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Analysing the ‘Greenspan put’”**

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## **Moral Hazard and the US Stock Market: Analysing the ‘Greenspan put’<sup>1</sup>**

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### **Abstract**

The risk premium in the US stock market has fallen far below its historic level, which Shiller (2000) attributes to a bubble driven by psychological factors. As an alternative explanation, we point out that the observed risk premium may be reduced by one-sided intervention policy on the part of the Federal Reserve which leads investors into the erroneous belief that they are insured against downside risk. By allowing for partial credibility and state dependent risk aversion, we show that this ‘insurance’ – referred to as the Greenspan put -- is consistent with the observation that implied volatility rises as the market falls. Our bubble, like Shiller’s, involves market psychology: but what we describe is not so much ‘irrational exuberance’ as exaggerated faith in the stabilising power of Mr. Greenspan.

Keywords: Asset bubble, Monetary policy, Greenspan put, Risk premium.

JEL Classification: G12, E52, D84.

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## Non-technical Summary

With the collapse of Communism in 1989 and the increasingly skilful management of the market economy (as exemplified by Mr Greenspan, Chairman of the Fed since 1987), the risks associated with owning US equities clearly fell towards the end of the last century: and the development of the New Economy markedly improved US growth prospects, especially in the high technology sector. More optimism on growth and less fear of world war and depression surely justified a substantial re-rating of the stock market. But could fundamental factors justify the spectacular asset price increases seen over that period, when for example the S&P500 - a broad-based index of top US companies - sustained an average growth rate of 12% for more than a decade, rising from about 330 in 1987 to over 1500 in the new millennium?

Now that the S&P has fallen by about a third, it is easy to suggest that the market overreached itself. But Mr Greenspan had first expressed fears of “irrational exuberance” in 1996; and Robert Shiller ( 2000) asserted unequivocally that there was a bubble in the U.S. stock market, due largely to psychological factors. For the NASDAQ index of high technology stocks (which grew very rapidly from 2000 to over 5000 before collapsing by more than two thirds), Shiller is surely correct: people bought rising New Economy stocks in anticipation of continued price increases and the scramble for new offerings resembled a gold rush. But what about the wider stock market indices such as the S&P 500? and those focussed more on the Old Economy such as the Dow Jones? We argue that there has been a bubble there too; but not of the simple extrapolative variety, more like an insurance bubble.

The idea explored in this paper is that investors in the US had come to expect that the Federal Reserve would take decisive action to prevent the stock market from falling -- but not to stop it rising: and were confident that the intervention would succeed. Two key examples of the Fed’s ability to prevent market crashes are the prompt action taken to limit “market break” of 1987 and to alleviate the “liquidity crunch” of 1998, in both cases by cutting interest rates and pumping in liquidity. By treating serious market collapses as jump processes, we show how avoiding them can justifiably reduce the risk premium by eliminating a ‘Peso problem’.

Impressed by these dramatic rescue operations, investors were, we believe, lulled into a false sense of security, thinking that the Fed was providing a general downside guarantee on stock

values. The effect of such portfolio insurance would be like a put option: but the reality is a bubble -- because the put will not exist when it comes to be exercised. Central Bank intervention may be able to contain self-fulfilling crises in financial markets; but it cannot shield equities from the adverse effect of low corporate earnings.

Two pieces of survey evidence of this “meta moral hazard” are discussed. First is a small survey of major fund managers and chief economists in London and New York carried out in early 2000 to investigate the hypothesis that “confidence in an ever-increasing stock market is due to the belief that monetary policy will be used to support the market and that corrections will elicit reductions in interest rates until the market turns around”. The authors concluded that “the results are quite clear. All respondents believe that the Fed reacts more to a fall than a rise, and all except two believe that this type of reaction is in part responsible for the high valuations on the US market”. The second is a much bigger national opinion survey conducted in 2001 by the Securities Investor Protection Corporation (SIPC) to see whether individual US investors were aware of the risks they face in the stock market. The SIPC found evidence of widespread belief among individual investors that they are insured against stock market losses.

To capture the idea of an insurance bubble, imagine that market participants were freely given an undated put option with an exercise price some fixed proportion of the last market peak. By pricing a ‘Greenspan put’ into the market valuation, we show how erroneous belief in the stabilising power of the Fed can raise stock market prices and reduce the implied risk premium. Calibrating the model using a range of plausible parameters, we find that believing the Fed can prevent the market falling by more than 25% from its previous peak can raise the market by more than 50% and bring the observed risk premium down from 4.3% to about 2.6% even though underlying attitudes to risk are unchanged. With a more sophisticated “sliding put” markets can go a lot higher, lifted by a ‘virtuous circle’ of self-fulfilling expectations - as shown in an earlier version of this paper (dated January, 2000). On the other hand, it is unrealistic to postulate that the Fed’s intervention is fully credible, and partial credibility weakens the value of the hypothetical insurance. (It is also shown that - with ‘habit persistence’ by investors - a partially credible put can be consistent with the characteristic negative correlation between stock price volatility and market value.)

Since the Fed cannot determine the real value of stocks, the resulting asset prices are not rational. Like Shiller's, our "insurance bubble" involves market psychology: but what we describe is not so much "irrational exuberance" as exaggerated faith in the stabilising power of Mr. Greenspan and the Fed. What are the policy implications? The central implication is that markets will crash when investors realise that Mr Greenspan is not superhuman. An alternative scenario is that investors gradually come to their senses, and there is a bear market as the insurance bubble subsides more slowly. Some high-tech investors are reportedly angry with Mr Greenspan because they were not bailed out when the NASDAQ was collapsing: evidence perhaps that there was moral hazard -- but it is on the wane.

*"The high recent valuations in the stock market have come about for no good reasons."*

Robert Shiller, *Irrational Exuberance*.

*"It's official. There is a Greenspan put option'.* Financial Times: Jan 4, 2001.

## 1. Introduction

Though US shares fell sharply in the stock market crash of 1987, they then appreciated at a record-breaking pace into the new millennium. The broad-based S&P 500 index of top US companies, for example, increased 360% from its pre-crash peak of about 330 in August 1987 to its recent peak of just over 1,500 in August 2000, an average annual growth rate of about 12%. This asset price boom implied that, relative to the past, estimated dividend growth rates had risen, the risk premium had fallen, or there was a bubble.<sup>2</sup>

While the “irrational exuberance” described by Shiller has surely played a role in the high tech sector, we believe that understanding the fall in the observed risk premium in the US stock market as a whole needs to take into account what is sometimes called “meta moral hazard”. The idea is that investors in the US came to expect that the Federal Reserve would take decisive action to prevent the market from falling but not to stop it rising: and believed that such intervention would be successful. So the Fed was apparently providing insurance against the possibility of a market crash. The effect is like a put: but the reality is a bubble, because the put will not exist when it comes to be exercised.

