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# WHO PUTS THE INFLATION PREMIUM INTO NOMINAL INTEREST RATES?

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## Abstract

For expectations of price inflation to affect interest rates, they must affect the behavior of borrowers and lenders or both. This paper analyzes the emergence of the inflation premium in long-term interest rates as the explicit result of borrowers' and lenders' behavior in the bond market in response to price expectations. The object of this analysis is not only to estimate the magnitude of the inflation premium due to this portfolio behavior but also to evaluate the respective contributions to it of borrowers' and lenders' responses.

The empirical results presented in this paper indicate that both borrowers' and lenders' portfolio behavior play an important role in the relationship between interest rates and inflation expectations. Estimation results for U.S. data provide evidence that, all other things equal, nonfinancial business corporations increase their supply (net issuance) of bonds in response to an increase in expected inflation; these results mirror the bond investors' responses found by the author in a previous paper. Partial equilibrium experiments based on the combined model of bond supply and bond demand indicate that, all other things equal, the portfolio responses to expected price inflation by borrowers and lenders together increase the bond yield by 2/3%, and modestly decrease the net quantity of bonds issued and purchased, in response to a 1% increase in expected inflation. This result follows as the consequence of a slightly greater response by lenders than by borrowers.

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It is a truism that, for expectations of price inflation to affect interest rates, they must affect the behavior of borrowers or lenders or both. Conversely, whatever Fisherian "inflation premium" the market associates with the yields on fixed-interest debt contracts must reflect the behavior of the borrowers and/or lenders who are the sellers and buyers of such contracts.

While many researchers have investigated the response of nominal interest rates to expectations of price inflation -- for example, estimating the equilibrium magnitude of the inflation premium or its dynamic adjustment under the assumption of adaptively formed expectations, or jointly testing alternative hypotheses about the inflation premium and the expectations formation process -- they have typically done so in the context of reduced-form models which necessarily abstract from the specific underlying channels of economic behavior leading to the inflation premium. Such reduced-form models also abstract from any specific differential contributions to the premium due to the behavior of different groups of market participants and therefore stand in contrast, in some respects, to Irving Fisher's own views which did allow for the possibility of asymmetrical behavior between borrowers and lenders.[1]

This paper analyzes the emergence of the inflation premium in long-term interest rates as the explicit result of borrowers' and lenders' behavior in the bond market in response to expectations of price inflation. By exploiting a structural modelling approach, this analysis seeks not only to estimate the magnitude of the inflation premium due to this portfolio behavior but also to identify the (in general differential) contributions to it of borrowers' and lenders' behavior. To anticipate, the empirical results suggest that the equilibrium portfolio responses to a marginal

1% of expected price inflation change the nominal long-term interest rate by about 2/3%, and that this premium reflects approximately equal responses by borrowers and lenders.

Section I briefly reviews the simple analytics of the inflation premium in nominal interest rates. Section II presents empirical estimates for a model of bond supply behavior by nonfinancial business corporations, the group which accounts for the great majority of borrowing in the U.S. corporate bond market; these estimates support the hypothesis that borrowers respond to expected price inflation in the direction consistent with producing an inflation premium in nominal long-term interest rates. Section III uses this model of borrowers' bond supply behavior, together with an analogous model of lenders' bond demand behavior developed in Friedman [10], to estimate the magnitude of the inflation premium due to portfolio behavior and to decompose it into elements associated with the respective portfolio responses of borrowers and lenders. Section IV summarizes the paper's principal conclusions.

## I. The Simple Analytics of the Inflation Premium

Nominal interest rates are relative prices set on loan agreements struck between borrowers and lenders. Since these nominal yields (or, conversely, prices of bonds) are proximately determined in a market in which loans are extended and received, it is a truism that any factor hypothesized to influence such yields (or prices) must do so by influencing some borrower's supply of bonds, or some lender's demand for bonds, or both.[2] For expectations of future price inflation to increase nominal interest rates, therefore, the underlying behavioral process must involve creating a net excess supply of bonds by increasing borrowers' willingness to borrow or reducing lenders' willingness to lend at a given nominal yield.

Two broad groups of hypotheses, both based on the appealing assumption that it is expected real wealth which ultimately matters for economic behavior, are able to provide an explanation of this effect consistent with expected utility maximizing behavior. First, saving and investment behavior may plausibly be responsive to anticipated real yields, along the familiar lines of the standard neoclassical analysis. Secondly, portfolio behavior may also be plausibly related to anticipated real yields -- i.e., price expectations may affect choices with respect to the composition of assets held and liabilities outstanding, wholly apart from the respective totals.[3] In a world of risk neutrality and zero transactions costs, for example, a straightforward extension of the expectations hypothesis of the term-structure is that lenders and borrowers (investors and shorts) would fully arbitrage any difference in expected real holding-period yields among all nominal-interest debts and all storable commodities. Furthermore, although in practice the opportunities for such portfolio substitutions are usually extremely limited -- i.e., it is difficult to invest in the consumer price index basket of goods -- restricted substitution possibilities need not preclude portfolio behavior from having a key influence especially on the dynamics which connect expected price inflation and nominal interest rates. As long as there remains at least the choice between money (or, equivalently, short-term interest bearing assets) and bonds (of long duration), borrowers' and lenders' portfolio behavior can still be the immediate vehicle by which expected price inflation affects nominal yields.

Represented formally, the portfolio behavior underlying the effect of expected price inflation on the nominal bond yield is

$$S = S(\ldots, r, p^e, \ldots), \qquad S_2 \geq 0 > S_1 \tag{1}$$

$$D = D(\ldots, r, p^e, \ldots), \qquad D_1 > 0 \geq D_2 \tag{2}$$

$$S = D \tag{3}$$

where S and D are, respectively, the supply of and demand for fixed-interest bonds; r is the (nominal) interest rate on bonds; $p^e$ is the expected rate of price inflation;

and the notation $S_i$ or $D_i$ represents a partial derivative with respect to the i-th argument shown. In addition to the interest rate and expected price inflation, the bond supply and demand in (1) and (2) in general depend on a number of variables not explicitly shown, including yields on other assets and liabilities, levels of wealth and economic activity, negative and positive cash flows, any exogenously determined balance sheet stocks, etc.

