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A TALE OF FIVE BUBBLES — ASSET PRICE INFLATION AND CENTRAL BANK POLICY IN HISTORICAL PERSPECTIVE

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ABSTRACT

This paper examines five bubbles that eventually popped, and discuses the feasibility of central bank policy. In all cases, we find that monetary policy was too loose during the period when the bubble was developing, and that a determined switch from an accommodating to a tight stance caused "the music to stop". We argue that despite the severe real effects of asset bubbles in all five examples, the case for targeting them explicitly is weak. Policy was flawed because it failed to pay sufficient attention to the output gap. We also present a more formal test, showing that policy errors influence the conditional volatility of equity returns as estimated in GARCH-M models. The conclusion examines US policy today in the light of our historical findings.

1. Introduction

Should asset bubbles be pricked? In many countries, this is one of the most vexed questions for monetary policy makers. Having successfully conquered high inflation during the 1980s and 1990s, many central banks have been faced with the ambiguities of success (Krugman 1999). Rapid growth has often proceeded alongside remarkably tame inflation and sharp increases in asset values, especially equities. The level of the stock market and other asset markets is of obvious concern to monetary policy. Asset prices can influence real activity in a number of ways. Consumer confidence may receive a boost via the wealth effect. Investment may be directed into ultimately unproductive areas. Also, through its beneficial effect on household and firm balance sheets, higher asset prices will affect borrowing and real activity if there are frictions in financial markets. Higher volatility in asset prices can therefore lead to instability in the rest of economy. Bursting bubbles have a tendency to affect output and employment, sometimes severely; for these reasons, some authors have argued that central banks should target the asset prices – and the level of the stock market – directly (Kent and Lowe 1997).

At the same time, identifying existing bubbles, and differentiating them from rapid increases in asset values driven by a permanent improvement in fundamentals, is no easy matter. Even in such famous cases as the US stock market in 1929, academic debate has failed to agree on the existence or otherwise of a bubble. Irving Fisher's famous remark in 1929 that "stocks appear to have reached a permanently-high plateau" reminds us that, even to the most discerning economic minds, the evidence appeared to point the other way (Dice 1929). Even after the crash, Fisher maintained that the stock market had not been overvalued (Fisher 1930). In the case of Japanese stock market in 1989, it was apparently also not clear to contemporaries that a bubble had developed. The Economist, in one of its reports on the Japanese stock market in April 1989, argued that

> "Japanese investors have become aware of ... the dramatic way Japan's blue-chip companies have changed the sources of their earnings through restructuring. This has made their profits too erratic to give any meaning to rigid measures such as the p/e ratio. Instead investors have started to assess a company's future stream of earnings by looking at the total value of a firm's assets... The implication is that shares may be underpriced."

When the British economy was in the middle of a house price and stock market boom underpinned by the joint effects of financial sector deregulation and loose monetary policy, the Chancellor of the Exchequer, Nigel Lawson, was boasting about the arrival of a new economy (King 1999):

> "The strength and durability of the economic upswing has now exceeded all post-war records... The plain fact is that the British economy has been transformed. Prudent fiscal policies have given business and industry the confidence to expand, while supply side reforms have gradually removed the barriers to enterprise."

If contemporaries can get it wrong, and even the benefit of hindsight provides little guidance, monetary policy is presented with a conundrum. Hard landings have often gone wrong, but throttling growth without any apparent resurgence of inflation may be difficult to defend in public – especially when central bank independence is not complete. "Giving growth a chance" appears to be a frequent outcome.

Reluctance to raise rates when the economy appears to be in a non-inflationary boom has recently received support from academic quarters. Bernanke and Gertler (1999) run a number of simulations under different policy rules for the central bank. In addition to the traditional inflation-targeting approach, they also simulate the outcome for the overall volatility of inflation and output in the case when the central bank targets the stock market directly. For a wide range of parameters, they find that bubble-busting policy rules would amplify swings in asset prices, thus defeating the purpose of the exercise.

They also contrast the outcomes of two types of monetary policy, comparing the US in the 1990s with Japan in the 1980s. Bernanke and Gertler find that monetary policy in Japan was too loose for too long, and that the aggressive tightening under governor Mieno from 1989 onwards could probably have been avoided had policy paid sufficient regard to the rapidly falling output gap in the late 1980s. In the US, in contrast, they find that monetary policy responded rapidly and appropriately to changes in inflation and the level of economic activity; a repeat of the Japanese boom-and-bust cycle is unlikely. They therefore argue that direct targeting of the stock market is unnecessary as long as monetary policy follows orthodox inflation-targeting (Bernanke and Gertler 1999).

2. Monetary Policy during the five bubbles

We analyze five cases of "asset bubbles" that have justly become famous in the literature. Some of them are from the recent past; others are important historical episodes. We examine US and German policy during the 1920s as well as the cases of Japan, Sweden and the UK in the late 1980s and early 1990s. In each case, rapid increases in the price of stocks and/or real estate eventually came to a halt, only to be reversed sharply. Many authors have also argued that the decline in asset prices was directly or indirectly responsible for the economic downturns that followed.

