Central Bank Policy, Inflation, and Stock Prices

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Introduction

On 8 October 1997, the Dow Jones Industrial Average fell 83.25 points. Much of the fall was attributed to comments about inflation and stock prices made by Federal Reserve Chairman Alan Greenspan to the House of Representatives Committee on the Budget. His comments imply a link between inflation and stock prices, while the market's response suggests a further relationship with central bank policy. The comments did not, however, clarify the nature of these implied relationships. On the one hand, Greenspan stated that, "Re-emergence of inflation is, without question, the greatest threat to sustaining what has been a balanced economic expansion virtually without parallel in recent decades" (Greenspan 1997). In addition, he said that stock values had reached a level "not often observed at this stage of economic expansion … it would clearly be unrealistic to look for a continuation of stock market gains of anything like the magnitude of those recorded in the past couple of years."

Representatives of the Bank of Canada have referred to similar issues, although with less concern. For instance, Gordon Thiessen, Governor of the Bank of Canada, seems to agree with Greenspan's view for the United States, saying, "There's no question though, that particularly in the United

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States, those prices are pushing the limits of what you can say about the expectation of interest rates staying low and profits going up." The link to inflation and policy is provided by the suggestion that "the Canadian economy isn't as far advanced in its cyclical expansion as the United States" (Thiessen 1998). In Canada, stock prices did not respond significantly to these statements, suggesting that the market shares the Bank's lesser degree of concern.

There are many possible interpretations of the concerns expressed in the Greenspan and Thiessen statements, although each one begs a related question, which appears in italics after statements 1 to 3.

1. Perhaps the central bank feels that stock prices have somehow indicated that expected inflation is high and that a policy response is required. This interpretation is inconsistent with the commonly held view that equity is a hedge against inflation. If it is a hedge, stock prices are not affected by expected or realized inflation, and the recent run-up of stock prices implies that the market expects growth with no implications for inflation.

   Moreover, it is not clear why stock prices would have declined after Greenspan's comments, because any action to bring down inflation would depress nominal corporate earnings and nominal required returns, leaving prices unchanged. On the other hand, if equity is not a good hedge against inflation, a change in expected inflation can bring about a change in equity values.

   Is equity a hedge against inflation?

2. Perhaps there is a direct relationship between stock prices, central bank policy, and future real activity. For instance, stock prices may reflect expected economic activity. If monetary policy is related to real activity, and if inflation is related to monetary policy, then stock returns may be related to inflation, albeit indirectly.

   What is the link between stock price movements and central bank policy?

3. Greenspan had previously referred to stock market prices as displaying "irrational exuberance" (Greenspan 1996), a term that seems to have been interpreted as an asset bubble. Researchers have long tried to understand "bubbles" in asset prices, but linking them to monetary policy is a more recent concern. A cover story in *The Economist* entitled "America's Bubble Economy"[1] illustrates the

1. *The Economist*, 16 April 1998.

> widespread belief that central bank policy needs to be cognizant of stock price behaviour. The article complains that, "Because the Fed has again left it rather late, it will be hard to prick the bubble without risking a recession."
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> *Why is a bubble in a specific asset, at a time when there seems to be no widespread inflation, a concern of the central bank? Can (or should) central bank policy be directed towards doing anything about such a bubble?*

The purpose of this paper is to provide an overview of what is known about the links among inflation, stock prices, and central bank policy so as to shed light on the questions raised above. My approach is to review some of the more influential work in the area, identify areas where knowledge is lacking, and raise some questions for future research.

The paper is organized around the three questions raised above. In the next section, I review the basic relationship between asset prices and inflation. I then look at some evidence on the extent to which stock prices provide an inflation hedge. These studies employ tests of the Fisher equation in the absence of explicit consideration of central bank behaviour. In Section 2, I review research that has dealt with central bank policy and stock prices. In Section 3, I consider the question of how such policy might be used to track and respond to a specific asset-price bubble, and the implications for the rest of the economy.

1 Inflation and Stock Prices

The relationship between stock prices, rates of return, and inflation is perhaps best illustrated in the context of the dividend-discount model. In a partial-equilibrium setting, we will take as given the fact that investors will set the price of a stock at time t, S_t, to a point where the expected return on the stock is equal to the exogenously given required rate of return. We will adopt the convention that expectations will be denoted with a circumflex (ˆ).

Consider first a world with no inflation, and a company that is expected to generate a real cash flow of $\hat{C}$ per period in perpetuity. Shareholders set the price by discounting expected dividends, which themselves are functions of cash flows, new financing, and new investment. Fortunately, Modigliani and Miller (1958) long ago established that, under perfect market conditions, the specific dividend and capital structure policy of a firm will be irrelevant to the firm's value. While real markets are far from perfect, the Modigliani–Miller world provides the appropriate setting in which to establish basic relationships. Under these conditions, we can assume that the firm pays out all free cash flow as a dividend, and the stock price is simply the present value of this perpetual dividend:

$$S_t = \frac{\hat{C}}{\hat{r}_t^0}.$$

Here, S_t is the stock price and $\hat{r}_t^0$ is the required real return given that the expected inflation rate, $\hat{I}_t$, is zero. Note that $\hat{r}_t^0$ will include a risk-free component and a risk premium denoted as $\rho_t(\hat{I})$.