Equating the supply of and the demand for bonds as in (3) determines the bond yield as the combined implicit function of all of the arguments of (1) and (2), and substituting the market-clearing bond yield into either (1) or (2) determines the market-clearing quantity of bonds outstanding. In particular, unless $S_2 = D_2 = 0$, the two-equation reduced form of (1)-(3) expresses both the interest rate and the quantity of bonds Q as functions of (among all the other arguments) expected price inflation:

$$r = f(\ldots, p^e, \ldots), \qquad f_1 > 0 \tag{4}$$

$$Q = g(\ldots, p^e, \ldots), \qquad g_1 \gtrless 0. \tag{5}$$

Figure 1 illustrates the familiar workings of the simple system (1)-(3) in (r, Q) space. Curves $S(\bar{p}^e)$ and $D(\bar{p}^e)$, which intersect at point $a = (\bar{r}, \bar{Q})$, represent the supply of and demand for bonds, both conditional on some fixed expectation of price inflation $\bar{p}^e$. Curve $S(\bar{p}^e + \delta)$, which represents the supply of bonds conditional on the inflation expectation $\bar{p}^e + \delta$, $\delta > 0$, is shifted to the right from $S(\bar{p}^e)$, indicating borrowers' increased willingness to sell bonds at any given nominal interest rate. Alternatively, although Q is the true dependent variable in a competitive market setting, it is conceptually possible to focus instead on the vertical distance between $S(\bar{p}^e + \delta)$ and $S(\bar{p}^e)$, for any given Q, via the "thought experiment" of asking what increase in r (i.e., what "upward shift") would be required to make borrowers content to supply exactly Q bonds after an increase of $\delta$ in their expectation of price inflation. Curve $D(\bar{p}^e + \delta)$, which represents the demand for

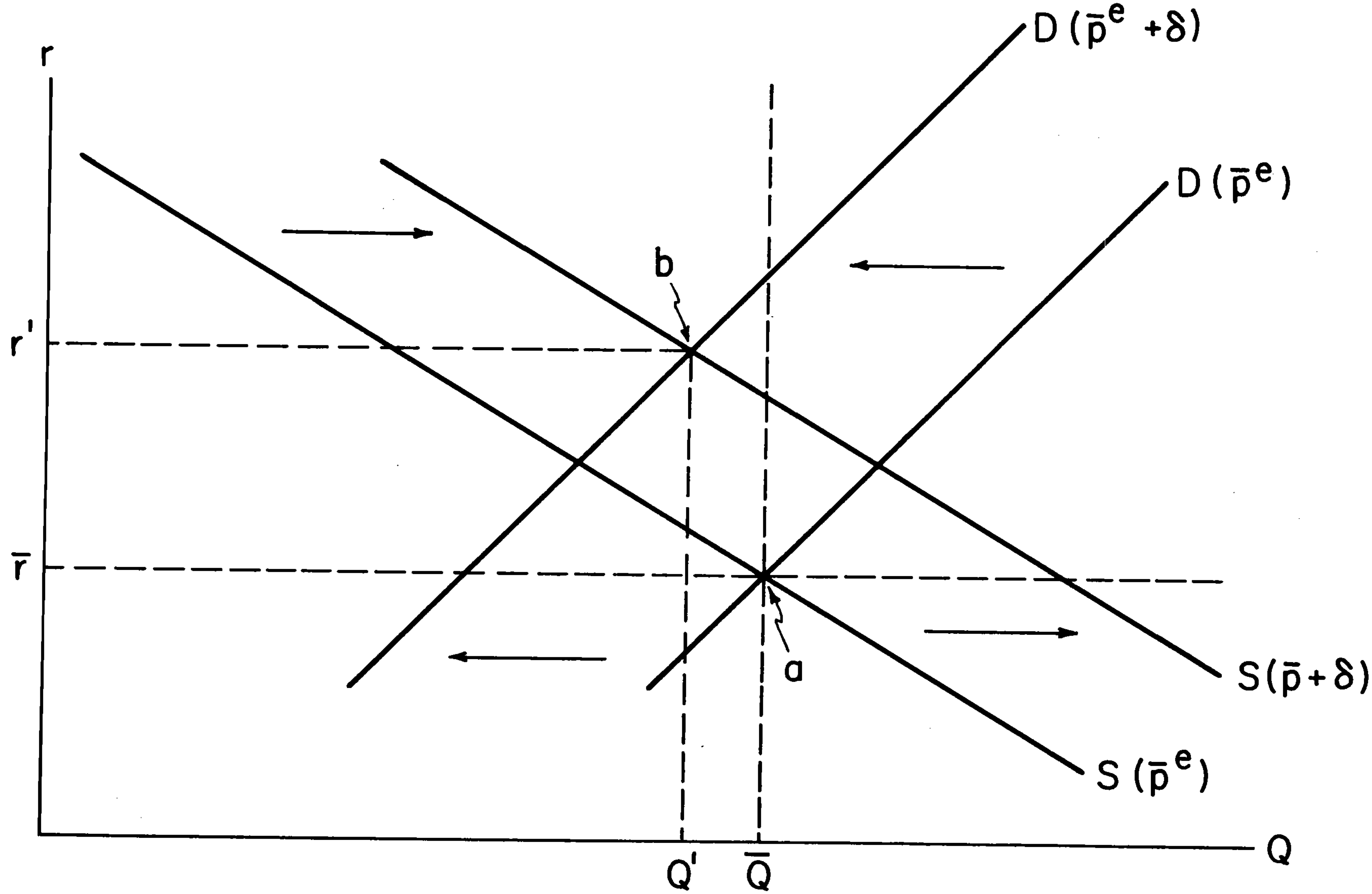


FIGURE 1

THE SIMPLE ANALYTICS OF THE INFLATION PREMIUM bonds conditional on the inflation expectation $\bar{p}^e + \delta$, is analogously shifted to the left (or, alternatively, "upward") from $D(\bar{p}^e)$.