Key evidence in support of this view are the prompt actions taken by Mr. Greenspan to limit the market crash of 1987 and the effects of the liquidity crunch of 1998, in both cases by cutting interest rates and pumping in liquidity. Evidence of resulting “meta moral hazard” is provided in (i) a small survey of major fund managers and chief economists in London and New York carried out in early 2000 and (ii) a national opinion survey by the Securities Investor Protection Corporation (SIPC) of over 2000 individual investors. The former investigated the hypothesis that “confidence in an ever-increasing stock market is due to the belief that monetary policy will be used to support the market and that corrections will elicit reductions in interest rates until the market turns around”. The authors concluded that “the results are quite clear. All respondents believe that the Fed reacts more to a fall than a rise, and all except two believe that this type of reaction is in part responsible for the high valuations on the US market” (Cecchetti *et al.*, 2000, p.75). In a five point “investors’ survival quiz” to see whether individuals were aware of the risks they face in the stock market, the SIPC found evidence of widespread belief among individual investors that they

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<sup>2</sup> The preferred explanation must, of course, be consistent with the subsequent fall of the S&P to around 1100

are insured against stock market losses.<sup>3</sup> Fewer than 1 in 5 (16%) knew that there is in fact no insurance “against losing money in the stock market or as the result of investment fraud”.

While the monetary authority cannot control the real interest rate in the long run, it can over the short run when prices and inflation expectations are sticky. So it can exert a temporary influence over share prices. If by correcting one crash and averting another, Mr Greenspan led investors to believe that they are effectively protected from downside risk, this “insurance” would greatly increase share prices and reduce the estimated risk premium.

Estimates of risk premia in the U.S. stock market as of early 2000 making a range of assumptions about the expected growth rate of dividends are shown in Table 1.<sup>4</sup> They are obtained by subtracting the risk-free real interest rate (the yield on U.S. Treasury Inflation Protected Securities) from the total yield on shares (i.e., dividend yield plus growth). The figure of 3.8% for dividend growth in the ‘high growth’ scenario (in row 3) is roughly twice its historical average over the period 1926-97 (shown in line 1). If we take the average of the low and high figures, we obtain the medium growth case shown in row two of the table. A comparable estimate by Blanchard (1999) at the bottom of the table differs from this average essentially in the choice of a lower real interest rate.

The implied equity risk premia are given in column 4. Even in the high growth case, the estimated equity premium is only 1.8%. In the low growth scenario the premium is actually negative. These estimates compare to a historical average over the period 1926-97 of about 7%. Some have argued that this *ex post* average overstates the true *ex ante* risk premium. Cecchetti *et al.* (2000) use a simple extrapolative model of expectation formation to arrive at the lower figure of 4.3% for the *ex ante* risk premium over the same period.

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in August 2001.

<sup>3</sup> For the full survey results, see “KEY INVESTOR SURVIVAL QUIZ FINDINGS” on the SIPC web site: <http://216.181.142.217/sipc/release0.html>.

<sup>4</sup> The figures in the table are based on those in Table 3.1 on p.58 of Cecchetti *et al.* (2000).

	Div. Yield	Div. growth	Real interest Rate	Equity risk Premium	Ex ante Risk premium	Warranted div. yield	Warranted Price
Low Growth	2.1	1.9	4.1	-0.1	4.3	6.5	0.32
Medium Growth	2.1	2.85	4.1	0.95	4.3	5.45	0.39
High Growth	2.1	3.8	4.1	1.8	4.3	4.6	0.46
Blanchard	2.0	3.0	3.0	2.0	4.3	4.3	0.46

**Table 1 Equity risk premium in the US stock market**

Note: The figures in rows 1-3 are based on those in Table 3.1 in Cecchetti *et al.* (2000). The dividend yield is calculated for the S&P500 Index at 1466 in early 2000. The figures in row 4 are based on Blanchard (1999). The warranted dividend yield is calculated as real interest rate – dividend growth + ex ante risk premium. The warranted price is the ratio of dividend yield to warranted dividend yield.

To see the market correction needed to restore risk premia to their *ex ante* levels, we first compute the ‘warranted dividend yield’ (i.e., the dividend yield consistent with a risk premium of 4.3%), and then divide this into the current yield to give a ‘warranted market price’, expressed as a proportion of current market price in the last column. Thus in the medium growth scenario, the warranted market price is about 40% of the market price at that time. In the high growth case, and Blanchard’s case, the warranted price turns out to be close to a half, implying that the market was about twice its fundamental value.

The ex post value of the equity premium in post-war US data reported by Campbell (1999) is 7.85% for the period 1947-96. But, as Cochrane (2001, p.460) observes “one nagging doubt is that a large part of the U.S. post-war average stock return may represent good luck rather than ex ante expected return”. If stock returns are liable to suffer occasional serious crashes -- due to bank panics, economic depressions, wars etc. -- the observed returns from a sample that does *not* include any crashes will be larger than the unconditional expected return. Brown, Goetzmann and Ross (1995) have observed that a number of major markets suffered important interruptions that lead to their exclusion from long-term studies of stock returns. (They cite Russia, China, Germany and Japan.) Along similar lines Rietz (1988) argued that the equity premium puzzle could be explained as a Peso problem. One way to correct for this bias is to model ex ante expectations of stock returns in order to capture the fact that investors learn from experience. Thus Cecchetti *et al.* (2000) estimate the ex ante (unconditional) risk



premium as described above, and we use their figure of 4.3% as a benchmark case in subsequent numerical calculations.<sup>5</sup>

Cecchetti *et al.* are circumspect about drawing definite conclusions from their analysis, but their calculations clearly point to significant overvaluation in the U.S. stock market. Blanchard acknowledged that there were good reasons to suppose that the risk premium might be lower than in the past; but he argued that the observed fall was greater than could be plausibly accounted for by factors such as better economic stabilisation and more efficient risk management and distribution. In a recent book, Shiller (2000) asserts unequivocally that there was a bubble in the U.S. stock market, due largely to psychological factors -- ‘irrational exuberance’.