2.1. Defining bubbles with the benefit of hindsight

There is no commonly accepted definition of a bubble (Kindleberger 1992). The New Palgrave describes them as periods of price increases, followed by a sudden and sharp reversal. There is also no widely accepted test that would confirm or refute the existence of a bubble in a particular case. Diba and Grossmann (1988) suggest that, in the case of a rational bubble, the first-order difference of stock prices will be non-stationary. Campbell and Shiller (1987) argue that, if dividends and stock prices fail to co-integrate, there is evidence of a bubble; a unit root in the price-dividend ratio implies "irrational exuberance" (Craine 1993). In almost all important cases, however, some authors have argued that there is no evidence of a bubble, while others have maintained that asset prices clearly diverged from fundamental levels.[1] Occasionally, the same authors appear to confirm one view, only to refute it the next year (Flood and Garber 1980). Hamilton (1986) argues that a variation on the "peso problem" may affect all bubble tests. If market participants anticipate a rare, but important event affecting fundamentals with a probability greater zero, then formal tests may show the existence of a bubble – even if there is none.

With the benefit of hindsight, we can bypass these problems by defining bubbles in terms of the magnitudes of asset price movements over a certain period of time. The exercise is in the spirit of Pagan and Sossounov (1999), who present a dating mechanism for bull and bear markets. We define bubble episodes as periods at the end of which asset prices fall by at least 30%, and do not recover their earlier peak for at least 5 years. We date the beginning of the bubble period as the point in time when prices first exceeded at which they later bottom out. The

[1] For the 1929 US stock market crash, cf. DeLong and Shleifer 1992 vs. Sirkin 1975.

country	US	Japan	Sweden	Germany	UK
peak	10-1929	12-1989	10-1989	12-1926	9-1987
trough	3-1932	7-1992	9-1992	4-1927	8-1992
start of bubble period	6-1926	8-1986	3-1986	2-1932	12-1986
total fall, peak to trough	78%	61%	55%	75%	31%

Table 2.1: Dating and characteristics of bubble episodes

period from the initial rise of asset values above the value reached at the lower turning point after the bubble "popped". Upper turning points require that the the level is not surpassed during the six months before or after. By this definition, there are five episodes which this paper will consider (table 2.1).

2.2. Monetary policy and the five bubbles

We employ the Taylor-rule as a yardstick for monetary policy. Taylor (1993) suggested that central banks should set interest rates according to the following rule:

$$r_t = r^f + \pi_t + g(y_t - y^*) + h(\pi_t - \pi^*)$$

where r_t is the short-term interest rate at time t, r^f is the long term real rate of interest, π^* is the inflation target, y_t is output at time t, y^* is the trend of output, and g and h are policy parameters. Taylor (1993) suggests $g = h = 0.5$ and $r^f = \pi^* = 2$. Simulation studies have found that sharper responses to increases in inflation, such as $h = 1$, may improve outcomes (Brayton et al. 1997). Perhaps because of its simplicity, the Taylor rule has become popular as a way of judging actual policy. Taylor (1997) examined US monetary policy over the period 1879 to 1997. Periods of low, stable inflation appeared to be systematically related to monetary policy following the Taylor-rule quite closely. How does the conduct of monetary policy during the bubble episodes compare with the Taylor rule?

2.2.1. The "roaring twenties" in the US

The Wall Street crash in 1929 is the canonical case of a bubble bursting with "a bang, not a whimper". While monetary policy during the Great Depression continues to be debated, the pivotal role of the stock market's boom and bust is not in question. Followers of the Temin-Bernanke school of thought argue that the indirect effects on confidence and balance sheets were in no small measure responsible for the speed and severity of the downturn in the early 1930s; the Friedman-Schwartz side of the argument emphasizes excessive monetary tightness.

Bubble busting was high on the list of priorities at the Federal Reserve. Following the death of governor Benjamin Strong in 1928, Adolph Miller pursued a policy of aggressive tightening combined with a deliberate targeting of stock market lending (Cecchetti 1996). All through 1928, the New York Federal Reserve Bank was trying to raise its discount rate, only to be turned down by the Board. The Fed's discount rate eventually moved from 3.5 percent in early 1928 to 6 percent in September 1929. Call money rates followed, rising from 4.78 percent in March 1928 to 8.6 percent a year later, before falling slightly to 7.2 percent in September 1929.

Figure 2.1 compares the course of interest rates with the prescriptions of the Taylor rule. By this yardstick, rates were too low for most of the 1920s. During the years 1925-27, interest rates should have been 200-400 basis points higher. Despite the tightening after the death of Strong, this is also true of the year 1929 itself. Only in 1928 was policy more or less on track. M2 (and, to a lesser extent, M1) continued to rise through 1928 and 1929. The reason for this was not a lax attitude towards inflation. The cpi for these years showed no indication of inflationary pressures; for most of the period, prices were falling at a modest rate. This was true despite very low unemployment (which fell to 3.2 percent in 1929). The variable that drives up the interest rate derived from the Taylor rule is the output gap. Compared to the long-run trend (derived from estimating a quadratic time trend on monthly data of industrial production for the years 1919-1985), the economy was growing much too quickly.[2] At its most extreme point, in 1929, the output gap is estimated at more than 10 percent of trend output.

Contemporaries were concerned with what they saw as loose policy. Friedrich von Hayek (1957, p. 161) argued that "up to 1927 I should have expected that the subsequent depression would be very mild. But in that year an entirely unprecedented action was taken by the American monetary authorities [who] succeeded, by means of an easy money policy ... in prolonging the boom for two years beyond what would otherwise have been its natural end."

Hayek is referring to the brief episode in 1927 when the Fed lowered its discount rate by half a percentage point, largely in response to the Bank of England's

[2] The use of industrial production in the estimation of output gaps is standard in the literature (cf. Clarida, Gali and Gertler 1998).