Following (4) and (5), the supply and demand curves conditional on the greater expectation of price inflation intersect at point $b = (r', Q')$. Here $r' > \bar{r}$ unambiguously, reflecting the additional premium in the interest rate, but the magnitude of the premium $(r' - r)$ in relation to $\delta$ depends on the specifics of borrowers' and lenders' behavior. While the neoclassical neutrality proposition associated with Fisher presumes $r' - r = \delta$, Mundell [18] and Tobin [26] have argued on the basis of portfolio effects that the premium is smaller than $\delta$, while Darby [4] and Feldstein [6] have argued on the basis of tax considerations that the premium exceeds $\delta$. In contrast to the effect on the interest rate, which is unambiguously positive, even the sign of the effect on the equilibrium quantity of bonds depends on the respective shapes and shifts of the supply and demand curves. In Figure 1 as drawn, $Q' < \bar{Q}$, but the opposite case is equally plausible on a priori grounds, and strict neoclassical neutrality would imply $Q' = \bar{Q}$.

## II. A Model of the Supply of Bonds under Inflation Expectations

Because corporate bonds in the United States are noncallable for either five or ten years from the date of issue, and because market imperfections usually render bond repurchases fairly expensive, a corporation's decision on whether to finance its external deficit at long or short term contains a major element of nonreversibility. Using a decision-tree framework to represent this asymmetry, Friedman [8] formulated and estimated a model relating a corporation's desired bond supply, for a given cumulated external deficit to be financed, not only to currently prevailing yields but also to expectations of future yields on the long- and short-term liabilities of the corporation, with both future yield expectations represented by autoregressive distributed lags.[4] Although that model included no explicit role for expectations of future price inflation, such expectations will indeed be relevant to the desired bond supply if inflation expectations influence expectations of future yields, as in Modigliani and Shiller [17], and/or if inflation expectations affect the expected relative yields on issuing debt versus equity.

The familiar linear homogeneous model of desired portfolio allocation, applied to the corporation's selection of liabilities to finance externally a given cumulated deficit requirement, is

$$\frac{L^*_{it}}{E_t} = \sum_k^N \beta_{ik} r^e_{kt} + \sum_h^M \gamma_{ih} x_{ht} + \pi_i, \qquad i = 1,\ldots,N \tag{6}$$

where $L^*_{it}$, $i = 1,\ldots,N$, is the corporation's desired amount of the i-th liability outstanding ($\sum_i^N L^*_{it} = E_t$); $E_t$ is the corporation's total cumulated external deficit; $r^e_{kt}$, $k = 1,\ldots,N$, is the expected "borrowing period" yield on the k-th liability; $x_{ht}$, $h = 1,\ldots M$, is the value of any additional variable (e.g., second central moments or other risk-related variables) which influence the portfolio allocation; and the $\beta_{ik}$, $\gamma_{ih}$ and $\pi_i$ are fixed coefficients which staisfy $\sum_i \beta_{ik} = 0$ for all k, $\sum_i \gamma_{ih} = 0$ for all h, and $\sum_i \pi_i = 1$. On the assumption of universal substitutability, the $\beta_{ik}$ also satisfy $\beta_{ik} < 0$, $k = i$, and $\beta_{ik} > 0$, $k \neq i$. After explicitly including the influence of expectations of price inflation, the desired bond supply equation corresponding to (6) is

$$\frac{B^*_t}{E_t} = \beta_{B1} r_{Bt} + \beta_{B2} r^e_{Bt} + \beta_{B3} r^e_{St} + \beta_{B4} p^e_t + \sum_h^M \gamma_{Bh} x_{ht} + \pi_B \tag{7}$$

where $B^*_t$ is the desired amount of bonds outstanding; $r_{Bt}$ is the currently prevailing (nominal) yield on new issues of the corporation's bonds; $r^e_{Bt}$ is the corporation's expectation of the average future value of $r_B$; $r^e_{St}$ is the corporation's expectation of the average current and future value of $r_S$, the yield on its short-term liabilities; and $p^e_t$ is the corporation's expectation of future price inflation. The basic choice of whether to issue (noncallable) bonds at time period t or to issue short-term liabilities then and pursue an optimal financing strategy from time period t+1 onward implies $\beta_{B2}$, $\beta_{B3} > 0 > \beta_{B1}$, and the implication of inflation expectations, under either of the rationales noted above, is accordingly $\beta_{B4} > 0$.[5]

The general portfolio allocation model (6), as well as the specific model (7) of desired bond supply, describes the determination of variables which are unobservable in the presence of transactions costs. To translate the implications of these expressions into an operational model of behavior, therefore, it is also necessary to apply some model of portfolio adjustment. The "optimal marginal adjustment" model developed in Friedman [9] relates net short-run portfolio adjustments not only to the discrepancies between the desired liability levels $L^*_{it}$ from model (6) and the corresponding previous-period outstanding stocks $L_{i,t-1}$, as in the standard stock-adjustment model, but also to current values of financial flow variables. The primary rationale for emphasizing these flow variables is that current financial flows are more easily (i.e., costlessly) allocated than are the currently outstanding financial stocks. This allocation-cost distinction between stocks and flows is especially relevant for borrowers whose outstanding long-term liabilities are typically noncallable, and, since transactions costs constitute the fundamental underlying motivation for using a model which admits discrepancies between actual and desired portfolio composition, it is worth while to model the implications of transactions costs with some care. The optimal marginal adjustment model incorporates in a tractable form the differential transactions costs between outstanding liability stocks and the new deficit flow by positing the allocation of current financial flows according to whatever proportions portfolio allocation model (6) indicates are the desired equilibrium proportions for the total portfolio.