While we do not deny that such “gold rush” behaviour was relevant in the high tech sector, we argue that the asymmetric conduct of the monetary authorities has played a key role in lifting the whole market. It was as if investors came to believe that diversified equity investment was insured subject to a deductible, i.e., with a market floor somewhat below current prices, but no ceiling. To characterise this perceived insurance, we assume specifically that stocks were valued as if market participants were in possession of an undated put with an exercise price some fixed fraction of the last peak. The idea of monetary intervention having price effects like the issue of derivatives is familiar from the work of Krugman (1991) on “target zones” for exchange rates. A credible target zone for the nominal exchange rate requires the central bank to have sufficient foreign exchange reserves. A perceived floor on the real price of stocks requires an element of irrationality and myopia of the part of the average investor.

By pricing a ‘Greenspan put’ into the market valuation, we show how erroneous beliefs in the stabilising power of the Fed can raise stock market prices and reduce the implied risk premium. Calibrating the model using a range of plausible parameters, we find that believing the Fed can prevent the market falling by more than 25% from its previous peak brings the

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<sup>5</sup> Of course, since their data period includes the Greenspan years as well as the Great Depression, this means that our calculation of fair value does give some credit to the Fed for preventing economic collapse and the recurrence of anything like the experience of the 1930s. Perhaps a somewhat lower figure could be justified, because the end of the cold war and the recent active intervention by the Fed have substantially reduced the perceived probability of such crashes going forward. Cochrane (2001, p.460) suggests that the true risk premium is more like 3-4%. Even with such a low risk premium, broad based measures of the US stock market were still overvalued in 2001.

observed risk premium down from 4.3% to about 2.6% even though underlying attitudes to risk are unchanged. This calculation is, however, based on the extreme assumption of absolute confidence in the Fed's ability to stabilise the market. If the perceived "insurance" is only partially credible, we find that the effect on market value is reduced but can still remain substantial.<sup>6</sup> An important policy implication discussed below is how such erroneous beliefs may be corrected without a catastrophic stock market collapse.

## 2. The Model of "Warranted" Share Values

We consider the problem facing a representative investor who can trade an asset which pays dividends at the rate  $D(t)dt$ . Dividends are assumed to evolve according to:

$$\frac{dD}{D} = \mu dt + \sigma dz, \quad (1)$$

where  $\mu$  is the trend,  $z$  is a standard Brownian motion and  $\sigma$  the standard deviation.

The price of the asset,  $V(D)$ , will satisfy the second order ordinary differential equation

$$\frac{1}{2}\sigma^2 D^2 V''(D) + (\mu - \pi)DV'(D) - rV(D) + D = 0, \quad (2)$$

where  $r$  is the risk-free interest rate and  $\pi$  is the risk premium (Miller *et al*, 2001, Section 3, provides a detailed derivation). One solution to this equation is

$$V^F(D) = \frac{D}{r - \mu + \pi}. \quad (3)$$

where the superscript  $F$  indicates the fundamental value of the asset. This is the continuous time version of the familiar Gordon formula where the asset price,  $V(D)$ , is the expected present value of all current and future dividends discounted by the risk adjusted rate of  $\hat{r} = r + \pi$ , i.e.,

$$V^F(D) = E_0 \int_0^{\infty} D(t)e^{-\hat{r}t} dt = \frac{D}{r - \mu + \pi}. \quad (4)$$

In Section 4 we consider the non-linear solutions that may arise as a consequence of believing that the Federal Reserve will intervene to put a floor under the market. But first we discuss why investors might come to hold such a belief.

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<sup>6</sup> We also find that combining partial credibility with a form of state-dependent risk aversion due to Campbell and Cochrane (1999) generates observed patterns of market volatility.

### 3. The Origins of Investors' Erroneous Beliefs

Let us suppose that, in the absence of active and skilful management of financial crises, the process driving dividends given in (1) would be augmented by a jump process, so:

$$\frac{dD}{D} = \mu dt + \sigma dz + dq, \quad (1')$$

where the jump component is a Poisson process  $q(t)$  with intensity parameter  $\lambda$  equal to the mean number of jumps per unit of time. After a jump has occurred at time  $t$ , the dividend takes on the value  $D(t+h) = D(t)y$  where  $0 < y < 1$  and  $1 - y$  indicates the percentage decline in dividends. So dividends will be subject to periodic large adverse movements which we shall term "crises".

The prospect of such crises must clearly affect the stock price. Applying Ito's Lemma extended to incorporate the presence of a jump process, one may show that the valuation equation in (2) is modified by the addition of an extra term<sup>7</sup>:

$$\frac{1}{2} \sigma^2 D^2 V''(D) + (\mu - \pi) D V'(D) - r V(D) + D + \lambda y^{-\gamma} (V(Dy) - V(D)) = 0. \quad (2')$$

where  $V(Dy) - V(D)$  is the size of the jump in the stock market value and  $\gamma$  is the coefficient of relative risk aversion in the utility function of the representative investor. As in the previous case, there exists a linear solution, which takes the form

$$V^F(D) = \frac{D}{r - \mu + \pi + \lambda(1 - y)y^{-\gamma}}. \quad (3')$$

Adding jumps to the dividend process implies that there are now two components to the risk premium:  $\pi + \lambda(1 - y)y^{-\gamma}$ . The first term,  $\pi$ , is the risk premium associated with Brownian motion in dividends and consumption. The second term associated with jumps is the product of the mean number of arrivals per unit of time,  $\lambda$ , the expected percentage decline in stock prices,  $1 - y$ , and the term  $y^{-\gamma}$  which captures the increase in the marginal utility associated with the decline in consumption. If we suppose, for example, that a crisis that cuts dividend flows by 50% ( $y=0.5$ ) will occur on average every fifty years ( $\lambda = 0.02$ ) and a coefficient of relative risk aversion of  $\gamma = 2$ , then this would yield a risk premium associated with the jumps

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<sup>7</sup> Here we assume that the downward jump in dividends causes the same sized downward jump in consumption with probability 1. For a detailed derivation, see Miller, Weller and Zhang (2001). A similar treatment can also be found in Bates (1991).

of 4%.<sup>8</sup> Clearly, the elimination of crises modelled in this way could substantially reduce the risk premium.

It could be that improved management of monetary policy can mitigate or even eliminate the downward jump component. (So, whenever the Poisson process indicates that a crisis is due, the central bank responds immediately by loosening the stance of monetary policy and cutting interest rates and successfully prevents the drop in dividends and the extra risk premium associated with it.) Let us go further and assume that this has in fact occurred, i.e., Mr. Greenspan has so improved upon the actions of his predecessors that the systemic bank collapses that led to the Great Depression are a thing of the past. This would lead to a justifiable reduction in risk premium.