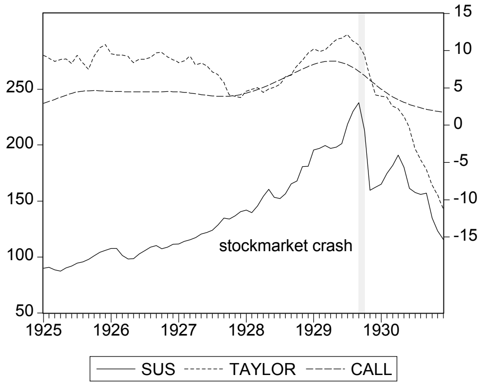

Figure 2.1: Monetary policy and the stock market, US 1925-30

shortage of gold reserves (Eichengreen 1992, p. 212). The Fed's loosening was facilitated by what appeared to be the onset of a recession. Between May and November 1927, US industrial production fell by 11 percent. What underpinned the rapid resumption of growth thereafter was in part the cut in interest rates. Eichengreen suggests that the Fed's actions as a result of international policy co-ordination were a success, keeping Britain on the gold standard. He also argues that "not one iota of evidence exists that this policy [raising rates in 1927] would have moderated the recession when it ultimately came".

The rapid expansion of output, combined with no inflationary pressures, was hailed as the birth of a "new economy". With new production techniques such as assembly lines and new industrial sectors such as automobiles surging ahead, there appeared little reason to doubt the foundations of the new prosperity.

The consequences for asset prices, however, were not benign. As figure 2.1 shows, the index of common stocks continued to surge during the period when monetary policy was too lax. Margin loans in particular grew apace immediately before the crash.

The debate between the Board and the Federal Reserve Bank of New York at the time was couched in the terms of "targeting speculation". It appears that surging equity prices were, however, only a messenger of misguided economic policy. The case for tightening could have been made entirely on the basis of the surge in output and the rapid decline in the pool of employable labor. In the absence of clear warning signs from the inflation rate, the Fed decided to wait and see; at the same time, the temporary combination of low inflation and rapid output growth stimulated the belief in a "new paradigm."

What was responsible for the benign inflation outcome at a time when capacity utilization increased rapidly and employment surged? The collapse in international commodity prices in the second half of the 1920s has often been noted. It is also partly responsible for the lack of inflationary pressure in the US paradox. The price of nonfood agricultural raw materials declined by one third between 1925 and 1929; the price of minerals and other raw materials fell even more sharply (Eichengreen 1992, p. 278-85).

What our narrative suggests is that the probability of any one country 'catching a bubble' is related to the way monetary policy is conducted. We implicitly assumed that there is an optimal policy for each country, which we do not observe directly. Instead, we use a simple rule devised by Taylor to suggest appropriate interest rates, and compare these with actual outcomes.

If our argument is correct, the probability of creating a bubble should be directly related to the mismatch between actual and implied interest rates. We define a measure of policy failure as the absolute difference between the actual interest rate and the level implied by the Taylor rule.

$$G_t = r_t - [2 + \pi_t + 0.5(y_t - y^*) + 0.5(\pi_t - 2)] \tag{2.1}$$

To what extent is the birth and continued existence of a bubble related to the degree of policy failure? Table presents logit regressions using G_t as an explanatory variable.C is a constant and q_t is output growth. In the US over the period 1923-1938, a bubble was more likely to develop when inflation was low, and when the interest rate implied by the Taylor rule was above the actual short-term interest rate (in this case, the call rate). Industrial output growth appears to have had no systematic effect on the likelihood of a bubble forming. Also, higher inflation appears to have reduced the chances of a 'irrational exuberance' taking hold.

2.2.2. Germany's golden twenties

Interwar Germany experienced a brief boom after the hyperinflation and the Great Depression. The slump came early – industrial production already turned down in 1928, not to recover before 1936 (Wagemann 1936). The hyperinflation had caused a major discontinuity in the institutional setup of central bank. With stabilization in 1923, the Reichsbank became independent. The second half of the twenties witnessed numerous clashes between the Reichsbank's flamboyant

regression	1	2	3
C	-1.4*	-1.4*	-2.2*
G_t	0.098*	0.1*	0.33*
q_t		5.5	0.63
π_t			-0.69*
% correctly classified	67.1	68.3	71.7

Table 2.2: Logit regressions, US 1923-1938

president, Hjalmar Schacht, and various governments, attesting to the fact that the central bank was indeed free from political meddling.

The German stock market experienced a brief boom after the hyperinflation. While prices surged to astronomical levels, equity was remarkably cheap, partly as a result of political uncertainty (Bittlingmayer 1998). On one day in 1923, all of Mercedes-Benz could have been bought for the price of 237 of its cars. When the currency stabilized, equity values surged. The boom was briefly interrupted by an economic downturn in 1926, which lasted less than a year. Thereafter, stocks resumed their upward movement, to the dismay of the Reichsbank. In 1927, it decided that enough was enough. As well as (eventually) raising interest rates, it leaned on the banks directly to curtail margin lending. When they went public with their agreement to cut lending to brokers and investors by 25 percent over the next few months, the market quickly collapsed.