Suppose now that expected inflation increases to some positive amount. This brings about two fundamental changes. First, the cash flows to the company may change as general inflation acts on both revenues and expenses. For simplicity, assume that, because of inflation, the real cash flow of $\hat{C}$ is converted to a nominal cash flow, $\hat{C}^n$, that grows at a constant per-cent-per-period rate $g(\hat{I})$ that depends on expected inflation. Second, the discount rate will change to a nominal rate, $\hat{R}_t(\hat{I})$, defined by

$$(1 + \hat{R}_t(\hat{I})) \equiv (1 + \hat{r}_t^+)(1 + \hat{I}_t)$$

or

$$\hat{R}_t(\hat{I}) \equiv \hat{r}_t^+ + \hat{I}_t + (\hat{r}_t^+ \times \hat{I}_t), \tag{1}$$

where $\hat{r}_t^+$ is the real required rate of return given that expected inflation is at some positive value.

Note that this is a definition that does not impose structure on the real rate of interest. In particular, we do not at this stage rule out the possibility that the real interest rate is a function of the expected inflation rate. As a result of these changes, the stock price will change to

$$\tilde{S}_t = \frac{\hat{C}^n}{\hat{R}_t - g(\hat{I})}.$$

Equity will be a hedge against inflation if $S_t = \tilde{S}_t$ or

$$\frac{\hat{C}}{\hat{r}_t^0} = \frac{\hat{C}^n}{\hat{R}(\hat{I}) - g(\hat{I})}. \tag{2}$$

There are various assumptions under which stocks would provide an inflation hedge. The most common starting point is the intuitively appealing assumption that the firm's free cash flow is increased by inflation. This requires that all transactions with customers, workers, and debtholders be real contracts—i.e., inflation-adjusted. Algebraically, this implies that $g=I$, and that the inflation hedge equation becomes

$$\frac{\hat{C}}{\hat{r}_t^0} = \frac{\hat{C}(1+\hat{I})}{\hat{R}_t(\hat{I})-\hat{I}} .$$

This condition will be satisfied if

$$R_t(\hat{I})-\hat{I} = \hat{r}_0(1+\hat{I})$$

or

$$R_t(\hat{I}) = \hat{r}_t^0+\hat{I}+(\hat{I}\times\hat{r}) . \quad (2')$$

Comparing equation (1) with equation (2′) and reviewing our assumptions implies that, for this example, two critical assumptions are needed to conclude that equity is an inflation hedge:

1. Nominal free cash flows must be equal to real cash flows multiplied by the inflation growth factor, and
2. The real interest rate must be independent of expected inflation (i.e., $\hat{r}_t^0=r_t^+$). This follows from the fact that $R_t(\hat{I}) \equiv r_t^+ + \hat{I} + (\hat{I}\times\tilde{r})$.

While the prediction that equity will act as an inflation hedge is sometimes referred to as the Fisher hypothesis, in fact it is more common to associate assumption (2) with Fisher's name. Thus, (2′) is often called the Fisher equation. It is possible that (2′) holds, but that equity is not a hedge because of imperfections such as taxes, or because inflation has an impact on expected nominal and/or real cash flows.

Empirical tests of the relationship between stock prices and inflation are primarily based on stock market returns and inflation through some variation of equation (2′). We will examine this work in Section 1.2. Before turning to this work, however, I will briefly discuss two studies that have focused explicitly on the cash flows of the firm.

1.1 Cash flows and inflation

Levi (1980) examined the relationship between money and corporate earnings, an important component of cash flows. By focusing on money, Levi does not explicitly deal with the formation of inflationary expectations and the relationship between these expectations and stock values. He does, however, relate the increases in the money supply to corporate earnings implicitly through inflation. Levi identifies three reasons to expect that inflation would not simply be reflected directly in earnings. First, he argues that wages may not react immediately to inflation. Second, inventory gains are directly related to inflation. Third, unexpected inflation will result in wealth transfers to and from holders of nominal debt.

Based on this view, Levi estimates the relationship between profits and both growth in the money supply and the rate of change of the growth in the money supply. This empirical analysis is performed on both real and nominal corporate earnings for the period 1949 through 1979. Both growth in the money supply and acceleration of money supply growth have a positive short-term effect on earnings. The increase lasts for less than a year and is followed two years later by a decrease in earnings.

The total net effect of money supply growth on both real and nominal corporate earnings is insignificant. However, changes in money supply growth have a significant positive net effect on both real and nominal earnings.

