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AN ANALYSIS OF CAUSAL RELATIONS AMONG INFLATION, FINANCIAL STRUCTURE, TOBIN'S q AND INVESTMENT

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Abstract

In this paper, causal relations among inflation, the debt-equity ratio, Tobin's q, and investment are examined. The hypotheses that are tested are: a) that inflation is structurally neutral with respect to investment and q, but not the debt-equity ratio; b) that there is instantaneous causality between inflation and the debt-equity ratio, between inflation and q, between inflation and investment and between q and investment; c) that there is no feedback from the vector comprised of inflation and the debt-equity ratio to the vector comprised of q and investment; and d) that there is no short-run feedback from inflation to the debt-equity ratio, from inflation to q, or from inflation to investment. I also test for Granger-causality from q to inflation, from the debt-equity ratio to inflation, and from investment to inflation.

In the introductory section of this paper, methods for analyzing the impact of inflation on financial markets are discussed. In section II, theoretical and empirical studies that describe relations among inflation, financial markets, and investment are reviewed. In section III, a model is presented and in section IV the model's predictions of causal relations are discussed. Section V reports methods employed in the essay. Section VI describes the empirical results. In section VII, findings are interpreted and conclusions for future research are discussed.

Introduction

The conjunction of high inflation rates, poor investment performance, low q, and high debt-equity ratios in the late 1960s and early 1970s led to numerous studies of the impact of inflation on financial markets and investment. None of these studies, however, has distinguished empirically between long- and short-run effects of inflation.

There are a variety of theoretical reasons why the short-run relation between inflation and financial variables may differ from the long-run relation. According to Modigliani and Cohn (1979), investors may learn to incorporate inflation in their valuations of equities correctly. Summers (1983) develops a theoretical model of Tobin's q that shows how the short-run relation between inflation and q depends on the sources of the shocks to inflation. In addition, dynamic theories of investment often yield ambiguous predictions regarding the short-run responses of endogenous variables to shocks (for example see Brock and Turnovsky [1981]).

In this paper, a general equilibrium model of investment and financial structure is presented. Firms choose a higher debt-equity ratio given higher inflation since nominal interest payments may be deducted from taxable income by corporations. An interior solution for the debt-equity ratio arises from a combination of an agency cost of debt and a tax advantage of debt. The comparative statics results and optimality conditions of the model imply a set of predictions regarding relations among contemporaneous and lagged values of q, the debt-equity ratio, inflation, and investment.

The influences of lagged and current values are disentangled by estimating measures of Granger-causality and instantaneous causality. The long- and short-run effects of inflation on q, on the debt-equity ratio, and on investment are tested by estimating measures of feedback at various frequencies. Although q in theory incorporates all information relevant for investment, given potential problems with measuring q it may be useful to focus instead on the role of financial structure in linking inflation to investment.

Related Literature

Theoretical analyses of the impact of inflation on financial markets generally focus on either q or the cost of capital as the channel through which inflation affects investment. Theoretical analyses of the effects of inflation on q have been conducted by Summers (1980, 1983). Summers (1980) incorporates inflation in a deterministic q model. Summers (1983) develops a stochastic q model. In neither case is there a role for financial structure. As in the q models developed by Hayashi (1982) and Yoshikawa (1980), in Summers' models q incorporates all information relevant to investment decisions. If inflation affects financial structure and the cost of capital, it will affect q and thus investment.

Theoretical analyses of the impact of inflation on financial structure have been reported by Cordes and Sheffrin (1983), Gordon and Malkiel (1981), and Lewellen and McConnell (1979). These analyses imply that higher inflation rates are associated with higher debt-equity ratios since corporate interest deductions are based on nominal rather than on real interest payments.

Summers (1983) offers the only analysis of the impact of inflation on financial markets distinguishing between long- and short-run effects. He isolates the long-run effect of inflation on interest rates and equity returns, using a band-spectral technique suggested by Engle (1974). He finds that inflation is not incorporated in equity returns at low frequencies so as to compensate stockholders in real terms.

The analysis of feedback (causality) has been developed by Geweke (1982a,1986). Linear dependence between two time series, X_t and Y_t, is equal to the sum of feedback from X_t to Y_t, feedback from Y_t to X_t, and instantaneous feedback between X_t and Y_t. The existence of feedback from X_t to Y_t is equivalent to the existence of Granger-causality from X_t to Y_t. There is instantaneous causality (instantaneous feedback) between X_t and Y_t if they are contemporaneously correlated after the effects of past values of both variables have been removed. The directional feedback measures (feedback from X_t to Y_t, or from Y_t to X_t) can be decomposed by frequency to yield empirical counterparts to long- and short-run feedback. Low-frequency feedback corresponds to long-run effects. Absence of feedback from X_t to Y_t at zero frequency is equivalent to the structural neutrality of X_t with respect to Y_t and implies that the comparative statics multiplier of X_t with respect to Y_t is zero.

The Model

The Consumer

The infinitely-lived representative consumer maximizes the present discounted value of utility. Utility is a function of consumption and real balances. Formally, the consumer's objective is to choose the sequence

$$\{c_t, b_t, m_t, E_t\}_{t=[0,\infty)} \text{ so as to}$$

[1] $$\text{MAX} \int_0^\infty \exp^{-\beta t} U(c_t, m_t)dt$$

subject to

[2] $$c_t + \dot{b}_t + z_t\dot{E}_t + \dot{m}_t = w_t\ell_t + s_t b_t - p_t^a(b_t + m_t) + dz_tE_t - \tau$$

[3] $$\lim_{t\to\infty} \exp^{-\theta t} b_t > 0, \quad \lim_{t\to\infty} \exp^{-\theta t} z_tE_t > 0 \text{ and}$$

[4] $B(0) = B_0$, $E(0) = E_0$, $M(0) = M_0$,

where

c_t = real private consumption

p_t^a = instantaneous anticipated rate of inflation

B_t = nominal corporate bonds

b_t = real corporate bonds; = B_t/P_t

M_t = nominal money balances

m_t = real balances; $m_t = M_t/P_t$

β = rate of time preference

w_t = real wage rate

ℓ_t = real employment

s_t = nominal interest rate on corporate bonds

Div_t = real dividends

d_t = dividend payout rate; $d_t = Div_t/z_tE_t$

z_t = relative price of equity in terms of output

E_t = the number of shares of equity

θ = the rate of return on consumption; $\theta = \beta - U_{cc}\dot{c}/U_c$

τ = the lump sum tax

q_t = shadow price of physical capital (Tobin's q)

μ_t = the growth rate of real balances; $\mu = \dot{m}/m$

Brock and Turnovksy (1981) discuss how transactions costs may imply that money appears in the utility function. I assume $U_c > 0$ and $\text{sign}(U_m) = \text{sign}(m^* - m)$ where m^* is the satiation level of real balances (see Friedman [1969]).

Expression [2] indicates that the representative consumer makes consumption expenditures, purchases bonds, demands additional equity shares, and accumulates real balances. The consumer receives real income in the form of wage payments, interest payments and dividends. Inflation reduces the real value of debt and money holdings. I assume perfect competition, all expectations or forecasts are fulfilled, and all markets clear. Expression [3] provides bounds on debt and equity. Expression [4] provides initial conditions for debt, equity, and money. I assume that firms determine the amount of labor demanded.