Applied to the case of a corporation financing a given external deficit, the optimal marginal adjustment model is

$$\Delta L_{it} = \sum_{k}^{N} \theta_{ik}(\lambda^*_{kt}E_{t-1} - L_{k,t-1}) + \lambda^*_{it}\Delta E_t, \qquad i = 1,\ldots,N \qquad (8)$$

where the desired equilibrium proportions

$$\lambda^*_{it} \equiv \frac{L^*_{it}}{E_t}, \; i = 1,\ldots,N \qquad (\sum_i \lambda^*_i = 1) \tag{9}$$

follow from (6), and the $\theta_{ik}$ are fixed coefficients satisfying $\sum_i \theta_{ik} = \bar{\theta}$ for all k, with $\bar{\theta}$ arbitrary. The first term on the right-hand side of (8) represents the re-allocation, according to a standard multivariate stock-adjustment model, of the corporation's previously outstanding stocks of liabilities $L_{i,t-1}$, $i = 1,\ldots,N$ (which sum to the previous period's total cumulated external deficit $E_{t-1}$). The second term represents the allocation of the current period's new flow deficit $\Delta E_t$ according to the desired equilibrium proportions $\lambda^*_{it}$, $i = 1,\ldots,N$. The key advantage of the optimal marginal adjustment model in the particular context of this bond supply model is that it captures the increased expected yield (and inflation) sensitivity of the allocation of the flow $\Delta E_t$ in comparison with the re-allocation of the stock $E_{t-1}$.

Expanding portfolio adjustment model (8) with the desired bond supply expression (7) used as the specific form of the portfolio allocation model (6) yields

$$\begin{aligned}
\Delta B_t = \; & \pi_B \cdot \Delta E_t + [\sum_k (\pi_k \cdot \theta_{Bk})] \cdot E_{t-1} \\
& + \beta_{B1} \cdot r_{Bt} \cdot \Delta E_t + [\sum_k (\beta_{k1} \cdot \theta_{Bk})] \cdot r_{Bt} \cdot E_{t-1} \\
& + \beta_{B2} \cdot r^e_{Bt} \cdot \Delta E_t + [\sum_k (\beta_{k2} \cdot \theta_{Bk})] \cdot r^e_{Bt} \cdot E_{t-1} \\
& + \beta_{B3} \cdot r^e_{St} \cdot \Delta E_t + [\sum_k (\beta_{k3} \cdot \theta_{Bk})] \cdot r^e_{St} \cdot E_{t-1} \\
& + \beta_{B4} \cdot p^e_t \cdot \Delta E_t + [\sum_k (\beta_{k4} \cdot \theta_{Bk})] \cdot p^e_t \cdot E_{t-1} \\
& + \sum_h \{\gamma_{Bh} \cdot x_{ht} \cdot \Delta E_t + [\sum_k (\beta_{kh} \cdot \theta_{Bk})] \cdot x_{ht} \cdot E_{t-1} \\
& - \theta_{BB} \cdot B_{t-1} - \sum_{k \neq B} (\theta_{Bk} \cdot L_{k,t-1}).
\end{aligned} \tag{10}$$

Here it is useful to distinguish the particular right-hand-side terms which do and do not have coefficients of known sign a priori. Each of the four variables $r_{Bt}$, $r^e_{Bt}$, $r^e_{St}$, and $p^e_t$, as well as $x_{ht}$, $h = 1,\ldots,M$, enters (10) twice, in nonlinear form both times. In each case the product of the variable and the deficit flow $\Delta E_t$ bears a coefficient which consists of a single parameter of known sign from (7). Similarly, the lagged stock of bonds $B_{t-1}$ enters (10) with coefficient $-\theta_{BB} < 0$ from the stock-adjustment component of (8). All other right-hand-side terms in (10) -- including the linear terms $\Delta E_t$, $E_{t-1}$ and $L_{k,t-1}$, $k \neq B$, as well as all nonlinear terms consisting of products with $E_{t-1}$ -- bear coefficients which are of unknown sign a priori.[6]

Nonfinancial business corporations represent the dominant source of private long-term borrowing in most developed economies. In the United States, domestic nonfinancial corporations -- including companies in manufacturing, extraction, utility, transportation, communications, and commercial businesses -- constitute the bulk of the economy's productive capacity, typically producing over half of the nation's gross national product. As of the end of 1975, \$254 billion of the \$317 billion of corporate bonds outstanding were their direct liabilities. Furthermore, long-term bonds are a key source of funds to these corporations, constituting more than 40% of their year-end 1975 credit market debt liabilities outstanding.

The result of estimating (10) for the net supply of bonds by U.S. nonfinancial corporate businesses, using quarterly data for 1960: I - 1973: IV and an instrumental-variables procedure to derive consistent estimators given the simultaneous determination of $\Delta B_t$ and $r_{Bt}$, is

$$\begin{aligned}\Delta B_t = {} & \underset{(3.8)}{2.311}\ \Delta E_t - \underset{(-5.8)}{6.448}\ (r_{Bt}\cdot\Delta E_t)^* + \underset{(1.6)}{0.04631}\ (r_{Bt}\cdot E_{t-1})^* \\ & + \underset{(5.1)}{5.223}\ (r^e_{Bt}\cdot\Delta E_t)^* - \underset{(-1.1)}{0.03025}\ (r^e_{Bt}\cdot E_{t-1})^* + \underset{(3.1)}{0.5203}\ r^e_{St}\cdot\Delta E_t \\ & + \underset{(2.7)}{0.3984}\ p^e_t\cdot\Delta E_t - \underset{(-3.2)}{0.01429}\ p^e_t\cdot E_{t-1} + \underset{(4.7)}{10.53}\ x_{1t}\cdot\Delta E_t \\ & - \underset{(-4.9)}{9.430}\ x_{2t}\cdot\Delta E_t + \underset{(3.3)}{0.6445}\ x_{3t}\cdot\Delta E_t - \underset{(-3.4)}{0.1047}\ B_{t-1} \qquad (11)\end{aligned}$$