Reilly (1997) provides a more detailed decomposition of corporate earnings, and relates these components of earnings to inflation. His starting point is the DuPont analysis of firm performance. The objective of this breakdown is to explain the accounting return on equity (ROE) (net income/ equity) using various accounting measures of performance. Specifically:

$$\left(\frac{EBIT}{Sales} \times \frac{Sales}{Total\ assets} - \frac{Interest\ expense}{Total\ assets}\right) \times \frac{Total\ assets}{Equity} \times (1 - Tax\ rate) = ROE,$$

where EBIT is earnings before interest and taxes. Alternatively, this can be expressed as

$$(((Profit\ margin \times Asset\ turnover) - (Interest\ rate)) \times Leverage)(1 - Tax\ rate).$$

Reilly examines these data for Standard & Poor's 500 firms as well as stock market returns and inflation from 1977 to 1995. He presents a correlation matrix that shows that

- inflation and stock returns are negatively correlated
- inflation and profit margins are negatively correlated
- stock returns and profits are negatively correlated

The negative correlation between profit margins and inflation may reflect the fact that firms are not able to pass on price increases through higher prices even though costs do increase. This is then reflected in stock returns, where the reduced expected cash flows result in lower prices.

It is worth noting that this conjecture can only explain the correlations over time if changes in inflation are, to a large extent, unexpected. According to efficient markets theory, if inflation is expected to squeeze profit margins in a predictable way over a long period of time, stock prices will reflect this immediately, and subsequent expected decreases in profit margins will not lead to lower returns.

1.2 Tests of the Fisher equation

There have been many tests of the Fisher equation, both on fixed-income and equity contracts. These tests have been based on expected inflation, unexpected inflation, and changes in expected inflation. Using fixed-income securities as the basis for a test has the advantage of being based on known *promised* cash flows. Government fixed-income securities have the added advantage of being risk-free; the promised cash flows will be equal to the expected cash flows. As a result, many tests of the Fisher hypothesis are based on government debt contracts. For example, recent work by Evans and Lewis (1995), Kandel, Ofer, and Sarig (1996), and Crowder (1997) all test the Fisher equation on fixed-income securities.

My focus, however, is on the information contained in stock prices, and I will concentrate on tests based on these prices. Equity markets provide additional information, in that stock prices reflect both inflationary expectations and expectations of real activity. However, the added information is difficult to disentangle.

Stock market returns have been studied over various time periods and for many countries. The general conclusion is that stocks are not a perfect hedge against inflation. Typically, returns on stocks are negatively related to realized, expected, and unexpected inflation.

The Fisher hypothesis, as presented in equation (2′), is a hypothesis about expectations. Unfortunately, any test of the hypothesis is restricted to observed values of the variables in question. Hence, in order to test Fisher's hypothesis we must first convert expected values into realized values:

$$R_t = \hat{R}_t + u_t \tag{3}$$

and

$$I_t = \hat{I}_t + \in_t ,$$

where, u_t and $\in_t$ are forecast errors. In other words, realized returns are equal to expected returns plus a forecasting error, and realized inflation is equal to expected inflation plus a forecasting error. If we assume rational expectations, these prediction errors should be uncorrelated with the predicted variables.

It is typical in these studies to ignore the cross term[2] $r_t \times i$, even though this results in a misspecified model. Given this specification, the realized real return r_t can be decomposed into an average return r and the

2. Here and throughout the rest of the paper, I suppress the circumflex on the real interest rate, because the context makes clear the expected inflation that is in effect.

remainder $\tilde{r}_t$, and expected values can be substituted in order to obtain the regression equation

$$R_t = r + \beta I_t + (\hat{r}_t + u_t - \beta \in_t) . \tag{4}$$

If expectations were observed without error, the Fisher equation implies that an increase in expected inflation will result in an equivalent increase in nominal interest rates (i.e., $\beta = 1$). However, Nelson (1976) points out that even if the hypothesis holds, the probability limit of the least-squares estimator of β will differ from 1 because of the inflation-forecasting error and owing to any reaction of market prices to unanticipated inflation. The inflation-forecasting error will reduce the β estimate, and a negative market reaction will reduce the estimate further. On the other hand, a positive market reaction will produce an offsetting increase in the estimated coefficient. As shown in the previous section, there is evidence that expected cash flows are affected by expected inflation. Hence, the net result makes interpreting tests of the Fisher equation difficult.

Given the importance of expectations, most studies explicitly include expected inflation as well as unexpected inflation, so that the final test is typically of the form

$$R_t = \alpha + \beta \hat{I}_t + \gamma (I_t - \hat{I}_t) + \eta_t . \tag{5}$$

That is, nominal returns are regressed on a measure of expected inflation and a measure of unexpected inflation. Unexpected inflation has an ambiguous interpretation, because its impact on prices depends on how these surprises alter expectations. An alternative interpretation by Geske and Roll (1983) is that unexpected inflation is a proxy for changes in expected inflation. They suggest introducing changes in expected inflation directly. Fama and Gibbons (1984) found that a variation of this model that allows α to vary through time according to a random walk fits the data somewhat better. Hence, several studies adopt this alternative specification.