Since the consumer is concerned with real rates of return on debt and equity, both debt and equity will be held only if their real rates of return are equal. This equality is given by expression [5] where θ is the rate of return on consumption; $\Theta = \beta - U_{cc}\dot{c}/U_c$.

[5] $s - p^a = \Theta = d + \dot{z}/z$.

The Firm

The representative firm maximizes the market value of debt plus equity. The firm is characterized by this objective and by expressions C61 - [11].

[6] $y^s = F(K, \ell)$

[7] $\Pi = y - w\ell - \Psi(I,K)$

C81 $n = sb + \tau_p [y - wl - sb - \Psi(I,K)] + RE + a(\lambda)b + DIV$

[9] $I = \dot{K} + \delta K$

[10] $K(0) = K_0$, $E^s(0) = Eo$, $B(0) = Bo$

Clll $I = RE + \dot{b} + p^a b$

where

p^a_t = instantaneous anticipated rate of inflation

B_t = nominal corporate bonds

b_t = real corporate bonds; $b_t = B_t/P_t$

β = rate of time preference

w_t = real wage rate

ℓ_t = real employment

s_t = nominal interest rate on corporate bonds

Div_t = real dividends

d_t = dividend payout rate; $d_t = Div_t/z_tE_t$

z_t = relative price of equity in terms of output

E_t = the number of shares of equity

I_t = real investment expenditures

K_t = real stock of physical capital

Γ_t = the cost of capital as derived in the text

γ_t = the cash flow of the firm

y_t = real output

Π_t = real gross profits

$\Psi(I,K)$ = real adjustment cost from investment

τ_p = corporate profits tax rate

RE_t = retained earnings

λ_t = the debt to equity ratio; $\lambda = b/zE$

$a(\lambda)b$ = cost of maintaining the bond portfolio

δ = the rate of depreciation of the physical capital stock

The firm maximizes the market value of debt plus equity rather than just the market value of equity. Bond covenants and other restrictions on the real and financial activities of the firm are assumed to force the firm to take into account the effect of its decisions on the market value of debt. Without some mechanism to reconcile the divergent interests of stockholders and bondholders, the firm's objective may not be well defined. Such is the case, for example, if bankruptcy risk influences the prices of the implicit Arrow-Debreu securities (see Auerbach [1982], p.53).

The term $a(\lambda)b$ in expression [8] is an agency cost due to bond covenants limiting both the real and financial activities of the firm. It is assumed that $a(0) = 0$, $a'() > 0$, and $a''() > 0$. As the debt-equity ratio rises, the covenants tighten since bondholders are at greater risk. The tightening of the covenants implies greater costs to the firm. The combination of this agency cost with the tax deductibility of interest payments yields an interior solution for the debt-equity ratio.

$\Psi(I,K)$ denotes the real cost to adjusting the capital stock. Both the production function and the adjustment cost function are linearly homogeneous. The production function exhibits positive but diminishing marginal productivities. It is also assumed that the adjustment cost function can be written as $h(I/K)I$ and has the following properties: $h(0) = 0$, $h'(0) > 0$, and $2h'(I/K) + (I/K)h'(I/K) > 0$. Thus, the total installation cost $h(I/K)I$ is convex, attaining its minimum when $I=0$. Expression C71 defines real gross profits as revenue, minus the wage bill and adjustment costs of investing. Expression [8] indicates that gross profits are split among interest, taxes, retained earnings, dividends, and the leverage related cost, $a(\lambda)b$.

Expression [9] indicates that investment either increases the capital stock or replaces worn-out capital. Expression [10] states initial conditions on the capital stock, the bond supply, and the equity supply. Expression [11] indicates that gross investment must be financed either through retained earnings, debt issue, or the decline in the real value of outstanding debt.[1] It is assumed that no additional equity is issued.

Manipulation of equalities C61 - [11], together with expression [5], yields a differential equation in the value of the firm that can be solved, subject to a transversality condition, to yield expression [12].

$$[12]\quad V_0 = b_0 + z_0 E_0 = \int_0^{\infty} \exp\left(-\int_0^{t} \Gamma(\tau)\,d\tau\right) \gamma(t)\,dt$$

Γ and γ are defined as follows:

$$[13]\quad \Gamma = \left[\frac{\lambda}{1+\lambda}\right]\left[\theta(1-\tau_p) - p^a\tau_p + a(\lambda)\right] + \left[\frac{\theta}{1+\lambda}\right]$$

$$[14]\quad \gamma = (1-\tau_p)[y - w\ell - \Psi(I,K)] - I$$

Formally, the firm's problem is to choose $\{ K_t, \ell_t, b_t \}_{t=[0,\infty)}$ so to maximize V_0.

The Government

The government's income statement identity is:

$$[15]\quad \dot{m} + p^a m + \tau_p [y - w\ell - \Psi(I,K) - sbl + \tau = g$$

The government sets the corporate tax rate (τ_p), the money growth rate $(\mu = \dot{m}/m)$, and its level of consumption (g), and allows the lump-sum tax (τ) to vary so as to satisfy the identity. I assume that g is exogenous and that consumers take the lump-sum tax as parametrically given.

Perfect Foresight Equilibrium

A perfect foresight equilibrium is a sequence of prices and quantities for which notional demands and supplies for bonds and equities are equal in the present and the future. This equilibrium is described by the optimality conditions C161 - [20], the definitions of θ and Γ (expressions C131 and [14]), and a material balance constraint (expression [21]).

The consumer's optimality condition is:

[16] $U_m(c,m)/U_c(c,m) = \theta + p^a$

The firm's optimality conditions are:

[17] $F_\ell = w$

[18] $q = 1 + (1 - \tau_p)[h(I/K) + (I/K)h'(I/K)]$

[19] $[\Gamma + \delta]q - (1 - \tau_p)\ [F_K + (I/K)^2 h'(I/K)] = \dot{q}$

[20] $a(\lambda) + a'(\lambda)\lambda(1+\lambda) = [\theta + p^a]\tau_p$

$\lim_{t\to\infty} \rho_t q_t K_t = 0 = \lim_{t\to\infty} \rho_t \Omega_t b_t$ (Transversality Condition)

where $\rho_t = \exp \int_0^t \Gamma(\tau)d\tau$

[21] $F(K,\ell) = c + g + \dot{K} + \delta K + h(I,K)I + a(\lambda)\lambda qK/(1+\lambda)$

Expression C161 states that the ratio of the marginal utility of cash to that of consumption equals the nominal interest rate. Expression C171 states that the firm equates marginal factor cost with marginal revenue product. Expression [18] states that marginal q, the shadow price of installed capital, differs from one by the after-tax decline in cash flow due to adjustment costs from investing. Expression [19] indicates that the shadow return from holding capital, q, plus the real after-tax increment to cash flow from an extra unit of capital, $(1 - \tau_p)(F_K - \Psi_K)$, must equal the required rate of return on capital, $(\Gamma + \delta)q$. Expression C201 is the first-order condition for the debt-equity ratio: $\partial\Gamma/\partial\lambda = 0$. It is straightforward to show that $\theta + p^a$ equals the nominal interest rate. Expression C201 indicates that an increase in the anticipated inflation rate increases the **debt-equity** ratio. Expression C21I is the material balance constraint.