Stock market returns were high in Germany prior to "Black Friday" – the stock market index increased by 164 percent between December 1925 and April 1927. Nonetheless, it remains doubtful if stocks were markedly overvalued. What largely brought valuations back into line despite strong returns was the sharp fall in interest rates, especially during 1926 (Voth 1999). In December 1925, when the run-up in stock prices got underway, the Reichsbank began to lower the discount rate of 9 percent. One year later, it had been cut to five percent. It was only at the time of the crash that monetary policy became significantly tighter. With output recovering strongly from late 1926 onwards, figure 2.2 shows that monetary appears to have remained too loose for too long. Estimating an output gap for Germany is difficult because of the disruptions of two world wars, the hyperinflation, as well as changes in the Reich's borders. To derive the interest rate from the Taylor rule, we used the normal procedure of comparing actual output to a quadratic trend for the period 1880 to 1962. This suggests that there was no output gap in 1927 – industrial production had surged by 26 percent

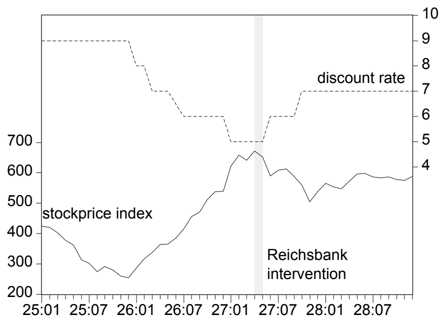

Figure 2.2: The German Stock market and Reichsbank discount rate, 1925 - 1928

year on year, and was 18.8 percent higher than in 1913 (Hoffmann 1965, p. 390-5). Inflation was increasing. While, in the middle of the mini-recession in 1926, the consumer price index increased by 0.25 percent p.a., inflation rose above 4 percent in 1927. The number of Germans in employment was growing strongly, and investment was surging (Balderston 1992). The Taylor rule consequently implies relatively high rates – an average of 9.5 percent for 1927. Instead, the Reichsbank started the year with an interest rate of 5 percent, and had tightened by 200 bp by the end of the year. Our analysis suggests that interest rates should have been tightened further, by an additional 200 basis points, before the stock market "bubble" was pricked by the Reichsbank's intervention.

If our calculations are affected by the country's tumultuous history and the resulting data problems, how large would the error have to be to justify Reichsbank policy? To derive an interest rate of 5 percent from the Taylor rule, the output gap would have had to be 4 percent; an interest rate of 6 percent would have required a gap of 2 percent. It is hard to see how Germany could have increased output on such a scale without fanning the flames of inflation.

2.2.3. Japan's bubble years

Over the years 1983 to 1989, the Topix index of stock prices more than quadrupled. Inflation was low over the period, barely broaching the 3 percent level in 1989. Over the period most often described as the "bubble years" (1986-89), average cpi inflation was a mere 1.2 percent (as compared to 2.9 percent during the five preceding years. The decline in oil prices was largely responsible, reducing

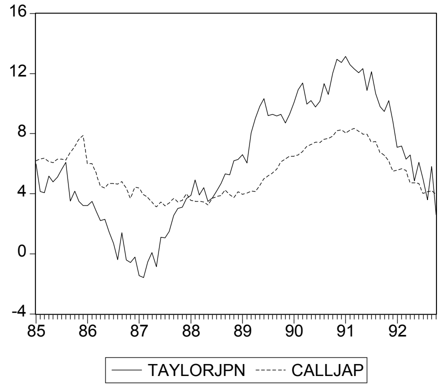

Figure 2.3: Japanese monetary policy 1986-1992

regression	1	2	3
C	-1.01*	1.16*	0.34
G_t	0.005	0.39*	0.3*
q_t			22.5*
π_t		-1.43*	-1.36*
% correctly classified	60.9	68.7	73.4

Table 2.3: Logit regressions, Japan 1983-1995

inflation to negative levels in 1987. At the same time, money growth (M2) accelerated, from around 5 percent in 1983 to 11.5 percent in 1988, before dropping slightly.

Figure 2.3 shows that monetary policy was relatively tight for a significant part of the so-called bubble years. From late 1987, however, the central bank kept interest rates significantly lower than the Taylor rule suggests. Output growth was clearly unsustainably rapid. Between the middle of 1987 and early 1989, industrial output surged by 20.4 percent, equivalent to 13% annualized growth. This was despite the fact that Japan appeared to be close to full capacity in 1987 already.

As in the US and Germany, there appears to be a systematic relationship between the size of the policy mistake committed by the monetary authorities and the chances of a bubble developing. This is most readily apparent once inflation is added to the logit regression (table 2.3). As in the US, lower inflation and rapid output growth increased the dangers of a bubble.

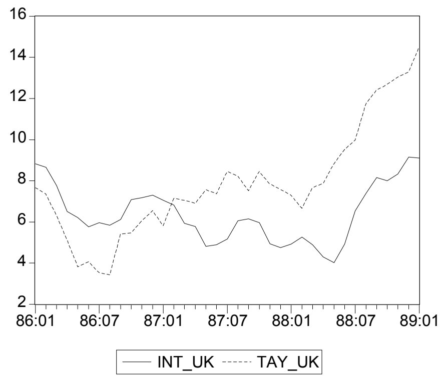

Figure 2.4:

regression	1	2	3
C	-3.6*	-3.1*	-3.81*
G_t	-0.23	-0.19	-0.21
q_t			37.9*
π_t		-0.9	-0.14
% correctly classified	87.9	87.9	88.4

Table 2.4: Logit regressions, UK 1983-1995

2.2.4. The UK in the 1980s

The UK bubble is unusual compared to the other episodes in our sample. The total fall in the index is markedly smaller, and the bubble period lasted less than a year. In its wider context, the bubble is best remembered for its effect on the housing market. Some studies make no mention of the UK stock market at all (King 1999).

We dated the beginning of the bubble in the UK from the end of 1986. This is indeed the point in time when monetary policy begins to become too expansionary, as compared with the Taylor rule. However, after the bubble pops, there is no change in the Bank of England's behaviour, which supplies liquidity to the financial system to avoid a credit crunch (as did the Fed in 1987). The housing bubble, which only deflated in 1989, has often been seen as a result of this policy (King 1999).