1.3 Empirical evidence

Early studies by Nelson (1976), Jaffe and Mandelker (1976), and Fama and Schwert (1977) form a widely cited base for the general result that stock prices are negatively related to realized, unexpected, and expected inflation. While there are various ways to estimate expected inflation, a widely used approach was established by Fama (1981), who argued that the yield to maturity on short-term treasury bills, r_{ft}, varies with monetary policy impulses through expected inflation. The basis of his argument is the hypothesis that the expected real return on treasury bills is constant through time, i.e., $\hat{r}_t = \hat{r}$. As a result, the yield to maturity on a treasury bill can be expressed as

$$r_{ft} = \hat{r} + \hat{I}_t$$

or

$$\hat{I}_t = r_{ft} - \hat{r} .$$

Fama and Schwert (1977) estimate the regression

$$I_t = \alpha + \beta r_{ft} + \in_t$$

and report strongly significant β estimates that are very close to 1. In subsequent work, Fama and Gibbons (1984) find that a better fit of the model is obtained by allowing α to drift over time according to a random walk. This provides a better fit of the data, and the β coefficient becomes indistinguishable from 1. The disturbance term from these regressions may be seen as the unexpected inflation component. Based on this result, Fama and Schwert (1977) estimate the following equation for returns on treasury bills, government bonds, real estate, human capital, and stock returns. Their data cover the United States from 1959 to 1971.

$$R_{tj} = \alpha_j + \beta_j r_{ft} + \gamma_j (I_t - r_{ft}) + \eta_t . \qquad (6)$$

This study provides one of the most comprehensive views of a puzzling result: While all other assets are at least a partial hedge against expected inflation, and some provide a hedge against unexpected inflation, common stock returns are (strongly and significantly) negatively related to expected inflation and, to some extent, to unexpected inflation. To illustrate, the estimates of β and γ for real estate are 1.15 and 0.56, respectively, and the estimates for stock returns (using a value-weighted index) are –4.88 and –4.11. This has the astonishing implication that a 1-per-cent change in expected inflation would lead to a 5-per-cent drop in equity values.

Cozier and Rahman (1988) estimate this model with data from Canadian markets covering the period 1958(Q2) to 1983(Q4). They modify the procedure by developing a more elaborate model of expected inflation that includes lagged values of inflation, treasury bill rates, the government budget deficit, and the rate of growth of M1. Based on this forecasting model, they derive quarterly series of expected and unexpected inflation. They report the following results (*t*-statistics are reported under each estimate).

1958(Q2)–1983(Q4) $\qquad R_t = 0.028 - 1.8531 - 3.460\,(I_t - \hat{I}).$

$$\underset{1.86}{} \qquad \underset{-1.92}{} \qquad \underset{-2.23}{}$$

1958(Q2)–1972(Q4) $R_t = 0.014 - 0.85\,\hat{I} - 2.62\,(I_t - \hat{I})$.

$\qquad\qquad 0.77 \qquad -1.53 \qquad -1.53$

1973(Q1)–1983(Q4) $R_t = 0.17 - 7.933\,\hat{I} - 6.225\,(I_t - \hat{I})$.

$\qquad\qquad 2.68 \qquad -2.78 \qquad -2.16$

Thus, the Canadian evidence is similar to that found in the United States. It is clear, however, that the negative relationship between stock prices and inflation has increased over the sample period. Consistent with this, Cozier and Rahman statistically reject the hypothesis that the parameters are stable over the subperiods.

Some debate has taken place on the role of unexpected inflation in these models. It is not clear how inflation surprises influence asset returns, because the returns will depend on how rapidly asset prices can adjust. Geske and Roll (1983) suggest that the unexpected inflation component is simply a proxy for changes in expected inflation. Moreover, changes in expected inflation can be directly measured by changes in treasury bill yields. Domian, Gilster, and Louton (1996) provide a recent update on the relationship between stock prices and inflation. Their study uses the change in monthly treasury bill rates and stock returns, and their sample covers the United States from 1952 to 1992. Their replication of earlier studies finds the same sort of results: Stock returns are significantly negatively related to changes in treasury bill yields.

Interestingly, Domian et al. (1996) also test the hypothesis that the relationship is asymmetric in that the response to positive shocks is different from that to negative shocks. They test this by estimating separate coefficients for positive and negative expectation changes. They find much larger and statistically significant coefficients based on negative revisions, but their estimates are insignificant for the positive revisions. Thus, it seems that decreases in expected inflation lead to increases in stock returns, but increases in expected inflation have no significant impact on returns.