$\bar{R}^2 = 0.95$ $\qquad$ SE = 329 $\qquad$ DW = 2.71

where $x_{1t}$ is a measure of the stock of fixed investment assets owned by the nonfinancial corporate business sector; $x_{2t}$ is a measure of the nonfinancial corporate business sector's cumulated retained earnings; $x_{3t}$ is a measure of current equity retirements; $\bar{R}^2$ is the adjusted coefficient of determination; SE is the standard error of estimate, in millions of dollars; DW is the Durbin-Watson statistic; the numbers in parentheses are ratios of coefficient estimates to standard errors; and an asterisk superscript indicates fitted terms from the first stage of the instrumental-variables procedure.[7] The respective autoregressive representations of the three unobservable expectations, generated within the estimation of (11), are[8]

$$r^e_{Bt} = r_{Bt} + \sum_{\tau=0}^{8} \zeta_\tau \Delta r_{B,t-\tau} \qquad \left(\sum_{\tau=0}^{8} \zeta_\tau = 1\right) \tag{12}$$

$\zeta_0 = 0.1632$ (12.5) $\quad \zeta_3 = 0.1424$ (32.3) $\quad \zeta_6 = 0.0796$ (10.0)
$\zeta_1 = 0.1537$ (13.4) $\quad \zeta_4 = 0.1260$ (27.7) $\quad \zeta_7 = 0.0527$ (6.5)
$\zeta_2 = 0.1522$ (22.3) $\quad \zeta_5 = 0.1045$ (16.4) $\quad \zeta_8 = 0.0257$ (4.4)

$$r^e_{St} = \sum_{\tau=0}^{16} \phi_\tau r_{S,t-\tau} \qquad \left(\sum_{\tau=0}^{16} \phi_\tau = 1\right) \tag{13}$$

$\phi_0 = 0.0266$ (1.0) $\quad \phi_6 = 0.1030$ (8.4) $\quad \phi_{12} = 0.0512$ (8.3)
$\phi_1 = 0.0088$ (0.3) $\quad \phi_7 = 0.1024$ (8.3) $\quad \phi_{13} = 0.0374$ (5.2)
$\phi_2 = 0.0435$ (2.8) $\quad \phi_8 = 0.0975$ (8.7) $\quad \phi_{14} = 0.0245$ (3.2)
$\phi_3 = 0.0694$ (9.4) $\quad \phi_9 = 0.0890$ (9.6) $\quad \phi_{15} = 0.0134$ (1.9)
$\phi_4 = 0.0874$ (11.5) $\quad \phi_{10} = 0.0778$ (10.8) $\quad \phi_{16} = 0.0049$ (1.0)
$\phi_5 = 0.0983$ (9.3) $\quad \phi_{11} = 0.0649$ (10.9)

$$p^e_t = \sum_{\tau=0}^{8} \psi_\tau p_{t-\tau} \qquad \left(\sum_{\tau=0}^{8} \psi_\tau = 1\right) \tag{14}$$

$\psi_0 = 0.1539$ (2.3) $\quad \psi_3 = 0.1557$ (3.8) $\quad \psi_6 = 0.0756$ (1.8)
$\psi_1 = 0.1486$ (2.3) $\quad \psi_4 = 0.1363$ (4.4) $\quad \psi_7 = 0.0436$ (0.9)
$\psi_2 = 0.1614$ (3.6) $\quad \psi_5 = 0.1081$ (3.9) $\quad \psi_8 = 0.0168$ (0.4)

where the numbers in parentheses are again ratios of estimates to standard errors. To identify coefficients $\beta_{Bk}$, $k = 2,\ldots,4$, in the underlying bond supply model, the estimation procedure used here arbitrarily imposed a unit sum constraint on each of the three sets of distributed lag weights.[9] The estimation procedure also constrained each set of lag weights beginning with $\tau = 1$ to follow a third-degree polynomial pattern with the implied right-hand tail passing through zero, and left the lead ($\tau = 0$) weight free of the polynomial constraint while including it within the unit sum constraint. In addition, in the case of $r^e_{Bt}$ and $p^e_t$, each of which appears in two separate multiplicative terms in (11), a nonlinear procedure was necessary to render identical the two appearances of what must logically be the same distributed lag.[10]

The estimation results in (11) are consistent with the implications of the model of bond supply developed in Friedman [8] and elaborated above to include the effect of expectations of price inflation. In particular, the estimated values of $\beta_{Bk}$, $k = 1,\ldots,4$, imply that, all other things equal, nonfinancial corporations issue <u>less</u> bonds as the currently prevailing bond yield is higher, <u>more</u> bonds as the expected future bond yield is higher, <u>more</u> bonds as the expected average of current and future short-term yields is higher, and <u>more</u> bonds as the expected rate of price inflation is higher. In addition, the estimated values of $\gamma_{Bh}$, $h = 1,\ldots,3$, imply that, all other things equal, nonfinancial corporations issue <u>more</u> bonds as their fixed investment assets are greater, <u>less</u> bonds as their retained earnings are greater, and <u>more</u> bonds as they retire equity.

## III. The Inflation Premium in Nominal Interest Rates

The model of nonfinancial business corporations' bond supply developed in Section II, together with the disaggregated model of bond demand developed in Friedman [10],[11] provides a quantitative framework directly analogous to the simple model reviewed in Section I. The estimated own-yield coefficients indicate the slopes of the curves shown in Figure 1, while the estimated inflation coefficients indicate the shifts of these curves corresponding to greater or lesser expectations of price inflation.