But what if the representative investor cannot distinguish between the interventions by the central bank designed to avoid financial crisis, which are feasible, and interventions designed to protect the investor against general downside risk, which are not? This possibility is supported by several observations. First, even for the central bank itself distinguishing between incipient crises and ongoing shocks to fundamentals is not as straightforward as the sharp statistical distinction between jump and continuous processes suggests.<sup>9</sup> Second, by their very nature actions designed to avert financial crisis will be more salient and will attract disproportionate attention from the average investor. When they are successful, as in 1987 and 1998, this is likely to increase the general perception that investors are protected from any sharp decline in stock prices. Third, the evidence from the survey of fund managers by Cecchetti *et al.* (2000) and of many individual investors by the SIPC described above supports the view that many investors had come to hold these beliefs.

It is because we assume that the US economy has moved to a regime in which the Federal Reserve can successfully prevent the crises represented by the jump component in the fundamental  $D(t)$ , that the value of the market is characterised by the equation (2). The

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<sup>8</sup> This figure must be treated as an upper bound since the decline in dividends caused by the downward jump leads to an equal proportional decline in consumption. If, however, people can insure against this downward decline in dividends, the decrease in their consumption would be smaller and so would be the corresponding risk premium associated with the jumps.

<sup>9</sup> This is well illustrated by the collapse of Long Term Capital Management and its subsequent rescue in 1998. Was the Fed orchestrated bail-out a well-timed prevention of disastrous market collapse; or was it, as some have argued, simply protecting certain privileged market participants from the consequences of their own poor decisions?

ability to prevent crises warrants a decrease in the discount factor (as the component attributable to jumps in the fundamental,  $\lambda(1-y)$ , disappears): and in the numerical simulations below, we use the risk premium of 4.3% estimated by Cecchetti *et al* (2000) instead of 7.8% by Campbell (1999), in part to reflect the removal of the Poisson process.<sup>10</sup> But “meta moral hazard” will arise if Fed policy actions designed to avert or eliminate infrequent crashes (the Peso problem) are interpreted as a solid guarantee that stock values cannot fall far even in normal times; and the uprating in share values will be much magnified by the accompanying irrational beliefs, as discussed in the next section.

#### 4. Moral Hazard and Stock Price Bubbles: the ‘Greenspan Put’

Since there is no explicit role for monetary policy in our model, in which the real interest rate is constant, we simply assume that the observation of asymmetric monetary policy interventions leads investors to believe that there exists a floor under the market price, i.e., it is as if they have a put option insuring them against downside risks. As this put is available without cost, it must be priced into the stock market to characterise the asset prices under such asymmetric monetary policy. It can be shown that the resulting market valuation is as if there existed a “reflecting barrier” at some low level of dividends, i.e., as if policy makers could credibly limit the downside on corporate dividends (though the strong assumption that the put is fully credible is relaxed later.)

To simplify the analysis, let the current value of the market be the peak  $\bar{S}_t$ . If the stock price lies in the range  $(\eta\bar{S}_t, \bar{S}_t)$ , then its value is determined by equation (2), with general solution

$$V(D) = \frac{D}{r - \mu + \pi} + A_+ D^{\xi_+} + A_- D^{\xi_-} \quad (5)$$

where  $A_+$  and  $A_-$  are two constants to be determined, and  $\xi_+$  and  $\xi_-$  are the positive and negative roots of the quadratic equation

$$\frac{1}{2} \sigma^2 \xi(\xi - 1) + (\mu - \pi)\xi - r = 0 \quad (6)$$

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<sup>10</sup> Another possible reason for choosing a lower discount factor is that successful anti-inflationary monetary policy has reduced the scope for “irrational discounting”, where nominal rates are used to discount real dividends (Modigliani and Cohn, 1979). This argument has, however, been criticised on the empirical grounds that changing inflation expectations changes stock prices by altering real dividend prospects and not the discount factor (Fama, 1981). For more empirical evidence on the link between inflation and stock market valuation, see Lintner (1975), Fama and Schwert (1977), Firth (1979) and Schwert (1981).

where it can be shown that  $\xi_+ > 1$  and  $\xi_- < 0$ .

We characterise the solution to (5) conditional on a given value for  $\bar{S}_t$ , and in what follows we omit the time subscript. If stabilisation is assumed to occur when stock prices reach  $\eta\bar{S}$ , this implies the following ‘value matching’ and ‘smooth pasting’ conditions:

$$V(D_b) = \eta\bar{S}, \quad (7)$$

$$V'(D_b) = 0, \quad (8)$$

where  $D_b$  is the dividend level corresponding to the value of stock prices where investors believe the market will be stabilised.

But when the market goes up, no change of policy is expected. The appropriate upper boundary condition is

$$\lim_{D \rightarrow \infty} V(D) = \lim_{D \rightarrow \infty} \frac{D}{r - \mu + \pi}. \quad (9)$$

So if dividends become very large, the effect of the stabilisation at the floor dissipates.

The boundary condition (9) implies that  $A_+ = 0$ . Using (7) and (8), one can solve for both  $A_-$  and  $D_b$  to obtain the following value function

$$V(D) = \frac{D}{r - \mu + \pi} + \frac{\eta\bar{S}}{1 - \xi_-} \left( \frac{D}{D_b} \right)^{\xi_-}. \quad (10)$$

where  $D_b$  is given by

$$\frac{D_b}{r - \mu + \pi} = \frac{\xi_- \eta\bar{S}}{\xi_- - 1}. \quad (11)$$

It is clear from (10) that with stabilisation, the stock value will lie everywhere above its fundamental value given in (4). In particular, at the point of stabilisation, the stock value is

$$V(D_b) = \frac{\xi_- - 1}{\xi_-} \frac{D_b}{r - \mu + \pi}. \quad (12)$$

This solution values the market portfolio augmented by a perpetual put option.<sup>11</sup> Since, for plausible choice of parameter values the term  $(\xi_- - 1)/\xi_-$  is around 2, it is evident that stock

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<sup>11</sup> The solution for such a put option in a partial equilibrium framework is familiar from Samuelson (1967) and Merton (1973). Note that for simplicity we do not take into account the effect any future rise in the market beyond the previous peak may have on the expected floor under the market.

values can be substantially inflated by expectations of Fed intervention. (Explicit numerical examples to illustrate the extent of potential ‘over-valuation’ are provided below.)