2 Central Bank Policy and Stock Returns

The strong counterintuitive result that stocks are a perverse hedge against inflation has prompted a considerable amount of research into the links among inflation, monetary aggregates, and real activity. Fama (1981) first attacked the issue by arguing that the negative relationship between inflation and stock returns was a spurious “proxy” for a negative relationship between inflation and real activity, and a positive relationship between real activity and stock returns. In order to explain the negative relationship between real activity and inflation, Fama appealed to money-demand theory and the quantity theory of money.[3]

The basic argument starts with a straightforward application of money-demand theory. The real money supply, m_t, is[4] given by the inflation-adjusted nominal money supply, M_t. Money demand is assumed to be increasing in *anticipated* real activity, $\hat{Y}_t$, and decreasing in the nominal interest rates, $\hat{r}_{ft}$. This relationship is expressed as

$$m_t = M_t - I_t = b_o + b_1\hat{Y}_t + b_2\hat{r}_{ft} + \epsilon_t ,$$

with the prediction that $b_1 > 0$ and $b_2 < 0$. This can be rearranged to give

$$I_t = -b_o - b_1\hat{Y}_t - b_2\hat{r}_{ft} + b_3 M_t + \eta_t .$$

To this set-up, Fama adds the assumptions that real activity, money, and the interest rate are exogenous and that prices are the only endogenous variables. As a result, increases in real activity will have a negative effect on prices, and increases in money will have a positive effect on prices. The important component is the real activity–price relationship. If real activity is expected to increase, the demand for money will go up. In order to accommodate this demand, prices will have to fall. Combining this with the assumption that stock prices anticipate real activity completes the story. Stock prices are positively related to real activity, but real activity is negatively related to stock prices. These two independent relationships lead to the spurious negative relationship between inflation and stock prices.

In support of this, Fama estimates the various relationships and finds support for each component. In particular, he finds that when proxies for future economic activity and money supply are included in regressions of stock returns on expected and unexpected inflation, the inflation factors become insignificant.

2.1 Introducing a monetary authority

Fama's work is important for bringing the role of monetary aggregates into the inflation–stock return discussion. It is deficient, however, in its view of the monetary authority. The money supply is taken as exogenous, and a simple quantity theory of money approach is taken. Geske and Roll (1983) moved the analysis on by explicitly including the monetary authority in the analysis.

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3. Similar results are obtained in equilibrium models by Stulz.

4. All variables are first differences except inflation and interest rates, which are already in rates of change.

Geske and Roll's primary point is that the causality may in fact work from stock returns to inflation rather than the other way around. They assume that the monetary authority follows a rule of monetizing a certain fraction of the government's annual deficit. Changes in the deficit are caused by changes in government expenditures relative to receipts. Geske and Roll assume that government expenditures are relatively fixed, while receipts vary with economic activity. If stock market returns forecast changes in economic activity, then they will be inversely related to expected government deficits. Thus, for instance, a decrease in stock returns indicates an increase in expected future deficits. Given the simple monetary rule postulated, this will translate into an increase in the supply of money and in inflation. Hence, expected inflation and stock returns would be negatively related.

Moreover, they argue that because treasury bill returns reflect expected inflation, the relationship between treasury bills and stock market returns will be of the form

$$r_{ft} - r_{ft-1} = \alpha_t - \beta_t \rho_t + \gamma[R_t - b r_{ft-1}] + \varsigma_t, \qquad (7)$$

where ρ_t is the risk premium on the stock.

If this equation is solved for R_t, the result would be

$$R_t = \frac{1}{\gamma}\alpha_t + \frac{\beta_t}{\gamma}\rho_t + b r_{ft-1} + \frac{1}{\gamma}(r_{ft} - r_{ft-1}) .$$

Suppose that the true relationship is as indicated in (7), and that γ is small and negative. Suppose further that the hypothesis is that stock returns are a hedge against inflation, and that this hypothesis is tested with the regression

$$R_t = \beta_0 + \beta_1 r_{ft-1} + \beta_2 (r_{ft} - r_{ft-1}) .$$

This regression will yield a large negative estimate of β_2(i.e., $1/\gamma$) even though the Fisher equation holds, and stocks are inflation hedges. Geske and Roll empirically evaluate each element of their argument individually and find support for their argument.

2.2 Monetary regimes

With demand and supply issues being introduced, the next step was to look at the manner in which central bank policy regimes would influence inflation. Kaul (1987) combined the money-demand considerations introduced by Fama with money supply considerations. However, rather than following Geske and Roll in using deficit financing as the appropriate description of monetary policy, Kaul described regimes as being either procyclical or countercyclical. He recognized that Geske and Roll's explanation of the "reverse causality" is consistent with any countercyclical monetary regime. Importantly, this recognition opens the door for procyclical policy, and the possibility that the prediction about the relationship between stock returns and inflation would either be eliminated or reversed.

Kaul empirically tests his model with data from the United States (1953 to 1983), Canada (1951 to 1983), the United Kingdom (1957 to 1983), and West Germany (1957 to 1983). Kaul conjectures that the period under study was one in which countercyclical monetary policy was being followed. He also argues that procyclical policies were in place in the 1930s, and to test this he runs similar tests over this period. Due to data limitations, he conducts his test of the Depression years with data from Canada and the United States only.

His starting point was to look at the basic relationship between stock returns, inflation, expected inflation, and a measure of expected future real activity[5] $(Y_t + 1)$. To test Fama's hypothesis that the negative relationship is spurious, the following regression was run both with and without future output included for the countercyclical period (1952 to 1983). If, in fact, inflation is a proxy for expected future output, including future output will eliminate the significance of the expected inflation parameter. The following function was estimated on the basis of annual, quarterly, and, where available, monthly data.

$$R_t = \alpha + \beta_1 \hat{I}_{t-1} + \beta_2 (\hat{I}_t - \hat{I}_{t-1}) + \beta_3 Y_{t+1} .$$

Similar results were found for all countries and time periods. Since the analysis for the recession years is available for Canada and the United States only, I will focus on these countries and, to save space, present monthly and annual data only (see Table 1).