Steady State

In the steady state, consumption, the capital stock, and the rate of inflation are constant. Thus the nominal money growth rate is constant and $p^a = \mu = \dot{m}/m$; the anticipated rate of inflation equals the money growth rate. These conditions imply that the steady state can be characterized by the following equations:

$$[22] \quad \frac{U_m[\,F(K,\ell) - \ldots.,\ m\,]}{U_c[\,F(K,\ell) - \ldots.,\ m\,]} = \beta + \mu$$

$$[23] \quad q = 1 + (1 - \tau_p)[h(\delta) + \delta h'(\delta)]$$

$$[24] \quad [\Gamma + \delta]q = (1 - \tau_p)\,[F_K + \delta^2 h'(\delta)]$$

$$[25] \quad a'(\lambda)\lambda(1+\lambda) + a(\lambda) = (\beta+\mu)\tau_p$$

$$[26] \quad \Gamma = \frac{\lambda}{1+\lambda}\,[\beta(1-\tau_p) - \mu\tau_p + a(\lambda)] + \frac{\beta}{1+\lambda}$$

$$[27] \quad F(K,\ell) = c + g + \delta K + h(\delta)\delta K + a(\lambda)\lambda qK/(1 + \lambda)$$

Comparative Statics of an Increase in the Money Growth Rate

Expressions **C241** and **C261** imply, respectively,

$$[28] \quad [\Gamma + \delta]\,\frac{\partial q}{\partial \mu} + q\,\frac{\partial[\Gamma + \delta]}{\partial \mu} = (1-\tau_p)F_{KK}\,\frac{\partial K}{\partial \mu}$$

$$[29] \quad \frac{\partial \Gamma}{\partial \mu} = [a(\lambda) + \lambda(1+\lambda)a'(\lambda) - \tau_p(\beta+\mu) - \lambda(1+\lambda)\tau_p]\,\frac{\partial \lambda}{\partial \mu}$$

From expression **C251** it is clear that an increase in the money-growth rate increases the steady-state interest rate $\beta + \mu$ and induces a higher debt-equity ratio: $\partial\lambda/\partial\mu > 0$. Expressions [25] and [29] imply $\partial\Gamma/\partial\mu < 0$. In addition, expression **C231** implies that q returns to its original steady-state level. In the long-run, the capital stock will increase although I/K will return to 6, the rate of physical depreciation of capital. Expression [28], together with $\partial q/\partial\mu = 0$ and $\partial\delta/d\mu = 0$, implies expression C301 and that the capital stock increases.

$$[30]\quad \frac{\partial K}{\partial\mu} = \left[\frac{\partial\Gamma}{\partial\mu}\right] \frac{q}{(1-\tau_p)F_{KK}}$$

The Model's Predictions of Causal Relations

Expressions [23] and C251 imply, respectively, that in the long-run, inflation has no effect on q, and that λ rises with an increase in inflation. In addition, in the long run inflation has no effect on I/K since I/K returns to 6.

Absence of long-run effect is equivalent to structural neutrality. The correspondence between the structural neutrality of X_t with respect to Y_t and the absence of feedback from X_t to Y_t at zero frequency is discussed in Geweke (1982a).

The model also implies predictions about instantaneous causality. Expression [20], the first-order condition for the debt-equity ratio implies that there will be instantaneous causality between inflation and the debt-equity ratio. Since nominal rather than real interest payments are tax deductible for corporations, a higher inflation rate will be associated with a higher debt-equity ratio. Expression C181 implies instantaneous causality between q and I/K. Expressions [13], [19], and C201 imply instantaneous causality between inflation and q, and between inflation and I/K. Expression [19] can be integrated, subject to the transversality condition, to show that

q_t is equal to the present value of future after-tax marginal products of capital net of adjustment costs. Expression [20] shows that the inflation rate, p^a, affects the debt-equity ratio and expression [13] indicates that the debt-equity ratio affects the cost of capital, Γ. Since inflation affects Γ, it affects q and thus I/K.

Corresponding to the predictions about instantaneous causality are predictions regarding the absence of directional feedback.' There should be no directional feedback between inflation and X, between inflation and q, between inflation and I/K, or between q and I/K.

Both Modigliani and Cohn (1979) and Summers (1983) suggest that the short-run relations between inflation and q, between inflation and X, and between inflation and I/K may differ from their long-run counterparts. The null hypotheses that there are no short-run feedbacks from inflation to X, from inflation to q, or from inflation to I/K are tested.

In addition, expression [18], implies that there is no feedback from the vector comprised of λ and inflation to the vector comprised of q and I/K, and that there is no instantaneous feedback between the vector comprised of X and inflation to the vector comprised of q and I/K.

Methodology

Estimation of vector autoregressions requires a choice of lag length. Rather than choose one lag length for the estimation, several lag lengths are utilized, and the sensitivity of the results with respect to the lag length is discussed. Since the data are quarterly, lag lengths of 2, 4, and 8 are used.

In order that the series analyzed be indeterministic, constant effects are removed by regressing each series ($\Delta \ln K_t$, $\Delta \ln P_t$, q_t, and λ_t; A is the first difference operator) on a constant and before analyzing the residuals. Much recent work has indicated that first-differencing is to be preferred to trend-removal as a prewhitening procedure. In particular, Nelson and Kang (1981) have pointed out that inclusion of a time trend rather than first-differencing can introduce 'spurious periodicity.' Kang (1985) has shown that detrending can alter the results of Granger causality tests.

In order to choose between first differencing and including trends in the estimation, a test developed by Dickey and Fuller (1979) is applied. Each series is regressed on a constant, itself lagged one period, and an arbitrary number of lagged first differences. Fuller (1976) has tabulated the distribution of the test statistic for the hypothesis that there is a unit root. If that hypothesis cannot be rejected, the series are differenced and then the test is applied to the differenced series.

The estimates of the overall measures of feedback can be evaluated with the χ^2 distribution if the disturbances u_1, u_2, v_1, and v_2 in expressions C331 and C341 are i.i.d. There is obviously small sample bias, however, since by construction the feedback measures are nonnegative. A procedure developed by Geweke (see Geweke [1986], pp.9-10) is employed to adjust the feedback measures and their frequency decompostion for small sample bias. This procedure yields adjusted point estimates and 60 percent confidence intervals. The width of the confidence intervals is chosen in recognition of the small sample available.

Interpretation of the estimates of feedback is difficult for two reasons. First, there is no clear-cut criterion to choose lag length. Second, even the confidence intervals constructed with the small sample adjustment exceed zero. Thus it is hard to test hypotheses claiming that feedback is zero.

Since there is no clear-cut criterion available to choose lag length, the feedback measures for different lag lengths are evaluated. Ambiguity arising from the necessity of looking at more than one lag length is more severe with the frequency decompositions than with regard to the overall measures of feedback. The unadjusted overall measures of feedback can be evaluated with the $\chi^2(j)$ distribution, where j is the lag length. However, there is no asymptotic distribution theory available with which to evaluate the unadjusted estimates of $f(X\to Y)[\omega]$. In addition, these estimates may fluctuate with lag length. Two conventions are adopted to deal with this ambiguity. First, conclusions valid for all lag lengths are emphasized. Second, the null hypothesis that there is no feedback is rejected only if feedback is significant for all lag lengths.

Since there is no asymptotic distribution theory available for the unadjusted estimates of $f(X\to Y)[\omega]$, confidence intervals constructed with the small sample bias adjustment are utilized. Feedback is considered significant if the left-hand endpoint of the confidence interval is greater than or equal to .05193. This level corresponds to feedback from X to Y explaining 5 percent of the variance in Y.