More generally, where the level of dividends is  $x$  times the floor value of dividends,  $D_b$ , i.e.,  $D = xD_b$ , the stock market ‘overvaluation’ is a function of  $x$ . Specifically, the ratio of the market value inclusive of the put to its underlying fundamental value is given by

$$V(D)/V^F(D) = 1 - \frac{1}{\xi_-} x^{\xi_- - 1}, \text{ where } D = xD_b \text{ and } x > 1. \quad (13)$$

In the case discussed above where  $(\xi_- - 1)/\xi_- = 2$ , i.e.  $\xi_- = -1$ , the valuation ratio reduces to

$$V(D)/V^F(D) = 1 + \frac{1}{x^2}. \quad (14)$$

Equation (13) gives the expression for over-valuation for any given level of dividends (as long as  $D > D_b$ ). To find the over-valuation at the latest peak, we need to compute the corresponding dividend level (in terms of  $x$ ) at the latest peak. If we let  $x_p = D_p / D_b$ , evaluate the stock value (10) at  $D_p$  and notice that  $V(D_p) = \bar{S}$ , we obtain the equation for

$x_p$

$$x_p - \frac{1}{\xi_-} x_p^{\xi_-} = \frac{\xi_- - 1}{\xi_- \eta}. \quad (15)$$

Specifically, for  $\xi_- = -1$  and  $\eta = 0.75$ ,  $x_p = 2.22$ .

One way of looking at the over-valuation in the stock price is to use (13). Another way is to express it in terms of the apparently lower risk premium estimated by using Gordon’s formula given in (3), ignoring the value of the put. Backing out the risk premium in this way, using (13) we can express the implied risk premium as a function of  $x$ , namely

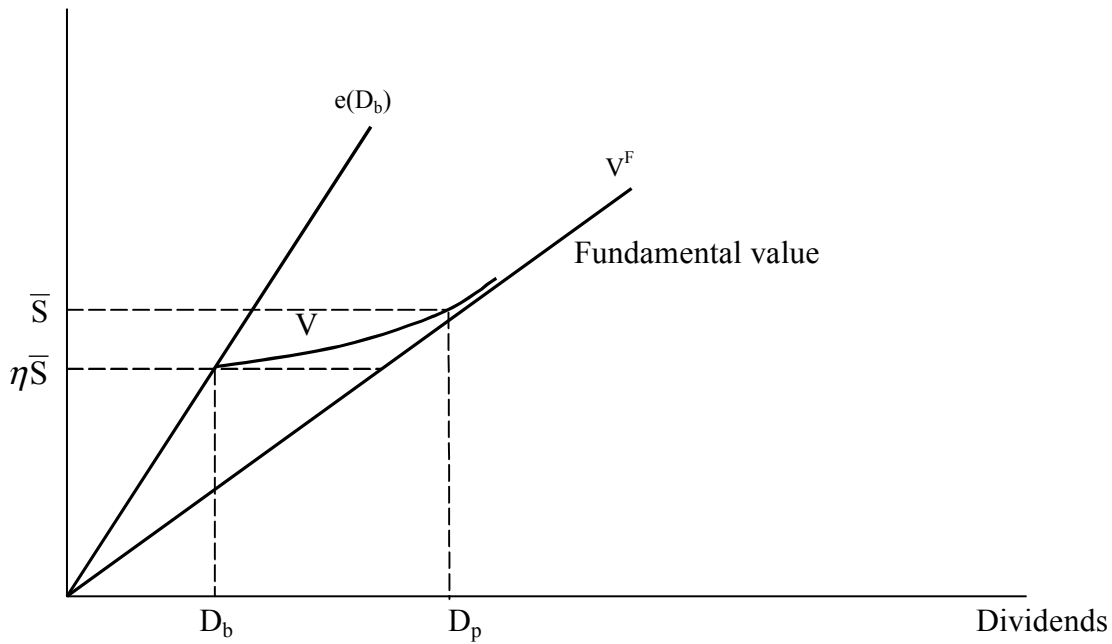
$$\pi_i(x) = \mu - r + \frac{r + \pi - \mu}{1 - x^{\xi_- - 1} / \xi_-}, \quad (16)$$

where  $\pi_i$  indicates the implied risk premium at  $x$  while  $\pi$  is the true risk premium and  $r$  is the real interest rate.

The solution for the stock price with an implicit put is illustrated in Figure 1 where the fundamental solution as in (4) is shown as the lower straight line from the origin. Given the previous peak of  $\bar{S}$ , the solution for the stock price in (10) is represented by the convex

curve  $V$ , which smooth pastes to a horizontal line where  $V = \eta\bar{S}$  and tends asymptotically towards the fundamental solution as  $D$  increases. From (11), it is obvious that all stabilisation points will lie on the steeper straight line  $e(D_b)$ . As the solution given in (10) is flat at the stabilisation points and steadily rises towards peaks, the stock price volatility is low when the stock price is low and increases as the stock price rises. (Note that the instantaneous variance of the stock price depends on the slope of the solution.)

Stock valuation



**Figure 1. Asymmetric monetary policy, moral hazard and stock price bubbles.**

The solutions given by (10), conditional on  $\bar{S}$ , technically exist for  $D > D_p$ ; but if dividends exceed  $D_p$  they will be setting a new peak, so the level of the perceived stabilisation should also be increased, i.e., the exercise price should ratchet up whenever the peak increases. Such “sliding puts” are very attractive and would reduce the observed risk premium even further (see Miller *et al*, 2000 for detailed analysis). For expositional purposes, however, we use a simple put in this paper.

As Figure 1 shows, insuring the market against down-side risk increases stock values and reduces the observed risk premium. Here we use numerical examples to illustrate the magnitude of these effects assuming the put is fully credible. The parameter values for the baseline case are as follows: the real interest rate  $r = 0.035$ , the true risk premium  $\pi = 0.043$ ,



the dividend growth rate  $\mu = 0.03$ , and the volatility of stock prices  $\sigma = 0.2$ . Stabilisation is assumed to occur when stock prices are 25% below the previous peak, so  $\eta = 0.75$ . To examine the sensitivity of the results, we vary  $\pi$  from 0.03 to 0.07,  $\sigma$  from 0.15 to 0.25,  $r$  from 0.025 to 0.045 and  $\eta$  from 0.5 to 0.75. Table 2 shows how risk premia and stock price overvaluation relative to fundamental market value vary with changes in  $\pi$ ,  $\sigma$ ,  $r$  and  $\eta$ . As the implied risk premia and stock price overvaluation depend on how far dividends are from the point of exercise, we provide values for  $x=1$ ,  $x=(1+x_p)/2$  and  $x=x_p$ , where  $x$  is the ratio of current dividends to their level at the point of exercise. To illustrate typical market overvaluation and the effect on the observed risk premium, we concentrate on the results for  $x=(1+x_p)/2$  (shown in columns 3 and 4) as they represent an average between peak and floor.