Figure 2 and Table 1 summarize the results of six partial-equilibrium experiments, based on this combined supply-demand model, which associate quantitative magnitudes with the elements of the inflation premium discussed in Section I. Each of these experiments takes the form of an equilibrium solution of the model, determining the net quantity of bonds purchased and the (constant) bond yield indicated by the model under specific variations in the underlying exogenous conditioning variables -- including the exogenous expectation of price inflation. A "control" solution of the supply-demand model, conditional on the sample-period means of all of the model's exogenous variables, (including observed sample-period means in place of the unobservable expectations of price inflation and the short-term yield), gives the values 6.09% for the bond yield and $2,343 million for the net bond quantity. Point "a" in Figure 2 corresponds to these values.[12]

What equilibrium adjustment in the nominal interest rate will the combination of borrowers' and lenders' portfolio behavior induce in response to expectations of greater price inflation? Point "b" in Figure 2 plots the values given by an alternative solution of the model which differs from the control solution only in that the underlying exogenous inflation expectation is greater by 1%. As Table 1 shows, the equilibrium value of the bond yield in this experiment is 6.73% -- 0.64% more than the control solution value -- and the net quantity of bonds issued and purchased is slightly less than in the control solution.

Two further experiments decompose this impact of additional expected price inflation into elements due to the respective portfolio behavior of lenders and borrowers by solving the model holding first borrowers' and then lenders' behavior constant (i.e., by making first the bond supply curve and then the aggregated bond demand curve vertical). As the values plotted by point "c" indicate, the "upward

TABLE 1

EQUILIBRIUM SOLUTION VALUES FOR SUPPLY-DEMAND MODEL

| Solution | Solution Values | | Differences from Control | |
|---|---|---|---|---|
| | r (%) | ΔQ ($ million) | r (%) | ΔQ ($ million) |
| a (control) | 6.09 | 2,343 | -- | -- |
| b | 6.73 | 2,267 | 0.64 | -76 |
| c | 6.79 | 2,343 | 0.70 | 0 |
| d | 6.72 | 2,343 | 0.63 | 0 |
| e | 6.31 | 1,268 | 0.22 | -2,075 |
| f | 6.51 | 3,343 | 0.42 | 1,000 |

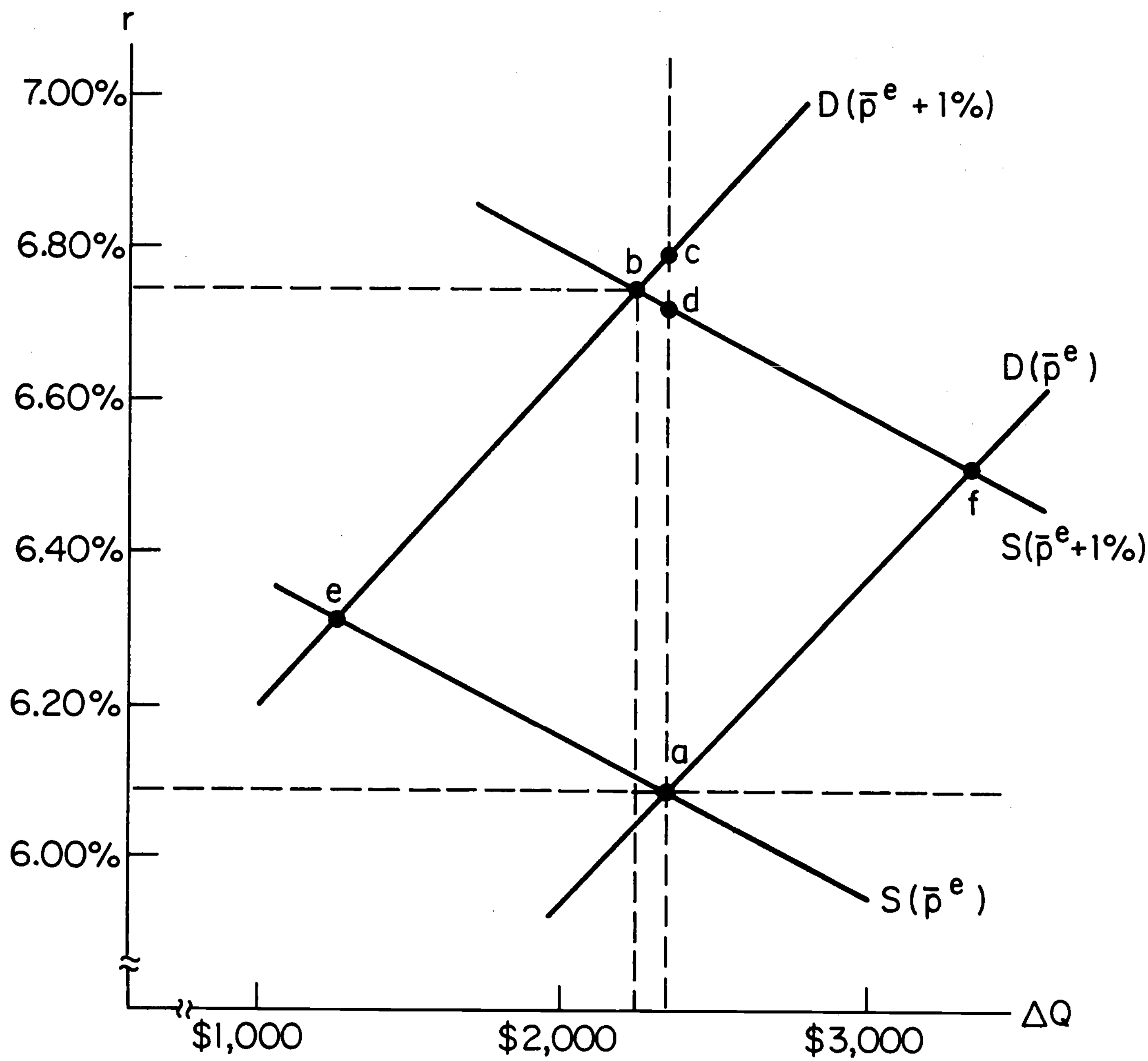


FIGURE 2

EQUILIBRIUM SOLUTION RESULTS FOR THE SUPPLY-DEMAND MODEL shift" of the demand curve is 0.70%.[13] By contrast, the "upward shift" of the supply curve, indicated by point "d," is only 0.63%. Hence the new supply-demand equilibrium, after the 1% increase in expectations of price inflation, increases the nominal interest rate by more than 0.63% but less than 0.70% and slightly decreases the net bond quantity.