For the overall measures of feedback, the χ^2 statistics for the unadjusted estimates are presented, as well as the confidence intervals from the small sample adjustment.[3] Feedback will be considered significant if the χ^2 statistic is significant at the .90 level and if the left-hand endpoint of the confidence interval exceeds .05193.

Besides the initial estimates and the adjusted estimates with confidence intervals, the transformations, $1-\exp(F[X \rightarrow Y])$, $1-\exp(F[Y \rightarrow X])$, and $1-\exp[F(X \rightarrow Y)[\omega]]$ are presented. These yield the proportion of variance in Y explained by feedback from X to Y, the proportion of variance in X explained by feedback from Y to X, and the proportion of variance in Y explained by feedback from X to Y at frequency ω, respectively. Only the results of applying these transformations to the adjusted point estimates is reported.[4]

Evaluation of predictions concerning short-run feedback is made difficult by the fact that 'short-run' does not correspond to any particular frequency. Frequencies have been chosen corresponding to 4, 8, 12, and 16 quarters, as well as ten frequencies that are evenly spaced between 0π and 1.0π.

For the tests of the q theory (tests of the hypotheses that: (1) q and investment instantaneously cause each other but do not Granger-cause each other and that, (2) the vector comprised of inflation and the debt-equity ratio does not cause the vector comprised of q and investment) only unadjusted estimates are reported. This makes the results comparable to results of studies not employing a small sample bias adjustment.

Results

Based on the results of the Dickey-Fuller test for unit roots, the hypotheses that there are unit roots in the autoregressive representations of $\Delta\ln(K_t)$, $\Delta\ln(P_t)$, q_t, and λ_t cannot be rejected. Once each of these series is differenced, however, $\tau(\rho_1)$ is significant, indicating that the series should not be differenced again (tabulation of the results of these tests are available from the author). Accordingly, the measures of feedback are estimated with the second differences of the logarithms of the price level ($\Delta\Delta P_t$) and the capital stock ($\Delta\Delta K_t$), the first difference of q_t (Δq_t), and the first difference of λ_t (AX,).

Tables 1A and 1B pertain to the evaluation of the prediction that, in the long-run, an increase in inflation has no effect on the debt-equity ratio. In Table 1A, the adjusted estimates of feedback from inflation to q are reported. Table 1B reports the proportion of variance in Aq explained by feedback from $\Delta\Delta p$ to Aq, the proportion of variance in $\Delta\Delta p$ explained by feedback from Aq to $\Delta\Delta p$, and the frequency decomposition of the proportion of variance in Aq explained by feedback from $\Delta\Delta p$ to Aq. It is clear that lag length affects the results. Inflation is structurally neutral with respect to q with lag lengths of 2 and 4, but not 8. Table 2B indicates that when the lag length is 8, feedback from inflation to q explains over 23 percent of the long-run variation in q. The comparative static multiplier reported in Table 7 is negative, indicating that an increase in inflation decreases the long-run level of q. However, only with a lag length of 8 is this decrease significant according to the criteria adopted here.

The prediction that an increase in inflation increases the long-run level of the debt-equity ratio is evaluated with the results reported in Tables 3A and 3B. There is no feedback with a lag length of 2. There is long-run feedback with a lag length of 8, but not 4. Long-run feedback from inflation to λ explains 25.84 percent of the variation in the debt-equity ratio with a lag length of 8. From Table 7 it is clear that an increase in inflation increases the long-run debt-equity ratio with lag lengths of 4 and 8, but not 2. Thus the only evidence of higher inflation leading to significantly higher long-run λ occurs when the lag length equals 8.

The results displayed in Tables 3A and 3B indicate that there. is no long-run feedback from inflation to I/K regardless of lag length.

The unadjusted estimates of instantaneous feedback reported in Table 5 indicate that at no lag length is there instantaneous feedback between inflation and q, between inflation and 1, or between inflation and I/K. The confidence intervals based on the small sample adjustments confirm this conclusion.

The results reported in Tables 2A and 5 support the prediction that there is no directional feedback between inflation and λ. Table 2A shows that for no lag length is there significant feedback from inflation to λ or from λ to inflation. This conclusion also follows from the unadjusted estimates reported in Table 5. Tables 1A and 5 provide mixed evidence regarding the prediction that there is no directional feedback between inflation and q. In Table 1A we see that there is no significant directional feedback between inflation and q. Table 5, however, reports that there is feedback from inflation to q at the .900 level with lag lengths of 4 or 8. Tables 3A and 5 provide mixed evidence regarding the prediction that there is no directional feedback between inflation and I/K. In Table 3A, we see that there is no directional feedback between inflation and I/K, except with a lag length of 8. Inflation Granger-causes I/K when the lag length is 8. According to Table 5, this feedback is significant at the .900 level.

The χ^2 statistics for the unadjusted measures of directional feedback between q and I/K are reported in Table 7. Tobin's q causes I/K at the .975 level for all lag lengths. I/K does not cause q. The prediction that there is no directional feedback between q and I/K is not supported by the data.

Evaluating predictions regarding the short-run is difficult since 'short-run' does not correspond to a particular frequency. If 'short-run' means less than 8 quarters, then there is feedback from inflation to X (see Table 2A). At 10, 12, 16, or 20 quarters, however, there is feedback with a lag length of 8. Similar results apply to the inflation-q relation. Table 2A indicates that there is no feedback from inflation to q at less than 10 quarters with any lag length. There is feedback at all periodicities exceeding 10 quarters when the lag length is 8. Essentially the same results hold for the inflation-I/K relation. Inflation causes I/K only with a lag length of 8 and at periodicities of at least 8 quarters.

The results reported in Table 6 indicate that there is feedback from the vector comprised of X and inflation to the vector comprised of q and I/K only when the lag length is 8 and the significance level is .90. At all lag lengths, there is instantaneous feedback between the vector comprised of X and inflation to the vector comprised of q and I/K.

Conclusions

It cannot be concluded that inflation has long-run effects on financial markets. Only with a lag length of 8 are there long-run effects on q and λ. Regardless of lag length, inflation has no long-run impact on investment.

It also cannot be concluded that there are instantaneous feedbacks between inflation and q, X, or I/K. Only with a lag length of 8 is there short-run feedback from inflation to q or I/K. Regardless of lag length, inflation has no short-run impact on λ.

Since the findings could be characterized as showing that the variables examined are simply unrelated, Tables 5 and 6 report the χ^2 statistics for the unadjusted estimates of the measures of linear dependence. The measure of linear dependence F(X,Y), is the sum of $F(X\rightarrow Y)$, $F(Y\rightarrow X)$, and $F(X\cdot Y)$. F(X,Y) equals zero only if X and Y are uncorrelated at all leads and lags. Tables 5 and 6 report the χ^2 statistics for the estimated measures of linear dependence. For almost all the relations investigated there is linear dependence at the .900 level. Only for the inflation-X relation at a lag length of 4 is there no linear dependence.

The long-run decline in q found when the lag length is 8 may be explained by the omission of tax effects from the empirical analysis. Feldstein (1980) claimed that biases in the tax laws may have impaired investment in inflationary periods. Jorgenson and Sullivan (1981) showed that higher inflation would increase the effective corporate tax rate under the tax laws prevailing from 1946 to 1980. Thus it could be that τ_p, the corporate tax rate, did not remain constant over the sample period. It is clear from the first order condition for investment, expression [23], that an increase in τ_p results in a lower long-run q but produces no long-run change in I/K. The presence of feedback from inflation to q and I/K with some lag lengths, however, cannot easily be explained by the omission of tax effects. If taxes affect q or I/K but not inflation, then the unconditional measure of feedback from inflation to q or I/K would be upwardly biased (see Geweke [1982b]). Upward bias in the estimates of feedback from inflation to q or I/K would result if taxes affected inflation but not q or I/K. This latter scenario seems unlikely.