		At $x=1$		At $x=(1+x_p)/2$		At $x=x_p$	
		$\pi_i$	$V/V^F-1$	$\pi_i$	$V/V^F-1$	$\pi_i$	$V/V^F-1$
<b>Baseline</b>		<b>0.015</b>	<b>1.36</b>	<b>0.026</b>	<b>0.53</b>	<b>0.032</b>	<b>0.29</b>
Changes in $\pi$	$\pi = 0.03$	0.012	1.09	0.02	0.43	0.024	0.23
	$\pi = 0.07$	0.02	2.0	0.038	0.76	0.048	0.43
Changes in $\sigma$	$\sigma = 0.15$	0.019	1.01	0.03	0.39	0.035	0.21
	$\sigma = 0.25$	0.012	1.77	0.024	0.68	0.03	0.38
Changes in $r$	$r = 0.02$	0.02	2.12	0.028	0.80	0.033	0.44
	$r = 0.05$	0.01	2.04	0.025	0.40	0.032	0.21
Change in $\eta$	$\eta = 0.50$	NA	NA	0.033	0.26	0.038	0.11

**Table 2. Sensitivity of observed risk premia ( $\pi_i$ ) and overvaluations ( $V/V^F-1$ ) to parameter changes.**

In the baseline case (shown in bold in row 1) the effect of the put is to cut the observed risk premium by about 40% (to 0.026) and the stock price is over-valued by some 50%. At peak dividends, the observed risk premium is twenty-five percent below its true value and the overvaluation is 29% (as shown in the last two columns of the table). (This overvaluation is a good deal less than the estimates by Blanchard (1999) and Cecchetti et al. (2000) discussed in Table 1: if, however, as in Miller *et al* (2000) the downside guarantee is indexed to market peaks, the baseline overvaluation would increase substantially.)

Row 3 shows that the observed risk premium rises less than proportionately with the true risk premium, so overvaluation increases. As is familiar from option pricing theory, higher underlying volatility makes a put more valuable, so in row 5 the observed risk premium falls and stock price over-valuation increases with  $\sigma$ . Row 7 shows that a higher real interest rate reduces both the observed risk premium and the overvaluation. In row 8, we see that reducing the stabilisation floor  $\eta$  to half the previous market peak significantly reduces the overvaluation but increases the observed risk premium. (For  $x=1$ , percentage overvaluation is independent of  $\eta$ .)

These calculations can be criticised on two grounds. First, they assume that the Fed's intervention is fully credible; and second, they predict a positive correlation between stock price volatility and market value (contrary to the pattern of volatility observed in the market). The following two sections address these criticisms.

## 5. Imperfect Credibility

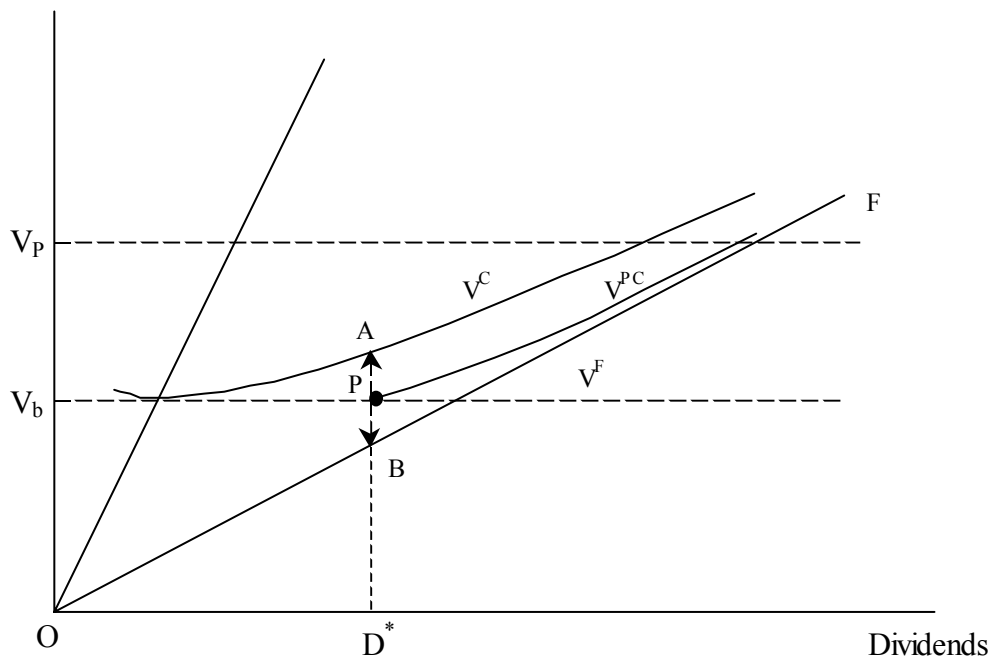
Ex ante investor uncertainty as to whether the Fed will act to stabilise the market will surely curb meta moral hazard. Take the case where the market has doubts about the Fed, but is willing to 'learn from stabilising' in that the exogenous ex ante uncertainty will be completely resolved by what happens the first time the market falls 25% below the previous peak. If the Fed acts, by cutting rates and pumping in liquidity to stabilise the market, then the market resolves to trust the Fed completely: if not, it loses all credibility.

We begin with the boundary conditions defining the solution, which is illustrated in Figure 2. Let  $V^F$  be the fundamental valuation in the absence of any put, and  $V^C$  be the fully credible solution derived in the last section, where  $V_p$  represents stock market value at the previous peak, and  $V_b$  the level at which central bank reaction is expected with probability  $\pi$ . The required solution  $V^{pc}$  must satisfy the differential equation in (2) above, with boundary conditions modified to take account of the jumps in valuation that will occur when fundamentals reach  $D^*$ , where  $V^{pc}(D^*) = V_b$ . At  $D^*$  the solution must satisfy an "expected value matching" condition

$$\pi V^C(D^*) + (1 - \pi)V^F(D^*) = V^{PC}(D^*) \quad (17)$$

For any positive  $0 < \pi < 1$ , this condition identifies  $D^*$  and provides the lower boundary condition for  $V^{pc}$ . The upper boundary condition requires that the solution should approach the fundamental solution  $V^F$  as  $D$  becomes large. But, because the put is less credible, it has less effect on stock prices, so the partially credible solution lies in between the fully credible solution and the fundamental solution.

Market value



**Figure 2. Partial credibility and asset prices.**

In the case illustrated, the probability of intervention is 0.5 and the point P where uncertainty is resolved lies midway between A on  $V^C$  and B on  $V^F$ . Were intervention less likely, the intervention point P would move to the right. In the limit, where there is no ex ante credibility ( $\pi$  is zero), the solution degenerates to the fundamental value  $OF$ .