There are two striking features of these results. The first is the degree to which the basic relationship between stock prices and inflation is reversed in the 1926 to 1940 period. The second is the extent to which realized future output alters the results of the analysis. This supports Fama's notion that the stock price–inflation relationship captures the positive relationship between stock prices and real activity, and the negative relationship between real activity and inflation. Kaul provides further support for this hypothesis by estimating the positive relationship between stock returns and subsequent real activity for both regime periods. He finds that the estimated relationship is significantly positive in both periods. He also estimates the relationship between inflation and current and future real output for both periods, but

5. This was proxied by the growth in industrial production or GNP for the period $t + 1$.

Table 1

Relationship between Inflation, Stock Prices and Real Activity

Regime	Frequency	α	β_1	β_2	β_3
Canada					
Post-war (1952–1983)	Monthly	0.007	–1.791	–6.901	–
		(2.09)	(–2.40)	(–2.03)	–
	Monthly	–0.007	–0.1331	–5.091	0.0192
		(–1.37)	(–0.16)	(–1.51)	(4.09)
	Annual	0.0814	–1.600	–1.053	–
		(1.62)	(–1.69)	(–0.79)	
	Annual	–0.103	–0.322	–0.062	3.231
		(–1.22)	(–0.34)	(–0.05)	(2.87)
Depression era (1926–1940)	Monthly	0.001	1.24	9.447	–
		(0.15)	(0.91)	(1.90)	–
	Annual	0.030	2.110	3.931	–
		(0.51)	(1.25)	(2.42)	
United States					
Post-war (1953–1983)	Monthly	0.014	–2.6301	–10.5201	–
		(4.28)	(–3.83)	(–3.85)	–
	Monthly	0.003	–1.1101	–9.4721	0.162
		(0.81)	(–1.49)	(–3.54)	(4.54)
	Annual	0.150	–2.243	–2.235	–
		(2.71)	(–2.11)	(–1.50)	
	Annual	–0.018	–0.135	–0.898	5.4071
		(–1.53)	(–0.14)	(–0.77)	(4.52)
Depression era (1926–1940)	Monthly	0.004	0.042	0.934	–
		(0.53)	(0.03)	(0.51)	–
	Annual	0.0730	2.216	4.3061	–
		(1.02)	(1.21)	(2.15)	

Note:

– Data not available.

only for the United States. Here he finds a sharp difference between the two periods. The relationship is either insignificant or significantly positive in the 1926 to 1940 period, and significantly negative in the 1953 to 1983 period.

It may be that the results presented are unrelated to the monetary authorities in that there may have been no change in the money supply process. Kaul appeals to Friedman and Schwartz (1963) for support of the hypothesis that the Depression era was characterized by procyclical monetary policy. Friedman and Schwartz find that between 1929 and 1933 GNP in the United States fell by 30 per cent, unemployment increased dramatically, and the money supply fell by about 25 per cent. Kaul estimates a money supply function for the four countries in the post-war period. The model relates money supply growth to the federal deficit and the unemployment rate. He finds a significantly positive relationship between deficits and money growth for all four countries, but an insignificant relationship between money growth and the unemployment rate for all countries except West Germany.

The main contribution of Kaul's work is to find evidence that supports both Fama's and Geske and Roll's view of the link between inflation, stock prices, and monetary policy. This is done essentially by bringing supply and demand together through a more complete, though still partial, model of the monetary authorities. In a subsequent paper, Kaul (1990) considers more explicit characterizations of monetary policy. In particular, he uses the operating targets announced by the monetary authorities to characterize the money supply process. When interest rates are the target, Kaul conjectures that the money supply process will be countercyclical. When money supply targets are established, the money supply process is considered neutral. The hypothesis is that a countercyclical monetary policy is likely to generate a stronger negative relationship between stock prices and inflation than is a neutral or procyclical regime.

Kaul considers data from four countries and identifies three money supply control periods: 1953 to 1960 and 1979 to 1986 for the United States, and 1951 to 1960 for Canada. He also identifies four interest rate regimes: 1961 to 1979 for the United States, 1961 to 1983 for Canada, and 1957 to 1983 for the United Kingdom and West Germany. Kaul concludes that the negative relationship between inflation and stock returns is significantly stronger during periods when interest rate targets are announced than during periods of money supply targets.

3 A Research Agenda: Monetary Policy and Bubbles

The literature discussed to this point is based on an understanding of asset prices and monetary policy that, while still incomplete, has been refined considerably over a relatively long history. A more recent and more incomplete line of inquiry concerns the relationship of central bank policy to the possibility of a bubble in stock prices.