One possible source of measurement error is the use of actual inflation rather than expected inflation. McCallum (1984) has emphasized that, even in the long-run, expectations may not equal realizations. In Tables 4A, 4B, and 5, I provide evidence regarding the causal relations among actual inflation (measured with the CPIU) and expected inflation. The expectations series is from the Michigan Survey of Households and represents the expected rate of change of the CPIU over the next 12 months. At low frequencies, feedback from actual inflation to expected inflation accounts for a substantial portion of the variation in actual inflation. This is a rough indication that the bivariate relations of inflation and q, inflation and λ, and inflation and I/K are more likely to correspond to relations involving expected inflation at low than at high frequencies.

Another possible source of measurement error is the difficulty in measuring the denominator of q, the replacement value of the stock of physical capital. If measurement errors are uncorrelated with true variables at all leads and lags, the existence of measurement error will result in an understatement of the overall measure of linear dependence. The effect on individual feedback measures is generally ambiguous.

Overall, the results cast doubt on the usefulness of the q theory. There is instantaneous causality between the pairs; q-I/K and inflation-A, but not between q and I/K. Both of these results and the finding that q Granger-causes I/K are inconsistent with the q theory. The results are also inconsistent with the view that changes in inflation induce firms to vary their debt-equity ratios so as to minimize the cost of capital. Inflation doesn't influence the debt-equity ratio in either the short- or long-run.

Suggestions for Future Research

Before further analyzing the relations examined in this paper, it is necessary to explain the generally low levels of feedback. Use of actual expectations data may reduce measurement error. If this can be accomplished, then it may be worthwhile to introduce taxes in the empirical analysis.

The failure of q to incorporate all information contained in current values of inflation and the debt-equity ratio suggests further research on the influence of financial structure and inflation on q. One possible avenue of research would be to incorporate financial structure into a model such as Fischer's (1983) where q Granger-causes I/K due to lags in the investment process.

Development of a structural model capable of explaining the results may be fruitful. A useful guide to such work may be found in the signs of the comparative statics multipliers reported in Table 7. In the long-run, an increase in inflation increases the debt-equity ratio, decreases q, and increases I/K. In addition, an increase in q leads to an increase in I/K and an increase in I/K leads to a decrease in q. Inflation is lowered by increases in either I/K or λ. An increase in q increases inflation. Not all of these effects, of course, are statistically significant.

Glossary of Terms

c_t = real private consumption

P_t = the price level

p_t = rate of change of P; $p = \dot{P}/P$.

p_t^a = instantaneous anticipated rate of inflation

B_t = nominal corporate bonds

b_t = real corporate bonds; $b_t = B_t/P_t$

M_t = nominal money balances

m_t = real balances; $m_t = M_t/P_t$

β = rate of time preference

w_t = real wage rate

ℓ_t = real employment

s_t = nominal interest rate on corporate bonds

Div_t = real dividends

d_t = dividend payout rate; $d_t = Div_t/z_tE_t$

z_t = relative price of equity in terms of output

E_t = the number of shares of equity

θ = the rate of return on consumption; $8 = \beta - U_{cc}\dot{c}/U_c$

I_t = real investment expenditures

K_t = real stock of physical capital

Γ_t = the cost of capital as derived in the text

γ_t = the cash flow of the firm

y_t = real output

Π_t = real gross profits

$\Psi(I,K)$ = real adjustment cost from investment

τ_P = corporate profits tax rate

RE_t = retained earnings

λ_t = the debt to equity ratio; $\lambda = b/zE$

$a(\lambda)b$ = cost of maintaining the bond portfolio

δ = the rate of depreciation of the physical capital stock

τ = the lump sum tax

g = real government expenditure on goods

q_t = shadow price of physical capital (Tobin's q)

μ_t = the growth rate of real balances; $\mu = \dot{m}/m$

Footnotes

[1] This treatment of the effect of inflation on firm value follows that of Modigliani and Cohn (1979). They rationalize the appearance of such a term by equating it with the repayment of the principal made possible by inflation. Note that, from expressions [12], [13], and [14], the value of the firm is unaffected by inflation in the absence of a deduction for nominal interest payments.

[2] The absence of lagged values in the first-order conditions implies that past values should not help predict, given current values. Suppose that an unanticipated change in the corporate tax rate immediately increased q and I/K. Immediately after the shock, past values of q and I/K would not reflect the new information contained in current q. Thus, current q could be expected to add to the ability of past q and past I/K to predict I/K.

Suppose that both q and I/K have been increasing as K rises. Given perfect foresight, at each point in time the level of q is sufficient to predict I/K. Thus, past values of I/K will not help predict I/K, given past values of q. Past values of I/K contain the same information as past q, and thus past q should not add to the ability of past I/K to predict I/K.

[3] The χ^2 statistics for the original point estimates are provided to facilitate comparison of these results with the results of research conducted without the benefit of a small sample bias adjustment.

[4] Ideally, I would report confidence intervals for the (nonlinear) transformations of the feedback measures. Here, however, I report the results of applying the nonlinear transformation to the confidence intervals. The two types of confidence intervals, of course, need not be the same.

Data

All data are quarterly and seasonally adjusted for nonfinancial corporations (NFCs) from the first quarter of 1952 through the fourth quarter of 1984.

q: The q series through 1976 is from Von Furstenberg (1977). Von Furstenberg has supplied me with data from 1977 through 1984. I have removed the replacement value of land from the denominator. Von Furstenberg (1977) provides a detailed description of his calculation of q.

λ: The debt-equity ratio is the market value of interest bearing financial liabilities divided by the market value of equity. Both series are from Von Furstenberg.

P: I utilize the GNP deflator published by the Bureau of Economic Analysis (BEA).

K: The real net capital stock is calculated by the perpetual inventory formula: $K_t = K_{t-1} + (1-\delta)I_{t-1}$. I calculate series for structures and equipment separately and add the two together. For each series, I utilize the end-of-1951 and end-of-1984 constant dollar net stock figures for NFCs (BEA) and the constant dollar gross expenditure series, I_t (billions of 1967 dollars, also from BEA). Given the end-of-1951 stock and the gross investment series, my estimate of δ yields the actual end-of-1984 stock via the perpetual inventory formula. The constant dollar net investment series is $(1-\delta)I_t$ where I_t is the gross investment series. For conformity with the Von Furstenberg data, I center the capital stock series on the middle of each quarter.

Explanations of Tables 1A – 7

For all estimates, the number of observations is 131 – lag length.

Tables 1A, 2A, 3A, and 4A report the estimated measures of feedback adjusted for small sample bias as discussed in Geweke (1986, pp. 9–10). The left-hand and right-hand end points of the 60% confidence intervals are listed under the columns labelled "20%" and "80%" respectively. For the decomposition of feedback from X to Y by frequency, the column labelled "ω" indicates the frequency in radians at which the feedback is evaluated (0π to 1.0π) and the column labelled "$2\pi/\omega$" indicates the corresponding periodicity in quarters.