Finally, points "e" and "f" plot the values corresponding to experiments in which first only lenders and then only borrowers are assumed to change their inflation expectations (i.e., in which the supply and demand curves are conditional on different expectations). As the logic of the underlying supply-demand model suggests, these solutions show that such an asymmetrical shift in expectations produces a smaller shift in the nominal bond yield but a much larger shift in the net quantity of bonds issued and purchased, in comparison with the effect of a symmetrical change in expectations by both borrowers and lenders.

## IV. Concluding Remarks

The effect of expected price inflation on nominal interest rates is an important element in the set of complex interrelations which connect the financial and nonfinancial markets. Moreover, the role of portfolio behavior is expecially interesting in this context since, of the different kinds of economic behavior which may underlie this effect, it is the most plausibly flexible in the short run. The empirical results presented in this paper indicate that both borrowers' and lenders' portfolio behavior play an important role in the relationship between interest rates and inflation expectations.

First, at the single-equation level, estimation results for U.S. data provide evidence that, all other things equal, nonfinancial business corporations increase their supply of bonds in response to an increase in expected inflation. These results mirror the bond investors' responses found in Friedman [10].

Secondly, partial equilibrium experiments based on this model of bond supply and the model of bond demand developed in Friedman [10] indicate that, all other things equal, the portfolio responses to expected price inflation by borrowers and lenders increase the equilibrium bond yield by 0.64%, and modestly decrease the net quantity of bonds issued and purchased, in response to a 1% increase in expected inflation. This result follows as the consequence of a slightly greater response by lenders than by borrowers.

It is important to emphasize that, for several reasons, the indicated adjustment of 0.64% for 1% of expected price inflation is far from the last word on the effect of inflation expectations on interest rates. At the single-equation level, for example, the underlying bond supply and bond demand equations impose arbitrary constraints in order to identify empirically several key coefficients in the absence of direct observations of expectations, and they do not allow for any changing tax effects over time. Similarly, the multi-equation experiments are clearly of only a partial-equilibrium nature not just in that they incorporate only portfolio behavior, holding constant saving and investment behavior,[14] but also in that they focus only on the market for bonds. Nevertheless, these results are instructive in providing at least limited evidence suggesting approximately symmetrical but less than one-for-one inflation adjustments in portfolio behavior on both sides of the market.

## Footnotes

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1. See Fisher [7, pp. 75-77] and the illuminating discussion in Rutledge [20].

2. The concept of the nominal yield's being "proximately determined" in the loan market is not inconsistent with the principle of general equilibrium in the asset markets or for the economy as a whole. In well developed financial markets, of course, the relevant group of "lenders" includes not only those who make primary loans directly to borrowers but also those who acquire debt securities in a secondary market.

3. In simple consumption-loan models there is typically no well defined distinction between saving behavior and portfolio behavior in the conventional sense as meant here; see, for example, Samuelson [21]. In addition, even in models in which these two kinds of behavior are distinct, they are not in general independent; see, for example, Fama [5], Merton [16], and Samuelson [22].

4. See Friedman [8] for further details on the derivation of the desired bond supply model. For a development of the implications of the nonreversibility element associated with the call deferment, using a dynamic programming approach, see Bodie and Friedman [1].

5. Coefficients $\beta_{Bj}$ measure first-moment effects only; in the completely specified model coefficients $\gamma_{Bh}$ measure any effects associated with variances, covariances, etc.

6. Since (6) and (8) deal with the corporation's supplies of all liabilities, (10) is implicitly an element of a set of equations satisfying the "adding up" constraints specified above. By contrast, the more limited focus of this paper is on the supply of bonds - and, more specifically, on its implications for the inflation premium. As Ladenson [12] and Smith [25] have shown, it is not necessary to use constrained estimation techniques to guarantee that the parameter estimates of the full set of supply equations satisfy the "adding up" constraints, so that there is no inconsistency involved in estimating only one supply equation rather than the entire set. Nevertheless, a complete model including all liabilities (and assets too) would permit the researcher to adopt the philosophy as well as the mechanics of Brainard and Tobin [2] in examining the implications for other equations of the presence of a given variable in any one equation. The construction of such a complete model, however, lies well beyond the scope of this paper.

7. See Friedman [8] for details of the estimation procedures, data and definitions of variables, as well as a discussion of the rationale underlying the effects of $x_1$, $x_2$ and $x_3$ on corporations' desired bond supply. The specific instrumental-variables procedure used here is the augmented principal components method due to Brundy and Jorgenson [3], and the set of relevant instruments includes not only the exogenous variables in the bond supply equation but also those in the six bond demand equations developed in Friedman [10].

8. Friedman [10] tested autoregressive versus "rational" (in Muth's [19] sense) representations of interest rate and price inflation expectations, in analogous equations describing the behavior of bond investors, and found that the autoregressive representations were markedly superior. As Modigliani and Shiller [17] usefully illustrated, also in the context of interest rate and price inflation expectations, general autoregressive expectations of this form are consistent with a combination of extrapolative and regressive components. Some writers, e.g., Sargent [24] and McCallum [15], have referred to such expectations as "partly rational."