It is clear from the public debate and the Bank of Canada's policy statements that the concern for the general problem is widespread, but our understanding of the issues is still quite rudimentary. In testimony before a

Senate committee on 23 April 1998 (Thiessen 1998), Governor Gordon Thiessen commented on North American markets:

> … if those markets become too speculative and then crash, they will have some implications for the rest of the economy.
>
> We are monitoring them very closely, but I find it difficult to say more than that. There could be a moment when, quite evidently, things have gotten out of hand and you must respond to them.

Thiessen's comments raise several questions that we do not have answers to, including:

i) When do markets become "too speculative"?

ii) How do we identify bubbles?

iii) How will it be evident that things are out of hand?

iv) What are the implications of a stock market crash for the rest of the economy?

v) When a response is needed, what should that response be?

While we know relatively little about these issues, some work has been done that takes a few steps towards understanding.

3.1 When do markets become too speculative? How do we identify bubbles? How will it be evident that things are out of hand?

The notion that stock prices are experiencing a bubble implies that they exceed some sort of normal or fundamental value. The problem, of course, is determining what that fundamental value is. Reinhart (1998) attempts to determine the normal prices empirically. Based on a dividend-discount model of the type that I used in Sections 1 and 2, Reinhart constructs an empirical model of the earnings/price ratio (E/P) of the Standard & Poor's 500. The model relates the E/P to interest rates, expected inflation, and the unemployment rate and is estimated with data from 1980 to 1996. Values predicted from the model are then compared with actual values of the E/P ratio to determine whether stocks are overvalued or undervalued. Reinhart concludes that stock prices are currently overvalued by 5 to 28 per cent.

The estimated model is not very different from the models used to look at the inflation–stock return relationship in general. The interpretation, however, is drastically different, and flies in the face of the efficient-market hypothesis. If the deviations identified were true underpricing or overpricing, wealth-maximizing agents would simply trade on these estimates to create wealth. Moreover, it is possible to construct more elaborate models that fit the data more precisely. For instance, Donaldson and Kamstra (1996) show that the dividend-discount model, when augmented by a neural-network model, can fit data well, even data from periods of highly volatile prices. Unfortunately, the problem of empirically identifying a price bubble may be beyond fitting models of this sort to the data.

Despite the difficulty of determining when a bubble has occurred, Kent and Lowe (1997) construct a theoretical model of speculative bubbles and monetary policy based on the assumption that central banks somehow know when an increase in asset prices is not justified by the data. This is obviously an unrealistic assumption, and the authors recognize it as such. They go on, however, to argue that including this assumption is justified because, whether or not central banks can in fact judge fundamental values, they do make judgments and act accordingly.

Kent and Lowe highlight at least two important research issues in this work. First, a continuation of the difficult (perhaps impossible) task of identifying asset bubbles is needed. Clearly, we can construct some model of fundamental values that can be used to judge returns as abnormal, but more work is needed on the reasonableness of these models. A second issue related to the first is, How costly would such a policy rule be? If central banks act on their perception of a bubble, it is important to consider the costs and benefits of various policy rules, including the models that are part of their decision rule. This requires explicit recognition of the costs that are imposed on the economy when policy intervention occurs when it should not, and when policy intervention does not occur when it should.

3.2 What are the implications of a stock market crash for the rest of the economy?

If prices did increase above “fundamental values” and then suddenly return to that level, the direct costs would be restricted to the wealth transfers involved. Traders who bought high and sold low would experience a wealth loss that would be offset by the wealth gain of those with whom they transacted. There would also be a disruption as plans change suddenly in response to sudden changes in the budget constraint.

Beyond this, however, there is a concern about more general disruptions in commerce due to the false signals sent by the market. For instance, Reinhart (1998) suggests that overpricing may have the following effects.

> If prices are moving above fundamentals, relative prices are misaligned, dictating some misallocation of resources. Households might be consuming out of their paper wealth,

> firms buying capital based on inflated market relative to book value, households and businesses taking on debt because leverage ratios look good, and new firms starting up because capital markets are so receptive.

If the distortions described did in fact occur they would call in to question many fundamental business practices. For example, the conjectures imply that, in addition to equity prices departing from fundamentals, lending decisions must also depart from fundamentals. Loans are made on the basis of the ability of the borrower to repay the lender. Indeed, part of this ability is based on collateral value, but typically cash flow projections are critical to the decision. On the other hand, Kent and Lowe (1997) argue that bubbles are in fact supported by inflated values through collateral provisions that are based on the most recent market data.

An important research issue is to examine the linkages between asset price growth and the intermediation process. The fundamental problem here is an agency one. In the case of banks, lenders are acting on behalf of depositors and deposit insurers. Rules governing collateral coverage and appraisal decisions can be thought of as part of the agency contract. To what extent are these rules, intended to solve one problem (the agency problem), contributing to the possibility of asset-price bubbles?

Another more direct route through which asset bubbles cause system-wide problems is in their impact on aggregate demand through wealth effects. This is a problem that may emerge with or without bubbles, but is clearly a larger problem with bubbles.

3.3 When a decision to respond is made, what should that response be?

Assuming that stock-price bubbles can be identified and the central bank has decided to try to eliminate the bubble, what alternatives does it have?