Tables 1B, 2B, 3B, and 4B report transformations of the point estimates presented in tables 1A, 2A, 3A, and 4A respectively. These transformations are:

1) $1-\exp[F(X\rightarrow Y)]$, which equals the percentage of variation in Y explained by feedback from X to Y;

2) $1-\exp[F(Y\rightarrow X)]$, which equals the percentage of variation in X explained by feedback from Y to X; and

3) $1-\exp(f[X\rightarrow Y][\omega])$, which equals the percentage of variation in Y at frequency w explained by feedback from X to Y at frequency w.

Table 5 reports the χ^2 statistics for the unadjusted point estimates of $F(X\rightarrow Y)$, $F(Y\rightarrow X)$, and $F(X\cdot Y)$ when the X–Y pairs are: 1) inflation and q; 2) inflation and X; 3) inflation and I/K; and 4) the actual rate of change of the CPIU and the expected rate of change of the CPIU.

Table 6 presents the χ^2 statistics for the feedback measures for the tests of the q theory. The X–Y pairs in this table are: 1) I/K and q; and 2) the vector comprised of q and I/K and the vector comprised of λ and inflation.

Table 7 reports the comparative statics multipliers for the bivariate autoregressions of q and inflation, λ and inflation, and I/K and inflation, respectively.

Table 1A

Estimates of Feedback: Inflation and Tobin's q

X_t: $\Delta\Delta \ln(P_t)$
Y_t: Δq_t

		2 Lags			4 Lags			8 Lags		
		(20%)		(80%)	(20%)		(80%)	(20%)		(80%)
$\hat{F}(X \to Y)$		.005	.016	.028	.029	.051	.069	.040	.067	.086
$\hat{F}(Y \to X)$		.000	.003	.008	.005	.009	.013	.007	.009	.013
$\hat{F}(X \cdot Y)$		.000	.000	.000	.000	.000	.000	.000	.000	.000
$\hat{f}(X \to Y)[\omega]$										
ω	$2/\omega$									
0		.000	.004	.007	.046	.113	.183	.166	.266	.341
.1	20.0	.000	.004	.007	.043	.107	.168	.163	.307	.445
	16.0	.000	.004	.007	.041	.104	.161	.141	.288	.412
	12.05	.000	.004	.008	.036	.094	.148	.086	.205	.343
	11.98	.000	.004	.008	.036	.094	.150	.084	.203	.340
.2	10.0	.001	.001	.009	.036	.084	.136	.051	.129	.216
	8.0	.001	.005	.009	.024	.066	.115	.016	.044	.065
.3	6.7	.001	.006	.011	.017	.046	.084	.001	.003	.005
.4	5.0	.002	.009	.016	.003	.016	.018	.000	.001	.003
.5	4.0	.004	.016	.033	.000	.000	.000	.001	.002	.003
.6	3.0	.008	.029	.062	.011	.028	.054	.002	.009	.015
.7	2.9	.011	.038	.067	.052	.110	.170	.053	.175	.272
.8	2.5	.007	.031	.055	.043	.077	.111	.003	.009	.015
.9	2.2	.005	.024	.044	.008	.021	.032	.004	.011	.015
		.004	.022	.042	.001	.007	.011	.008	.058	.082

Table 1B

Transformations
of
Point Estimates in Table 2A

X_t: $\Delta\Delta \ln(P_t)$
Y_t: Δq_t

Lags:		2	4	8
$1-\exp[-\hat{F}(X\rightarrow Y)]$		1.597	4.972	6.480
$1-\exp[-\hat{F}(Y\rightarrow X)]$		0.300	8.960	0.896
$1-\exp[-\hat{F}(X\cdot Y)]$		0.000	0.000	0.000
$1-\exp(-\hat{f}(X\rightarrow Y)[\omega])$				
ω	$2/\omega$			
0		0.399	10.684	23.356
.1	20.0	0.399	10.147	26.435
	16.0	0.399	9.877	25.024
	12.05	0.399	8.972	18.535
	11.98	0.499	6.387	4.305
.2	10.0	0.100	8.057	12.103
	8.0	0.499	6.387	4.305
.3	6.7	0.598	4.496	0.300
.4	5.0	0.896	0.996	0.100
.5	4.0	1.587	0.000	0.200
.6	3.3	2.858	2.761	0.896
.7	2.9	3.729	10.417	16.054
.8	2.5	3.052	7.411	0.896
.9	2.2	2.371	2.078	1.094
1	2.0	2.176	0.698	5.635

Table 2A

Estimates of Feedback: Inflation and the Debt-Equity Ratio

X_t: $\Delta\Delta \ln(P_t)$
Yt: $\Delta\lambda_t$

		2 Lags			4 Lags			8 Lags		
		(20%)		(80%)	(20%)		(80%)	(20%)		(80%)
$\hat{F}(X\to Y)$		.000	.000	.000	.011	.018	.029	.034	.052	.068
$\hat{F}(Y\to X)$		.007	.010	.013	.003	.007	.010	.001	.011	.017
$\hat{F}(X\cdot Y)$		.000	.000	.000	.000	.000	.000	.000	.000	.000
$\hat{f}(X\to Y)[\omega]$										
$\underline{\omega}$	$\underline{2/\omega}$									
0		.000	.000	.000	.009	.052	.097	.139	.299	.369
.1	20.0	.000	.000	.000	.010	.053	.101	.194	.356	.473
	16.0	.000	.000	.000	.010	.053	.100	.226	.345	.450
	12.05	.000	.000	.000	.011	.051	.094	.158	.246	.321
	11.98	.000	.000	.000	.011	.051	.094	.156	.243	.320
.2	10.0	.000	.000	.000	.012	.048	.090	.080	.130	.192
	8.0	.000	.000	.000	.013	.041	.076	.010	.025	.038
.3	6.7	.000	.000	.000	.010	.032	.059	.000	.001	.002
.4	5.0	.000	.000	.000	.006	.017	.028	.001	.002	.004
.5	4.0	.000	.000	.000	.002	.009	.012	.002	.008	.014
.6	3.3	.000	.000	.000	.002	.008	.011	.001	.006	.010
.7	2.9	.000	.000	.000	.004	.011	.018	.001	.007	.012
.8	2.5	.000	.000	.000	.001	.005	.007	.000	.000	.000
.9	2.2	.000	.000	.000	.000	.000	.001	.002	.010	.018
1	2.0	.000	.000	.000	.000	.000	.000	.004	.036	.069

Table 2B

Transformations
of
Point Estimates in Table 3A

X_t: $\Delta\Delta\ln(P_t)$
Y_t: $\Delta\lambda_t$

Lags:		2	4	8
$1-\exp[-\hat{F}(X\to Y)]$		0.000	1.784	5.067
$1-\exp[-\hat{F}(Y\to X)]$		0.000	0.698	1.094
$1-\exp[-\hat{F}(X\bullet Y)]$		0.000	0.000	0.000
$1-\exp(-\hat{f}(X\to Y)[\omega])$				
ω	$2/\omega$			
0		0.000	5.067	25.844
.1	20.0	0.000	5.162	29.953
	16.0	0.000	5.162	21.808
	12.05	0.000	4.972	21.573
	11.98	0.000	4.972	2.469
.2	10.0	0.000	4.687	12.190
	8.0	0.000	4.107	2.469
.3	6.7	0.000	3.149	0.100
.4	5.0	0.000	1.686	0.200
.5	4.0	0.000	0.896	0.797
.6	3.3	0.000	0.797	0.598
.7	2.9	0.000	1.094	0.698
.8	2.5	0.000	0.499	0.000
.9	2.2	0.000	0.000	0.996
1	2.0	0.000	0.000	3.536