In the case of the UK, the logit regressions fail to show a significant link

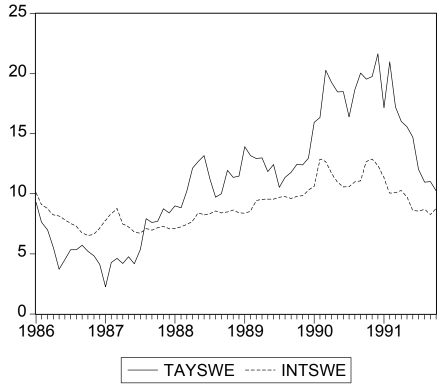

Figure 2.5: Swedish monetary policy 1986-1992

between policy mismatch and the rise of a bubble. As noted before, the bubble was perhaps too small (and lasted for too brief a period) to be analysed in this fashion.

2.2.5. The Swedish bubble

Sweden experienced a rapid rise in share prices at almost exactly the same time as Japan; also, the fall in prices was almost equally severe, bringing down the AFGX index by 55 percent from its peak in October 1989 to the trough in September 1992. Initially, strong output growth went hand in hand with low inflation. From the second half of 1987 onwards, Swedish interest rates were markedly lower than the Taylor rule would have suggested. For the entire period until the end of the bubble in 1989, monetary policy was not tight enough.

It also continued to be relatively loose after the stock market collapse; rising inflation (reaching a peak of 13 percent in 1991) was the inevitable outcome.

Just as in the case of Japan, the policy mismatch measure only becomes large and significant if inflation is included in our regressions. Strong output growth is negatively related to the chance of a bubble developing (presumably because rising asset values are underpinned by improvements in fundamentals), and higher inflation also undermines the chances of asset prices rising rapidly, only to collapse shortly thereafter.

regression	1	2	3
C	-0.828*	1.83	2.5*
G_t	0.015	0.21*	0.27*
q_t			-35.6*
π_t		-0.365*	-0.44*
% correctly classified	58.4	61.43	62.32

Table 2.5: Logit regressions, Sweden 1983-1995

3. Policy reaction functions

In the previous section, we essentially compared monetary policy across a range of countries and periods that allegedly exhibited a "bubble" with the prescriptions of the Taylor rule. It is now time to present a more formal test of policy failure. We proceed in two steps. First, we estimate policy reaction functions that describe the actual conduct of monetary policy during the periods of asset price inflation. Second, we augment the standard policy functions with stock prices to see if, during the episodes analyzed in this paper, the central banks appeared to have targeted the level of equity prices directly.

A general result of the simple comparisons in section 2 was that interest rates were kept too low during the run-up in asset prices. Since most of these episodes coincided with low inflation, it is possible that central banks did not pay sufficient attention to the general state of the economy. By remaining preoccupied with inflation as such, and by not reacting to indicators of future inflation such as the output gap, central bankers would have effectively taken their eyes off the ball. To examine if this interpretation is correct, we estimate Taylor-style reaction functions. The main difference is that, following Clarida, Gali and Gertler (1998), we estimate forward-looking functions:

$$r_t = \alpha + \beta E\pi_{t+1} + \gamma\left(y_t - \widehat{y}\right) + \varepsilon_t \tag{3.1}$$

where E is denotes expectations. We assume that central banks attempt to forecast over the next six months.[3] Following Bernanke and Gertler (1999), we also add stock prices to our reaction functions to examine if this has a major effect.

[3]Replacing the $E\pi_{t+1}$ with its actual realization will leave our results unaffected as long as the forecast error has zero mean.

	1	2	3
β	0.09*	0.11*	1.27*
γ		-0.1	0.1*
δ			4.95*
α	5.2*	5.4*	0.99*
R^2	0.14	0.14	0.9

Table 3.1: Policy reaction functions, US 1925-29

3.1. Interwar US

Taylor (1999) demonstrated that the standard approach to estimating policy reaction functions can be applied to the gold standard period as well. This is especially true of the United States, which acted as an 'anchor' country for the interwar gold standard.

For the period 1925-1929, there appears to be no inflation-targeting at all. Equation 1 in table 3.1 suggests that the Fed kept interest rates at 5.2 percent on average, and did little or nothing to raise them in response to changes in inflation. The output gap also has no effect on interest rate policy (eq. 2). More familiar parameter estimates are only returned once explicit targeting of the stock market is taken into account (eq. 3). Instead of being almost completely unresponsive to changes in inflation, the Fed now appears as reasonably aggressive, raising real interest rates by 27 basis points once inflation increases by one percentage point. Note, however, that even this result is not true uniformly over time. Recursive estimates of β demonstrate that the Fed only showed a response larger than unity from late 1928 onwards; before that date, it failed to tighten sufficiently to keep real rates from falling whenever inflation increased.

Targeting the stockmarket directly apparently did little to stabilize either the course of output or prices.

