First Bubbles* (MIT Press, 2000).
Kindleberger, C., *Manias, Panics, and Crashes* (New York, Basic, 1978).
Mehra, R. and Prescott, E. C., 'The equity premium: a puzzle', *Journal of Monetary Economics*, Vol. 15 (March 1985), pp. 145–62.
Eatwell, J., Milgate, M. and Newman, P. (eds) *The New Palgrave: a Dictionary of Economics* (New York, Stockton, 1987), p. 281.
Rosser, J. B., Jr., *From Catastrophe to Chaos: a General Theory of Economic Discontinuities* (Kluwer Academic, 2nd ed., 2000).
Siegel, J., 'The nifty-fifty revisited: do growth stocks ultimately justify their price?' *Journal of Portfolio Management*, Vol. 21, 4 (Summer 1995), pp. 8–20.
Siegel, J., *Stocks for the Long Run* (McGraw-Hill, 3rd ed., 2002).
Sirkin, G., 'The stock market of 1929 revisited: a note', *Business History Review*, Vol. 44, 2 (Summer 1975), pp. 223–231.