Table 3A

Estimates of Feedback: Inflation and I/K

X_t: $\Delta\Delta \ln(P_t)$
Y_t: $\Delta\Delta \ln(K_t)$

		2 Lags			4 Lags			8 Lags		
		(20%)		(80%)	(20%)		(80%)	(20%)		(80%)
$\hat{F}(X\to Y)$		.001	.005	.010	.003	.009	.020	.059	.079	.103
$\hat{F}(Y\to X)$		.007	.008	.013	.020	.032	.039	.028	.047	.063
$\hat{F}(X\bullet Y)$		.000	.000	.000	.000	.023	.040	.008	.024	.038
$\hat{f}(X\to Y)[\omega]$										
ω	$2/\omega$									
0		.001	.005	.009	.000	.007	.014	.010	.053	.089
.1	20.0	.001	.005	.009	.001	.008	.015	.066	.121	.163
	16.0	.001	.005	.009	.001	.009	.015	.081	.149	.216
	12.05	.001	.005	.009	.001	.010	.018	.092	.194	.305
	11.98	.001	.005	.009	.001	.010	.018	.093	.195	.308
.2	10.0	.001	.006	.009	.001	.011	.018	.099	.217	.331
	8.0	.002	.006	.010	.002	.014	.021	.076	.185	.261
.3	6.7	.002	.007	.012	.003	.016	.027	.026	.090	.159
.4	5.0	.003	.008	.015	.003	.020	.042	.000	.002	.002
.5	4.0	.004	.011	.019	.002	.019	.032	.023	.066	.115
.6	3.0	.004	.012	.020	.000	.008	.012	.001	.009	.016
.7	2.9	.003	.008	.012	.000	.001	.002	.009	.021	.037
.8	2.5	.001	.002	.003	.000	.001	.002	.027	.063	.113
.9	2.2	.000	.000	.000	.000	.004	.007	.027	.088	.123
1	2.0	.000	.000	.000	.000	.005	.010	.066	.198	.305

Table 3B

Transformations of Point Estimates in Table 4A

X_t: $\Delta\Delta\ln(P_t)$
Y_t: $\Delta\Delta\ln(K_t)$

Lags:		2	4	8
$1-\exp[-\hat{F}(X\to Y)]$		0.797	0.898	7.596
$1-\exp[-\hat{F}(Y\to X)]$		0.797	3.149	4.591
$1-\exp[-\hat{F}(X\cdot Y)]$		0.000	2.274	2.371
$1-\exp(-\hat{f}(X\to Y)[\omega])$				
ω	$2/\omega$			
0		0.499	0.698	5.162
.1	20.0	0.499	0.797	11.397
	16.0	0.499	0.896	13.843
	12.05	0.499	0.996	17.634
	11.98	0.499	0.996	17.717
.2	10.0	0.598	1.094	19.507
	8.0	0.598	0.996	16.890
.3	6.7	0.698	1.587	8.607
.4	5.0	0.797	1.980	0.200
.5	4.0	1.094	1.882	6.387
.6	3.3	1.193	0.797	0.896
.7	2.9	0.797	0.100	2.078
.8	2.5	0.200	0.100	6.106
.9	2.2	0.000	0.399	8.424
1	2.0	0.000	0.499	17.963

Table 4A

Estimates of Feedback: Actual and Expected Rates of Change of the CPIU

X_t: Admp,
Y_t: Δdmp_t^a

		2 Lags			4 Lags			8 Lags		
		(20%)		(80%)	(20%)		(80%)	(20%)		(80%)
$\hat{F}(X\rightarrow Y)$		.073	.110	.145	.246	.311	.375	.250	.323	.410
$\hat{F}(Y\rightarrow X)$		.019	.034	.045	.030	.051	.073	.015	.034	.045
$\hat{F}(X\cdot Y)$		.000	.000	.000	.000	.000	.000	.000	.000	.000
$\hat{f}(X\rightarrow Y)[\omega]$										
ω	$2/\omega$									
0		.315	.525	.669	.923	1.191	1.403	.471	.925	1.328
.1	20.0	.249	.388	.543	.962	1.319	1.607	2.056	2.764	3.180
	16.0	.219	.336	.484	.880	1.283	1.599	2.034	2.629	3.064
	12.05	.166	.260	.369	.744	1.027	1.449	.339	.722	.916
	11.98	.166	.258	.368	.738	1.018	1.437	.326	.699	.886
.2	10.0	.132	.209	.293	.495	.718	.947	.159	.269	.347
	8.0	.095	.153	.223	.238	.354	.437	.080	.137	.204
.3	6.7	.069	.115	.167	.097	.158	.217	.084	.138	.196
.4	5.0	.042	.070	.101	.011	.032	.047	.034	.114	.171
.5	4.0	.028	.046	.064	.005	.020	.027	.015	.059	.092
.6	3.0	.019	.031	.040	.025	.055	.071	.067	.108	.167
.7	2.9	.012	.019	.026	.061	.147	.182	.034	.072	.114
.8	2.5	.006	.010	.014	.025	.064	.088	.000	.001	.002
.9	2.2	.001	.003	.005	.002	.006	.008	.003	.018	.029
1	2.0	.000	.001	.002	.000	.000	.000	.001	.010	.016

Table 4B

Transformations of Point Estimates in Table 5A

X_t: Δdmp_t
Y_t: Δdmp^a_t

Lags:		2	4	8
$1-\exp[-\hat{F}(X\rightarrow Y)]$		10.417	26.729	27.603
$1-\exp[-\hat{F}(Y\rightarrow X)]$		3.343	4.972	3.343
$1-\exp[-\hat{F}(X\bullet Y)]$		0.000	0.000	0.000
$1-\exp(-\hat{f}(X\rightarrow Y)[\omega])$				
ω	$2/\omega$			
0		40.844	69.608	60.347
.1	20.0	32.159	73.260	93.347
	16.0	28.538	72.280	92.785
	12.05	22.895	64.192	51.422
	11.98	22.740	63.868	50.292
.2	10.0	18.860	51.227	23.586
	8.0	14.187	29.813	12.803
.3	6.7	10.863	14.615	12.890
.4	5.0	6.761	3.149	10.774
.5	4.0	4.496	1.980	5.729
.6	3.3	3.052	5.351	10.237
.7	2.9	1.882	13.671	6.947
.8	2.5	0.996	6.200	0.100
.9	2.2	0.300	0.598	1.784
		0.100	0.000	0.996