3.2. UK

For the period 1983-96 as a whole, the Bank of England appears to have been relatively tough on inflation. Even if it did not raise interest rates by 150 bp for every 1 percentage point rise in inflation, as the Taylor rule would suggest, it more than compensates for changes in inflation. As the recursive estimates of β in figure 3.2 make clear, this is largely a recent development. While initially relatively tough – at least stabilizing real interest rates – monetary policy was

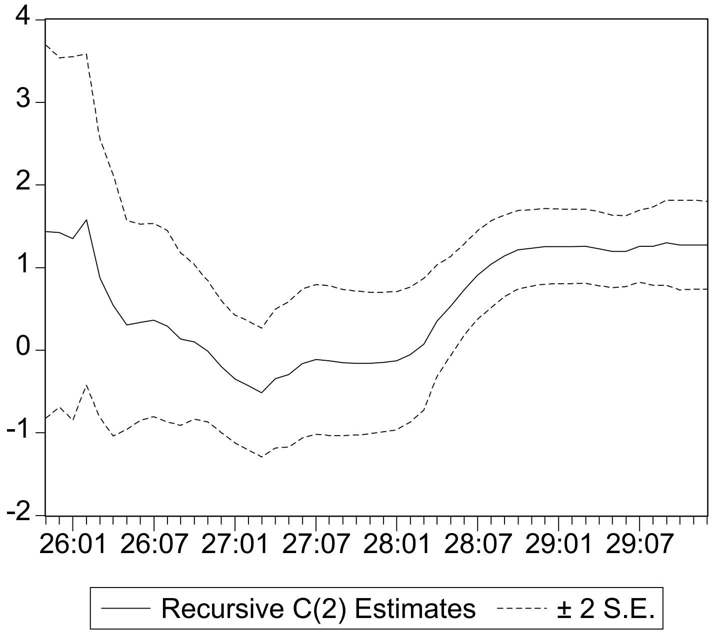

Figure 3.1: Recursive Estimates of β,US 1925-29

	1	2	3	4
β	1.04*	1.14*	0.98*	0.65*
γ		-0.19*	-0.07	0.24*
δ				-3.43*
α	5.1*	4.67*	2.95*	3.05*
λ			0.39*	0.46*
R^2	0.61	0.64	0.7	

Table 3.2: Policy reaction functions, UK 1982-1996

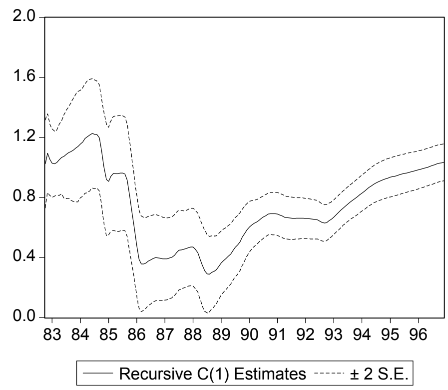

Figure 3.2: Recursive estimates of β,UK 1982-1996

very weak before and during the bubble period. It is only after both the stock market and the housing bubble have deflated that β returns to values not too far below unity.

The reaction to falls in the output gap is also relatively muted. There is no clear evidence that, in reaction to output rising above trend, the Bank of England would have raised rates. Only in the final specification (4), which implies a negative response to rising equity values, is there any suggestion of countercyclical policy.

3.3. Japan

Bernanke and Gertler (1999) report policy response functions for Japan for the period 1979 to 1997. They find that, overall, the Bank of Japan was actively trying to "lean against the wind", raising interest rates by 221 basis points for every percentage point rise in interest rates, and by a further 20 bp for every percentage point increase in the output gap.[4] They also document that policy seems to have reinforced the asset price explosion – for every ten percent increase in stock prices, interest rates were lowered by 286 bp. This is, in all probability, not the result of actual preferences of the Bank of Japan; rather, it seems to have lowered rates in response to other factors (such as the Plaza Agreement on

[4] We find that, for the period 1983-89, the response of the bank to inflation and the output gap was much lower. Bernanke's and Gertler's results may partly be driven by observations at the beginning of their sample period, when output and interest rates moved sharply.

	1	2	3	4
β	0.54*	0.76*	0.27*	0.08*
γ		-0.08*	0.19*	0.22*
δ				-1.56*
α	7.74*	6.18*	5.18*	12.01*
λ			0.66*	0.7*
R^2	0.53	0.61	0.63	0.80

Table 3.3: Policy reaction functions, Sweden 1982-1996

exchange rate targets), thereby unwittingly acting to loosen monetary policy at the very time when a stock market bubble was forming.

3.4. Sweden

In the case of Sweden, policy appears to have reacted only weakly to inflation; interest rates were high generally, and a one percent rise in inflation never elicits a response of at least 100 bp by the central bank. This implies that in booms, interest rates will be too low, and a rise in inflation causes real rates to fall. Specification 2 shows that this problem appears to be compounded by an implied negative response to the output gap. The former chairman of the Fed, Martin, once said that the aim of good monetary policy should be to take the punchbowl away when the party began to get going. The Swedish policy reaction functions suggest that, instead of taking the bowl away, the Swedish central bank was more prone to add a bit of gin to the punch. Regression 3 offers one explanations for why this seemingly perverse behaviour occurred. When we add German short-term interest rates (with coefficient λ) to our specification, it proves a good predictor of Swedish rates. The response to inflation is still too low, but once we control for the effect of German interest rates, there is a positive response to the output gap. The final specification adds stock prices to our policy reaction function. Just as in the case of Japan, where Bernanke and Gertler (1999) found a negative response to increases in stock prices, the our reaction functions imply a systematic tendency to lower rates in the face of a stock market boom.

4. A formal test

What our results suggest so far is that asset price volatility may be significantly related to policy errors. In particular, our historical case studies suggest that an inability to raise interest rates sufficiently when output is above trend may facilitate the growth of bubbles. Both the run-up in equity prices and the subsequent bursting of the bubble increase volatility.