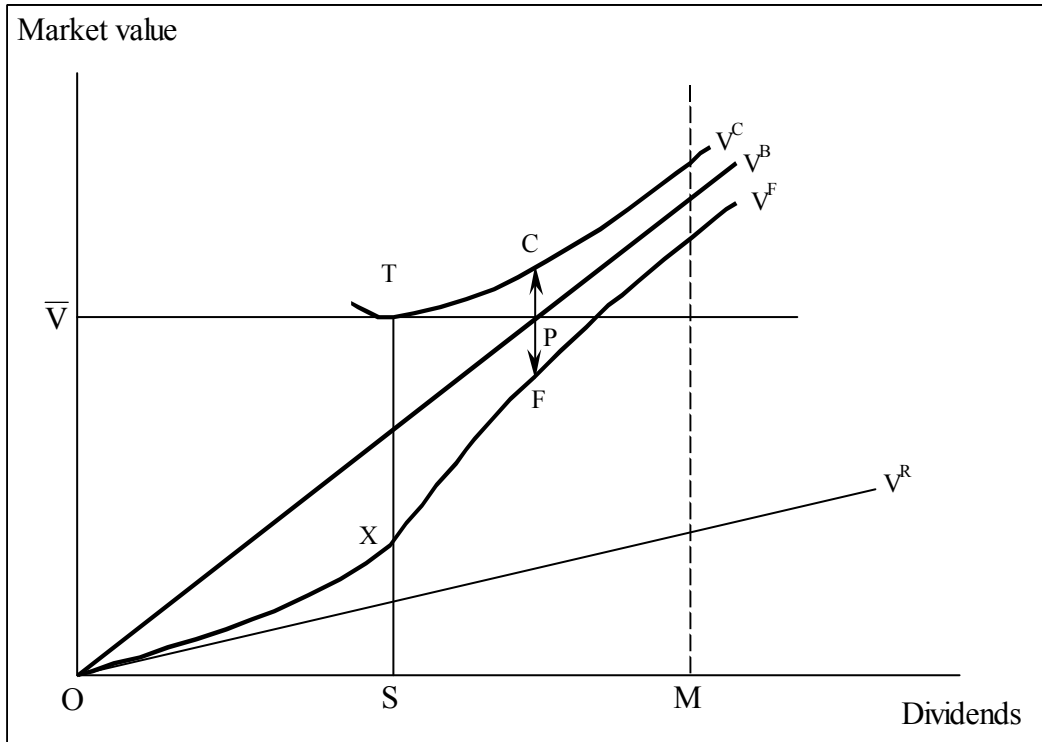
## 6. Habit persistence and asset price volatility

The account we have outlined faces an obvious challenge. It is well known that there is a tendency for stock price volatility to rise as the market falls. But even with partial credibility, our account implies that stock market value is a convex function of fundamentals, so volatility decreases on the downside. This is because we add convex put values to a linear fundamental value.

Campbell and Cochrane (1999) have proposed a theory of ‘habit persistence’ to explain a number of features of the data which present problems for standard asset pricing models. A key implication of their approach is that risk aversion is ‘state-dependent’, and investors become highly risk averse when times are bad. It also implies that asset values over some range are a concave function of fundamentals.

What happens if a put is added to stock held by investors with state-dependent risk aversion? Instead of working with the full complexity of the model of Campbell and Cochrane, we use a simpler approach to capture the key feature just mentioned. Specifically, we assume there are just two levels of risk aversion and an exogenous point at which consumers switch from one to the other.

To see how volatility increases as the market declines in this case, consider Figure 3. The schedules  $V^B$  and  $V^R$  value dividends using two different measures of risk aversion. The former uses the low measure characteristic of boom times, while the latter uses the high risk aversion characteristic of recessions. Assuming that investors’ risk aversion switches when dividends pass through the switch point labelled S, dividends will be valued as shown by  $V^F$  which starts tangent to  $V^R$  at the origin and diverges to approach  $V^B$  asymptotically as  $D$  goes to infinity. Note that while the value function is convex for dividends less than S, it is concave elsewhere, i.e., volatility will be increasing as dividends fall toward S.



**Figure 3. The “Greenspan put”, “habit persistence” and market volatility.**

Adding a fully credible put will generate convex market valuation, at least when exercise takes place when  $D \geq S$ . (For brevity, the shape of solutions when exercise takes place for  $D < S$  is omitted.) Consider first the boundary case where the market price at which optimal exercise occurs,  $X$ , is reached precisely when dividends fall to  $S$ , the switch point. The convex market valuation is shown as  $V^C$  in the figure, which is tangent to the strike price  $\bar{V}$  at  $T$  and approaches  $V^B$  asymptotically. Clearly, for strike prices higher than  $\bar{V}$  valuation will also be convex, with optimal exercise prices higher than  $X$ .

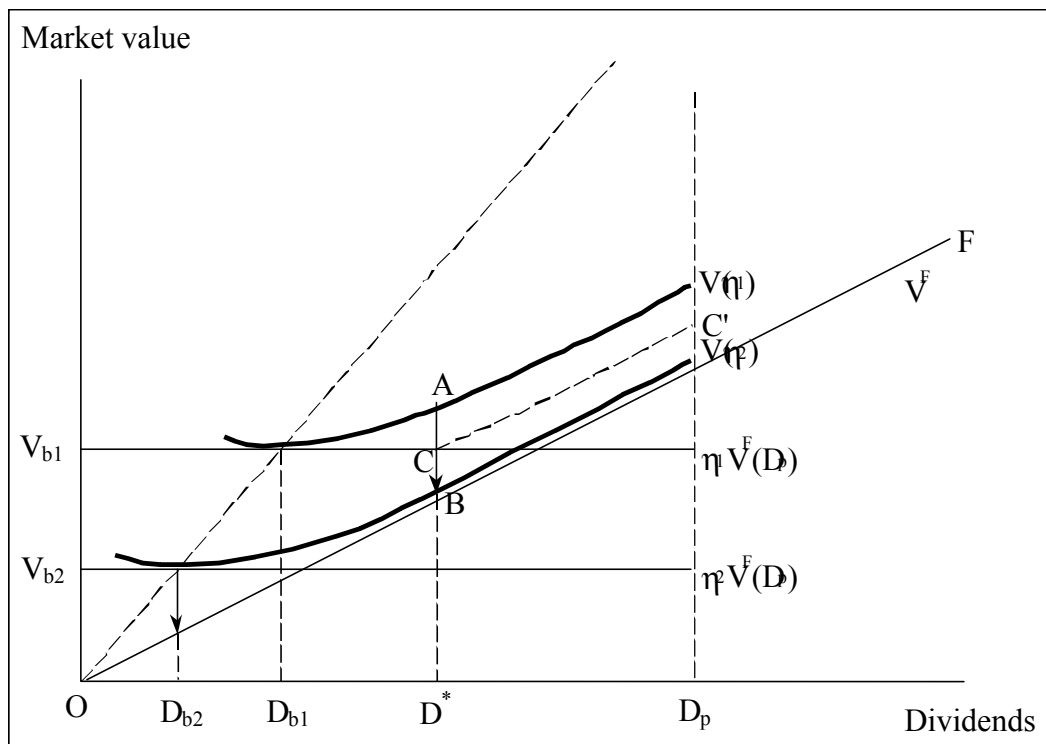
Consider asset values where dividends are at the level shown as  $M$  and action is expected at  $\bar{V}$  but its credibility is not assured. Start with the special case where asset valuation is a straight line and market volatility is constant. As is evident from the figure, appropriate choice of  $\pi^*$  will in fact generate  $V^B$  as the linear solution, where at  $P$  there is probability  $\pi^*$  of central bank stabilisation lifting asset values to  $C$ , but a  $1 - \pi^*$  risk of no action, with asset values falling to  $F$ . For intervention probability higher than  $\pi^*$ , asset values will be convex: but for probability less than  $\pi$  the solutions will be concave due to the concavity of the valuation function  $V^F$  for  $D > S$ .