9. The unit sum constraint implies that expectations are formed according to the belief that the stochastic processes generating the respective series are borderline stationary/nonstationary -- i.e., any interest rate or inflation rate which has persisted for a long time will continue to persist. For the process to be stationary, the lag weights would have to sum to less than unity, and the expectation would also have to include a constant term. Several other writers have also emphasized this point; see, for example, Lucas [14] and Sargent [23].

10. See Friedman and Roley [11].

11. The bond demand model separately represents the demand for bonds by life insurance companies, other insurance companies, private pension funds, state and local government retirement funds, mutual savings banks, and households. (An appendix showing these equations, not reproduced here because of space limitations, is available from the author.) As of yearend 1975, these six groups of investors together held $300 billion of the $317 billion of corporate bonds outstanding in the United States.

12. The "quantity" axis in Figure 2 corresponds to a within-period net flow of new bonds issued and purchased, in contrast to the discussion of Figure 1 in terms of the end-of-period stock of bonds outstanding. Since the end-of-period stock outstanding equals the (predetermined) beginning-of-period stock plus the within-period net flow, the two concepts are equivalent, but the flow representation seems more natural in the context of the short-run adjustment aspects of the underlying estimated models of bond supply and demand.

13. The "upward shift" in the demand curve reported in Friedman [10], calculated by averaging the period-by-period differences between two dynamic simulations of the six bond demand equations, was 0.65%. The difference reflects the model's nonlinearity.

14. In other words, these experiments hold constant corporations' external deficit ($\Delta E$ in Section II) and lenders' investable cash flows. See Lintner [13], for example, for an argument that the external deficit moves asymmetrically with lenders' cash flows as a result of price inflation.

<u>References</u>


1. Bodie, Zvi, and Friedman, Benjamin M. "Interest Rate Uncertainty and the Value of Bond Call Protection." Journal of Political Economy, forthcoming.

2. Brainard, William C., and Tobin, James. "Pitfalls in Financial Model-Building." American Economic Review, LVII (May, 1968), 99-122.

3. Brundy, James M., and Jorgenson, Dale W. "Efficient Estimation of Simultaneous Equations by Instrumental Variables." Review of Economics and Statistics, LIII (August, 1971), 207-224.

4. Darby, Michael R. "The Financial and Tax Effects of Monetary Policy on Interest Rates." Economic Inquiry, XIII (June, 1975), 266-276.

5. Fama, Eugene F. "Multiperiod Consumption-Investment Decisions." American Economic Review, LX (March, 1970), 163-174.

6. Feldstein, Martin. "Inflation, Income Taxes and the Rate of Interest: A Theoretical Analysis." American Economic Review, LXVI (December, 1976), 809-820.

7. Fisher, Irving. Appreciation and Interest. New York: The Macmillan Company, 1896.

8. Friedman, Benjamin M. "Substitution and Expectation Effects on Long-Term Borrowing Behavior and Long-Term Interest Rates." Mimeo, Harvard University, 1976.

9. Friedman, Benjamin M. "Financial Flow Variables and the Short-Run Determination of Long-Term Interest Rates." Journal of Political Economy, LXXXV (August, 1977), 661-689.

10. Friedman, Benjamin M. "Price Inflation, Portfolio Choice, and Nominal Interest Rates." Mimeo, Harvard University, 1977.

11. Friedman, Benjamin M., and Roley, V. Vance. "Identifying Identical Distributed Lag Structures by the Use of Prior Sum Constraints." Annals of Economic and Social Measurement, VI (Autumn, 1977), 429-444.

12. Ladenson, Mark L. "Pitfalls in Financial Model Building: Some Extensions." American Economic Review, LXI (March, 1971), 179-186.

13. Lintner, John. "Inflation and Securities Returns." Journal of Finance, XXX (May, 1975), 259-280.

14. Lucas, Robert E. "Econometric Testing of the Natural Rate Hypothesis." Eckstein (ed.), The Econometrics of Price Determination. Washington: Board of Governors of the Federal Reserve System, 1972.

15. McCallum, B.T. "Rational Expectations and the Natural Rate Hypothesis: Some Consistent Estimates." Econometrica, XLIV (January, 1976), 43-52.

16. Merton, Robert C. "Lifetime Portfolio Selection Under Uncertainty: The Continuous-time Case." Review of Economics and Statistics, LI (August, 1969) 247-257.

17. Modigliani, Franco, and Shiller, Robert J. "Inflation, Rational Expectations, and the Term Structure of Interest Rates." Economica, XL (February, 1973) 12-43.

18. Mundell, Robert. "Inflation and Real Interest." Journal of Political Economy, LXXI (June, 1963), 280-283.

19. Muth, John F. "Rational Expectations and the Theory of Price Movements." Econometrica, XXIX (July, 1961), 315-335.

20. Rutledge, John. "Irving Fisher and Autoregressive Expectations." American Economic Review, LXVII (February, 1977), 200-205.

21. Samuelson, Paul A. "An Exact Consumption-Loan Model of Interest with or without the Social Contrivance of Money." Journal of Political Economy, LXVI (December, 1958), 467-482.

22. Samuelson, Paul A. "Lifetime Portfolio Selection by Dynamic Stochastic Programming." Review of Economics and Statistics, LI (August, 1969), 239-246.

23. Sargent, Thomas J. "A Note on the 'Accelerationist' Controversy." Journal of Money, Credit and Banking, III (August, 1971), 721-725.

24. Sargent, Thomas J. "Rational Expectations, the Real Rate of Interest, and the National Rate of Unemployment." Brookings Papers on Economic Activity (No. 2, 1973), 429-472.

25. Smith, Gary. "Pitfalls in Financial Model Building: A Clarification." American Economic Review, LXV (June, 1975), 510-516.

26. Tobin, James. "Money and Economic Growth." Econometrica, XXXIII October, 1965), 671-684.