To test this hypothesis formally, we estimate GARCH-M models of the conditional return volatility in equity prices. GARCH models have the benefit of capturing intertemporal volatility-clustering (Engle and Bollerslev 1986, Engle and Ng 1993). Since investors expect to be be compensated for holding risky assets, GARCH-M models have become popular (Elyasiani and Mansur 1998); they are also straightforward in their application to national stockmarkets (Choudhry 1996). They incorporate the conditional variance into the return equation

$$y_t = \phi x_t + \delta \sqrt{h_t} + \varepsilon_t \tag{4.1}$$

$$h_t = \omega + \sum_{j=1}^{p} \beta_j h_{t-j} + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2 \tag{4.2}$$

where y is the stock return, x and z are a set of exogenous variables, ε is a random error, h is the conditional variance, and ϕ, δ, ω, β, and α are coefficients to be estimated. A significant α implies the presence of ARCH. Returns are driven by a set of exogenous variables and the conditional variance. δ is a measure of the "price of risk". If our argument is correct, then including a measure of policy failure, as proxied by the divergence between the interest rate set by a superior policy rule and actual levels, should enter equation 4.2 significantly.

We estimate GARCH-M(1,1) models for each country seperately, augmenting equation 4.2 to give $h_t = \omega + \gamma |G_t| + \sum_{j=1}^{p} \beta_j h_{t-j} + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2$ where γ measures the extent to which the variance is influenced by inept monetary policy (from eq. 2.1). If our argument is correct, $\gamma > 0$.

For four out of five episodes – including the recent experience in the US – there appears to be a systematic impact of policy failure on the volatility of equity returns. The effect was particularly strong in the US in the interwar period (where its effect is estimated at ten times its magnitude in the US today) and in Sweden in the 1980s. Note that the consequences of policy errors appear unaffected by the extent to which volatility of returns is clustering intertemporally. While $\alpha + \beta$

	UK 1981-1997	US 1980-1999	US 1925-33	Sweden 1982-1999	Japan 1984-1998
α	0.13*	1.12*	0.42*	0.19*	0.009
β	0.82	0.174*	0.09*	0.38	0.93*
γ	0.00004*	0.00008*	0.0008*	0.00019	0.00009*
ω	0.00003*	0.00027*	0.00004	0.001	0.000021

Table 4.1: GARCH-M(1,1) estimates

is close to unity in the cases of the UK, Japan, and the US in 1980-99, it was far below that value in Sweden and the US in the interwar years.

5. Conclusion: A look at US policy 1996-99

If one lesson emerges clearly from our case studies, it is that a failure to account for the output gap increases the danger of bubbles in asset markets developing. The tendency to "give growth a chance" is ultimately self-defeating, partly because new eras driven by rapid increases in productive potential are few and far between.

The US today shows strong similarities with our case studies in four respects. Growth has been unusually strong over the last 3 years, inflation has been low, and asset prices have surged. Also, over the last two years, monetary policy appears to have been too loose. As in the case of Japan, the US in the 1920, Sweden and the UK, the main reason for this is a failure to account for the decline in the output gap.

During Alan Greenspan's tenure, monetary policy appeared to have followed the Taylor rule to a surprising extent. Taylor (1999) argues that the higher responsiveness of monetary policy to both inflation and output growth during the period 1987-97 was crucial for the lower level and greater stability of inflation.

Figure 5.1 suggests that policy has changed significantly after 1996. While low inflation suggested that rates should not be raised, the growing output gap suggests that policy should have been tightened sharply after 1996. The failure to raise rates aggressively – partly as a result of the Asian crisis in 1998 – has left monetary policy too loose for a substantial period. This is exactly the combination of factors that underpinned earlier asset bubbles with their associated boom-and-bust cycles.

To examine if policy has indeed changed, as figure 5.1 suggests, we estimate

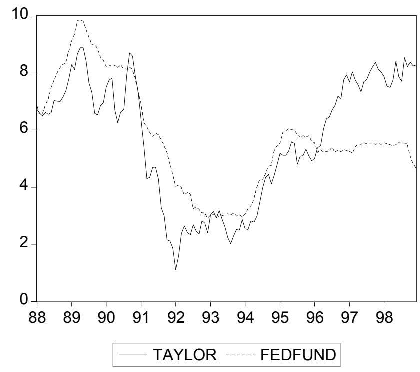

Figure 5.1: Federal Funds Rate and the Taylor Rule, US 1988 - 1998

coefficient	**1987:10-1996:01**	**1987:10-1999:10**	**1994:01-1999:10**
α	1.71*	0.43*	3.49*
β	1.48*	1.61*	0.57*
γ	0.42*	0.21*	0.07*
R^2	0.88	0.78	0.18

Table 5.1: OLS estimates of policy reaction functions

reaction functions for three periods, 1987:10 (when Greenspan took the reigns at the Fed) to 1996:01, 1987:10-1999:10, and 1994:01-1999:10, where α is the intercept, β the response to inflation, and γ the coefficient on the output gap.

A number of changes are apparent. First, the reaction to the output gap is getting progressively weaker. Over the period 1994-99, a rise in the output gap of 1 percent lead to a tightening of monetary policy by a mere 7 basis points. Second, the reaction to increases in inflation has also become much weaker. Note that, for $\beta < 1$, $\alpha > 2$ for policy to stabilize at all (assuming a real interest rate of 2 percent). For the period 1994-99, we find that policy is still stabilizing overall despite the weak responses to inflation and the output gap, but only because α is relatively high. There appears to be a "new economy" paradigm in US monetary policy, given the way interest rates have reacted to inflation and output growth. If the real interest rate has not increased, the resulting shift in the implied equilibrium inflation rate is considerable. Figure 5.2 shows how much the implied