Table 5

χ^2 Statistics for the Unadjusted Estimates of Feedback

Lags:	X_t	Y_t	2	4	8
	$\Delta\Delta\ln(p_t)$	Δq_t			
$n\hat{F}(X\to Y)$			4.061	9.417 *	13.75 *
$n\hat{F}(Y\to X)$			0.786	2.193	3.375
$n\hat{F}(X\cdot Y)$			0.131	0.000	0.000
$n\hat{F}(X,Y)$			4.978 **	11.610 ***	17.125 **
	$\Delta\Delta\ln(P_t)$	$\Delta\lambda_t$			
$n\hat{F}(X\to Y)$			0.000	3.870	11.500
$n\hat{F}(Y\to X)$			1.965	2.838	4.250
$n\hat{F}(X\cdot Y)$			0.131	0.258	0.250
$n\hat{F}(X,Y)$			2.096 *	6.966	16.000 **
	$\Delta\Delta\ln(P_t)$	$\Delta\Delta\ln(K_t)$			
$n\hat{F}(X\to Y)$			2.096	2.322 *	13.500
$n\hat{F}(Y\to X)$			1.965	6.579	8.375
$n\hat{F}(X\cdot Y)$			1.048	2.967	4.000
$n\hat{F}(X,Y)$			5.109 *	11.868 ***	25.875 ****
	$dmp_t - dmp_{t-1}$	$dmp^a_t - dmp^a_{t-1}$			
$n\hat{F}(X\to Y)$			17.685 ****	38.824 ****	42.750 ****
$n\hat{F}(Y\to X)$			5.633 *	8.514	8.500
$n\hat{F}(X\cdot Y)$			0.000	0.258	0.125
$n\hat{F}(X,Y)$			23.318 ****	47.596 ****	51.375 ****

*, **, ***, **** : significant at the .900, .950, .975, .990 levels, respectively

Table 6

χ^2 Statistics for Estimates of Feedback: Tests of the q-theory

Lags:	2	4	8
X_t: Δq_t Y_t: $\Delta\Delta \ln(K_t)$			
$n\hat{F}(X \rightarrow Y)$	15.458 ****	18.834 ****	19.250 ***
$n\hat{F}(Y \rightarrow X)$	3.930	4.773	9.000
$n\hat{F}(X \bullet Y)$	0.000	0.000	0.125
$n\hat{F}(X,Y)$	19.388 ****	23.607 ****	28.375 ****
X_t: $[\Delta\Delta \ln(P_t), \Delta\lambda_t]$ Y_t: $[\Delta\Delta \ln(K_t), \Delta q_t]$			
$n\hat{F}(X \rightarrow Y)$	8.568	12.627	44.440 *
$n\hat{F}(Y \rightarrow X)$	15.797 **	37.778 ****	44.940 *
$n\hat{F}(X \bullet Y)$	95.319 ****	92.592 ****	94.458 ****
$n\hat{F}(X,Y)$	119.684 ****	142.997 ****	183.838 ****

* : significant at the .900 level
** : significant at the .950 level
*** : significant at the .975 level
**** : significant at the .990 level

Table 7

Comparative Statics Multipliers

Comparative Statics Multipliers for Inflation-q:

lag length:	2	4	8
inflation→q:	-1.9799	-8.2491	-15.6383
q→inflation:	0.0044	0.0136	0.0088

Comparative Statics Multipliers for Inflation-A:

lag length:	2	4	8
inflation→λ	-0.0459	4.3536	12.6364
λ→inflation	-0.0072	0.0014	0.0119

Comparative Statics Multipliers for Inflation-IIK:

lag length:	2	4	8
inflation→I/K	0.0226	0.0259	0.0618
I/K→inflation	0.7440	1.4200	2.0311

References

Auerbach, Alan J. "Taxation, Corporate Financial Policy and the Cost of Capital." National Bureau of Economic Research Working Paper No. 1026, November 1982.

Brock, William A., and Stephen J. Turnovsky. "The Analysis of Macroeconomic Policies in Perfect Foresight Equilibrium." International Economic Review, vol. 22, no. 1, (February 1981) pp. 179-209.

Cordes, Joseph J., and Stephen M. Sheffrin. "Estimating the Tax Advantage of Corporate Debt." Journal of Finance vol. 38, no. 1 (March 1983) pp. 95-105.

Dickey, David A., and Wayne A. Fuller. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." Journal of the American Statistical Association. vol. 74, no. 366, Theory and Methods Section, (June 1979) pp. 427-431.

Engle, Robert F. "Band Spectrum Regression." International Economic Review. vol. 15, no. 1 (February 1974) pp. 1-11.

Feldstein, Martin, and Lawrence Summers. "Inflation, Tax Rules, and the Long-Term Interest Rate,". Brookings Papers on Economic Activity, 1:1978, pp. 61-99.

Fischer, Stanley. 1983. A Note on Investment and Lagged Q. Massachusetts Institute of Technology. December. Processed.

Fisher, Irving. The Theory of Interest. New York: MacMillan, 1930.

Friedman, Milton. The Optimum Quantity of Money and other Essays. Chicago: Aldine Publishing Co., 1969.

Fuller, Wayne A. Introduction to Statistical Time Series. New York: John Wiley and Sons, 1976.

Geweke, John. (1982a.) "Measurement of Linear Dependence and Feedback Between Multiple Time Series," Journal of the American Statistical Association, vol. 77, no. 378 (June 1982) pp. 304-324.

Geweke, John. (1982b). Inference and Causality in Economic Time Series Models. Social Systems Research Institute Working Paper No. 8219. August 1982. Madison, Wisconsin.

Geweke, John. (1986). "The Superneutrality of Money in the United States: An Interpretation of the Evidence." Econometrica, vol. 54, no. 1 (January 1986), pp. 1-21.

Gordon, Roger H., and Burton G. Malkiel. "Corporation Finance." in How Taxes Affect Economic Behavior, Brookings Institution. Henry J. Aaron and Joseph A. Pechman editors, Washington, D.C., (1981) pp. 131-198.

Hayashi, Fumio. 1982. "Tobin's Marginal q and Average q: A Neoclassical Interpretation." Econometrica. vol. 50, no. 1 (January 1982). pp. 213-224.

Kang, Heejoon. "The Effects of Detrending in Granger Causality Tests," Journal of Business and Economic Statistics. vol 3, no. 4, (October 1985), pp. 344-349.

Jorgenson, Dale W., and Martin A. Sullivan. "Inflation and Corporate Capital Recovery." in Charles R. Hulten, editor, Depreciation, Inflation, and the Taxation of Income from Capital. The Urban Institute Press (1981) Washington, D.C., pp. 171-238.

Kim, E. Han, Wilber G. Lewellen, and John J. McConnell. "Financial Leverage Clienteles," Journal of Financial Economics vol. 7, no. 1 (March 1979) pp. 83-109.

McCallum, Bennett T. "On Low Frequency Estimates of Long-run Relationships in Macroeconomics," Journal of Monetary Economics vol. 14, no. 1 (July 1984) pp. 3-14.

Modigliani, Franco, and Richard A. Cohn. Inflation, Rational Valuation, and the Market. Financial Analysts Journal, vol. 35 (March/April 1979) pp. 24-44.

Nelson, Charles R., and Heejoon Kang. "Spurious Periodicity in Inappropriately Detrended Time Series. Econometrica, vol. 49, no. 3 (May 1981) pp. 741-751.

Summers, Lawrence, H. "Taxation and Corporate Investment: a q - Theory Approach," Brookings Papers on Economic Activity, 1:1981, pp. 67-127.

Summers, Lawrence, H. "The Nonadjustment of Nominal Interest Rates: A Study of the Fisher Effect." in Macroeconomics, Prices, and Quantities. Brookings Institution. J. Tobin, editor, Washington, D.C., (1983) pp. 201-244.

Von Furstenberg, George M. "Corporate Investment: Does Market Valuation Matter in the Aggregate?" Brookings' Papers on Economic Activity, 2: 1977, pp. 347-397.

Yoshikawa, Hiroshi. 1980. On the q - theory of Investment. "The American Economic Review, vol. 70, no. 4 (September 1980), pp. 739-743.