Kent and Lowe (1997) build a model that assumes that asset-price bubbles arise exogenously, and that they “pop” with some exogenous probability. They then assume that there is some probability that an increase in interest rates might increase the chances of stock prices returning to their fundamental level. They also assume that inflation is directly related to the extent to which stock prices are above fundamental levels. Given these assumptions, and the objective of keeping inflation within targets, they derive optimal interest rate policies. These policies imply that a bubble will result in interest rates being set at a higher-than-neutral rate, and show that this rate will be lower the more efficient interest rates are in eliminating bubbles. The clear research issue raised by this argument is that of how to substantiate the very strong assumptions needed to support the argument.

Reinhart (1998) employs a less restrictive model in analyzing bubbles. Reinhart assumes that aggregate demand y is decreasing in real interest rates r and increasing in real equity values q,

$$y = \alpha_1 - \alpha_2 r + \alpha_3 q .$$

Changes in the level of inflation $\dot{I}$ are explained by deviations of output from a potential output level k,

$$\dot{I} = b \times (y - k) .$$

The central bank is assumed to follow a policy of setting a nominal interest rate R_{ft} based on deviations of output from full employment and inflation,

$$R_{ft} = \alpha(y - k) + \beta\dot{I} .$$

Finally, asset prices are in equilibrium if the dividend yield, based on the exogenous perpetual dividend stream $\hat{C}$, and capital gain are equal to the required rate of return

$$r + \rho = \frac{\hat{C}}{q} + \frac{\dot{q}}{q} , \tag{8}$$

where ρ is the equity risk premium and $\dot{q}$ is the change in equity prices. The steady state for this model requires that output be at the economy's potential, and that equity prices satisfy the dividend-discount model developed in Section 1,

$$q = \frac{\hat{C}}{r + \rho} . \tag{9}$$

Reinhart goes on to solve for the dynamics of the model where the equations of motion are the central bank control of interest rates and the equity price condition. In this model, a bubble can arise. Suppose that interest rates are at a long-run equilibrium level but equity prices are slightly above the equilibrium level. If equity prices rise more rapidly than interest rates, the total return on equity will satisfy (8), even though (9) is not satisfied. The assumption that prices can depart from those set by (9) is the critical step needed to justify the bubble. Monetary policy does not "pop" the bubble in this case because, although increased asset prices feed into inflation, the policy response function via inflation is, in some sense, too slow to curtail the growth in equity prices.

The question raised by this argument is, Why should the central bank be concerned with the stock-price bubble? If inflation is the concern, then it is being taken care of. Reinhart does, however, argue that other costs are incurred through the misallocation of resources. If, in fact, other costs are important, then the monetary policy rule should be altered. Reinhart considers this possibility by examining an alternative policy rule that includes deviations of equity prices from their steady state level. Since the steady-state prices are those given by the dividend-growth model, this is equivalent to a policy that targets departures from fundamental values. Reinhart shows that this added element to the central bank's policy rule can increase price volatility. This is because central bank policy responds to past price changes and can, as a result, become a destabilizing feedback mechanism.

The critical research issues here are: measuring the distortionary costs of equity prices that are greater than fundamentals; understanding how prices can, in a market setting, depart from fundamentals; and estimating the extent to which they do in fact depart. After all, it may be that current stock market values are simply a reflection of increased high-return investment opportunities due to, for instance, globalization of capital markets, coupled with an increase in the supply of funds to this market due to demographics and advances in risk-sharing devices.

Conclusions

I raised three questions in the introduction, and have reviewed the answers that research has so far provided to these questions.

The first is whether equity is a hedge against inflation. It appears that equity is not a perfect hedge to the degree that corporate cash flows are negatively related to inflation, suggesting that companies are, on balance, not able to pass general price increases along to their customers. This implies that corporate profits are squeezed to the benefit of some other supplier in the economy, such as government or labour. As well, the negative relationship between returns and inflation seems to show that equities are not a hedge. However, further study shows that this may indicate spurious correlation. Inflation and real activity appear to be negatively correlated, while returns and real activity are positively correlated. Hence, equities are not a hedge, in that they do not typically maintain value in the face of inflation. They would do so, however, if real activity were held constant.

Monetary policy is critical to the interpretation of the negative correlation between returns and inflation. For instance, countercyclical monetary policy implies that an expected decrease in real activity will lead to an increase in monetary growth and inflation. On the other hand, procyclical monetary growth implies the opposite. Evidence from different time periods, monetary regimes, and countries seems to support this relationship.

Finally, I reviewed the role of equity-price bubbles in monetary policy and inflation. Here there are more new questions than answers. Some progress has been made, however, in setting out conditions under which central bank policy might target the level of equity prices relative to some fundamental level. The feasibility and optimality of these policy prescriptions are, at this point, not well understood. In particular, a critical assumption is that central banks can identify a bubble when it sees one, and that there are costs of bubbles beyond the inflationary pressures they may generate. At this stage there is little evidence to support either assumption.

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