Clearly, when fundamentals decline, there are two factors affecting market volatility. On the one hand, there is the positive effect of an anticipated increase in risk aversion implied by CC's theory of habit persistence. On the other, there is the prospect of central bank stabilisation policy which tends to reduce volatility. In the special case shown as  $V^B$ , these forces are exactly in balance. But a little less credibility will generate both the *increasing volatility* characteristic of out-of-the-money puts and the *overvaluation* associated with "meta" moral hazard. In other words, the simple example shows that overvaluation can be combined with a market "smile". It answers the logical objection raised earlier, but suggests the need to work with modern theories of asset valuation when analysing the effect of central bank policy on the stock market.

## 7. Some policy implications

One strategy for removing asset price overvaluation due to misperceived insurance would be for Mr. Greenspan to make an announcement that prices are irrational and that the market will not in fact be supported at any level. He could for good measure raise interest rates as well. The risk of doing this is that it would cause a stock market collapse -- and possibly substantial "overshooting" -- with adverse real effects. Cecchetti *et al.* (2000) note that both in the US in 1929 and Japan in the late 1980s the monetary authorities took deliberate steps to prick stock market bubbles -- with disastrous consequences. Are there alternatives?

Edison *et al.* (2000), in a model of collateralised borrowing, find that it is only bubbles *above a critical size* which have substantial real effects when they burst. This suggests that it might be better if shareholders were gradually to relinquish their false beliefs, learning from experience that the "insurance" was an illusion. Then the insurance bubble could disappear gradually instead of bursting all at once.



**Figure 4: The gradual disappearance of the Greenspan put**

How this might play out is illustrated in Figure 4. Ex ante, agents are uncertain about the level of insurance being provided. Specifically, they entertain two possible levels of price support shown as  $V_{b1}$  and  $V_{b2}$  in the figure (corresponding respectively to fractions  $\eta_1$  and  $\eta_2$  of  $V^F(D_p)$ , the fundamental value of the stock market at the previous peak). Assume these are equi-probable -- and that the truth will be revealed when asset prices fall to  $V_{b1}$ . Then stock market values will lie on the dashed line in the figure which satisfies equation (5) above and with the boundary conditions that  $A_+ = 0$  and that there is no expected capital gain or loss when asset prices reach  $V_{b1}$ , i.e. point  $C$  lies midway between  $A$  on the schedule  $V(\eta_1)$  and  $B$  on  $V(\eta_2)$  (where these schedules correspond to fully credible puts). As can be seen from the figure, the put vanishes in two stages. To start with, asset prices lie on the dashed line  $CC'$  until dividends reach  $D^*$  when prices fall from  $C$  to  $B$  as agents down-grade the perceived level of insurance from  $\eta_1$  to  $\eta_2$ . Then asset prices lie on  $V(\eta_2)$  until dividends fall to  $D_{b2}$  and the put finally vanishes, with asset prices dropping to their fundamental value (as shown by the arrow leading to  $OF$ ).

This is, of course, only a stylised example: there could a more general distribution of prior beliefs over  $\eta$  which are revised gradually as experience shows that the level of insurance is less than expected.<sup>12</sup> In any case, the private sector will gradually learn that no one is insuring their equity portfolios, an extended process which avoids sudden large crashes and mitigates the real effects of deflating an insurance bubble. This analysis of the disappearing “Greenspan put” predicts that markets will fall by more than is justified by deteriorating fundamentals as the overvaluation is corrected --- a process that may now be in train.

## **8. Conclusion**

Recent high values of US stocks can only be explained with a market risk premium far below its long-run historical level (see Table 1 above). We have shown how the estimated risk premium can fall dramatically when intervention policy by the Federal Reserve leads investors to believe that they are protected against substantial market falls -- as survey evidence indicates they do.

Calibrations are used to show that a fully credible “Greenspan put” could reconcile highly overvalued stock prices with unchanged attitudes to risk.<sup>13</sup> The more realistic case of partially credibility is discussed along with the strategy of gradually deflating an “insurance” bubble.

We do not want to claim, of course, that it is only mistaken beliefs about monetary policy and the power of the Federal Reserve that explain recent high valuations. It seems clear ex post that exaggerated New Economy effects on US growth led to a speculative bubble in technology stocks. There may also be good reasons why the ex ante risk premium has fallen -- better “crisis management”, for example, and more efficient distribution of risk (“financial engineering”).

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<sup>12</sup> Alternatively, it may be that the perceived extent of insurance is not independent of the sectors contributing to the market fall: if the “deductible” is higher for the high tech sector for example, market falls led by high tech stocks may go further before intervention is expected.

<sup>13</sup> Although these calibrations imply that asset price volatility falls as the stock market moves down, this counterfactual prediction is not, we believe, an essential corollary of our theory. If the put is not fully credible and there are factors generating state-dependent risk premia, then the put is consistent with implied volatility increasing on the downside.



By showing the powerful effect that changing perceptions of downside risk can exert on asset prices, we have strengthened the case for treating recent high asset valuations with suspicion. Like Shiller's, our "insurance bubble" involves market psychology: but what we describe is not so much "irrational exuberance" as exaggerated faith in the stabilising power of Mr. Greenspan and the Fed.

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