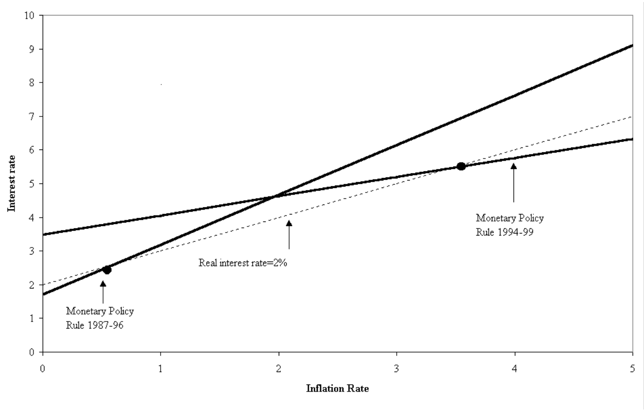

Figure 5.2: Implied target level of inflation

target rate of inflation has shifted over the past five years. While policy for the period 1987-96 points to a target rate of less than 1 percent, the conduct of the Fed over the past 5 years suggests an implied rate of approximately 3.5 percent.

A Chow breakpoint test for 1996:01 yields an F-statistic of 29.8, sufficient to reject the null of no breakpoint at the 99% confidence level. This is not to say that underlying central bank preferences necessarily changed markedly. For most of the period until 1996, output was below trend. If the central bank implicitly tries to "give growth a chance", it will not respond symmetrically to positive and negative output gaps. To test for this possibility more formally, we construct two variables, Δy^+ and Δy^- for periods when actual output is either above or below trend

$$\Delta y^+ = \begin{cases} y_t - y^* & \text{for } y_t - y^* > 0 \\ 0 & \text{for } y_t - y^* \leq 0 \end{cases} \tag{5.1}$$

with Δy^- constructed analogously. We estimate coefficients γ_1 and γ_2 for output gaps Δy^+ and Δy^- in the policy reaction functions. A simple measure of monetary policy bias is then $\phi = \frac{\gamma_1}{\gamma_2}$. If central banks act equally against falls in output below trend as they act against a surge above trend, $\phi = 1$; $\phi < 1$ implies that policy is more concerned with checking falls in output then it is with curtailing excessive output growth. For the US for the period 1987:10 to 1999:10, we obtain the estimates in table 5.2.

During downturns, the Fed brought down interest rates by 38 basis points for

coefficient	1987:10-1999:01
α	1.53*
β	1.47*
γ_1	0.11*
γ_2	0.38*
R^2	0.83

Table 5.2: OLS estimates of asymmetric policy reaction function

coefficient	1987:10-1999:9	1987:10-1999:9
α	0.5*	0.99*
β	1.58*	1.54*
γ	0.25*	0.28*
δ	-0.172*	
δ_1		-0.051*
δ_2		0.018
R^2	0.76	0.78

Table 5.3: OLS estimates of policy reaction functions

every increase in the output gap by 1 percentage point, a relatively sharp response (even if it is still markedly below the 50 bp implied by the Taylor rule). During expansions, output growth above trend only causes an increase in the bank's rate by 11 bp. This implies $\phi = 0.28$; during periods when output is above trend, the Fed reacts with an interest rate move less than one third the size of that witnessed during recessions.

Recently, some authors have suggested that a US-bubble today may partly be underpinned by investors believing that the Fed will cut rates quickly if equity prices fall. This would allow them to exit without all capital gains accrued so far evaporating. In effect, asymmetric policy responses by the central bank would give investors a put option, allowing them to sell their shares at a fixed discount to the current market level (Miller et al. 1999). To test for this possibility, we apply the same method as was used for asymmetric output gap responses. We estimate $r_t = \alpha + \beta\pi_t + \gamma(y_t - y^*) + \delta_1\,(s_t - s^*) + \delta_2\,(s_t - s^*) + \varepsilon_t$, where s_t is the level of the stock market index (for the US, the index of common stocks traded on the NYSE) at time t, and $*$ denotes the long-term trend value of a variable. δ_1 and δ_2 are constructed analogously to γ_1 and γ_2.

US policy appears to respond *negatively* to increases in stock prices (controlling for the effects of inflation and the output gap). The second column shows that, while there appears to be some tendency for the Fed to lower rates during periods when share prices slump, the same is true for periods when they surge above trend.[5] Not only is there no evidence of the Fed targeting asset prices, but its policy appears to act perversely during bull markets. For every percentage point that stock prices rise above their long-term trend level, interest rates are reduced by 5 basis points. Note that this is an exact parallel with other periods when bubbles were allowed to develop, such as in Japan during the late 1980s (Bernanke and Gertler 1999) and the US 1925-29.

Recent research has highlighted the difficulties inherent in making policy with real-time data (Orphanides 1997). Revisions of national accounts and other pieces of information that only become available later often make it difficult for central banks to take recent developments into account. Note, however, that this is not the kind of mismatch between sensible, forward-looking monetary policy and actual conduct that we have found in this paper. Instead of lasting for a few quarters, the policy mistakes that become apparent in the majority of cases have persisted for at least two years.

A comparison of recent US policy with the five bubble episodes examined earlier suggests that a hard landing may be impossible to avoid. Policy mistakes that lead to painful boom and bust-cycles – such as the failure to take the output gap into account – have been repeated. Our estimates suggest that, ceteris paribus, US rates appear to have been lowered in the face of surging equity values. Concerns about international financial stability have been allowed to dominate interest rate policy. This is an exact parallel with the easing of US monetary policy in 1927, designed to stabilize the resurrected gold standard. If past experience provides any guidance, current policy will have to shoulder a significant share of the blame if a sudden slump in asset prices leads to recession.

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