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INTERTEMPORAL SUBSTITUTION AND THE BUSINESS CYCLE

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ABSTRACT

This paper summarizes the theoretical role of intertemporal substitution variables in the "new classical macroeconomics." An important implication is that positive monetary shocks tend to raise expected real returns that are calculated from the usual partial information set, but tend to lower realized real returns. After reviewing previous empirical findings in the area, the study reports new results on the behavior of returns on the New York Stock Exchange and on Treasury Bills. The analysis isolates realized real rate of return effects that are significantly positive for a temporary government purchases variable and significantly regative for monetary movements. However, the results do not support the theoretical distinction between money shocks and anticipated changes in money. Since the study focuses on realized real returns, which can be measured in a straightforward manner, there is no evidence on the hypothesis that expected real returns, which are calculated on the basis of incomplete information, rise with monetary disturbances. Because this proposition is sensitive to the specification of information sets, it may be infeasible to test it directly.

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Intemporal substitution variables play a major role in the new "equilibrium" models of the business cycle. A central feature of these models is the response of supply to perceived temporary opportunities for unusual rewards to working or producing; that is, to relatively high anticipated real rates of return. In some cases, as in explanations for the non-neutrality of money, the intertemporal substitution mechanism is combined with confusions between general inflation and shifts in relative prices. In these circumstances the expectations of high returns are not borne out by the behavior of subsequently realized returns. In other settings, such as temporary increases of government purchases during wartime, economic expansion is stimulated by accurately perceived rises in real rates of return.

The first part of this paper summarizes the theoretical role of intertemporal substitution variables in the "new classical macroecomonics." Some of this discussion draws on material from my survey paper (Barro, 1980b). The later parts of this section stress empirical hypotheses concerning the contemporaneous and lagged effects of monetary and government purchases variables on realized real rates of return.

The next section describes briefly some previous empirical findings that relate to the business cycle role of intertemporal substitution variables. This discussion is followed by some new empirical evidence on realized real rates of return. The analysis deals with returns on New York Stock Exchange stocks and on Treasury Bills. The principal results concern reduced form effects of monetary and government purchases variables on these realized returns.

I. Theoretical Analysis

A. Setup of the Model

Consider the type of model where goods and services are traded in a large number of localized markets or "islands," indexed by a parameter z. A simple version of the imperfect information/intertemporal substitution story, due to Phelps (1970) and Lucas and Rapping (1969) and related to ideas advanced by M. Friedman (1968), allows individuals to receive current information on local prices $P_t(z)$, but at most lagged information about the economy-wide average price level P or other nominal aggregates like the money stock. The underlying idea is that local prices reflect a mixture of the unperceived nominal aggregates and a variety of local factors that are specific to markets, individuals, occupations, etc. Fluctuations in these local elements, which involve changes in the composition of technology and tastes, re-evaluation of individual talents or opportunities, and the like, are viewed as having far more significance than general business conditions for individual fortunes (Lucas, 1977, pp. 19-20). In particular, the exploitation of these local opportunities may require rapid and large responses by individuals, whether in terms of accepting or offering a job, making a sale, undertaking an investment project, and so on. Under imperfect information conditions, individuals attempt to purge the general price component from their observed price signals in order to make the appropriate allocative decisions.

Specifically, suppliers in a local market compare their observed current price or wage opportunities with expectations of prices or wages at alternative times and places. In a simplified setting where individuals visit only one market each period and where intermarket mobility over time is sufficient to make all markets look equally attractive one period ahead, the margin of substitution will involve a comparison of $P_t(z)$ with E_zP_{t+1}, which is the expectation formed today in market z of next period's general price level. In this setting the expected price for "next period" represents the perceived long-run average reward for the pertinent type of labor service or other good. Changes in current actual prices (wages) relative to anticipated future prices (wages) are viewed as inducing substantial intertemporal substitution on the supply side. In particular, the temporary nature of the perceived wage or price offer implies a substitution toward current activities and away from planned effort at an array of future dates. Similar intertemporal substitution would not arise for the case of a perceived permanent change in a relative price variable such as the current real wage rate.

The relation of observed to anticipated prices appears as the central relative price variable in the models of Lucas (1972, 1973), Sargent (1973), Sargent and Wallace (1975), Barro (1976), et al. The precise form of the relative price variable differs across models. For example, Lucas (1973, p. 327) writes his supply variable in logarithmic terms as $P_t(z) - E_zP_t$; that is, E_zP_t appears without explanation instead of E_zP_{t+1}. However, most of his results would be unaffected by this difference in form.

Sargent (1973, p. 434) and Sargent and Wallace (1975, p. 242) use the variable $P_t - E_{t-1}P_t$, where $E_{t-1}P_t$ is the average expectation formed last period of this period's price level. A direct comparison of P_t with $E_{t-1}P_t$ is difficult to reconcile with the intertemporal substitution or search stories of labor supply. Notably, in contrast to the intertemporal substitution model, the Sargent/Wallace setup seems to predict a supply response to a contemporaneously understood monetary change that was not predicted at date t-1. However, in many cases the contemporaneous expectations, E_zP_t or E_zP_{t+1}, would be formed by updating the prior value, $E_{t-1}P_t$, for the information contained in current data. If current information is limited to that contained in a local price observation, $P_t(z)$, then a formulation based on a variable like $P_t(z) - E_{t-1}P_t$, may be indistinguishable from one involving $P_t(z) - E_zP_t$. For example, if the Bayesian updating rule appears in linear form as $E_zP_t = \theta P_t(z) + (1-\theta)E_{t-1}P_t$, where the θ coefficient would depend on the relative values of price variances across markets and over time (see Lucas (1973, p. 328) and Barro (1976, p. 9)), then $P_t(z) - E_zP_t = (1-\theta)(P_t(z) - E_{t-1}P_t)$--that is, the two forms of relative price variables would be linearly related. The two specifications would be distinguished only by structural breaks that shifted the value of the θ parameter or by the existence of additional variables, such as war conditions or foreign shocks, that provided extra contemporaneous information about the general price level.

The impact of a variable like $P_t - E_{t-1}P_t$ has been rationalized along long-term nominal contracting grounds by Gray (1976) and Fischer (1977). The argument is that previous expectations of current prices determine some portion of current contractual nominal wages, which would then be compared with current prices to determine the supply of commodities by firms. This interpretation is disputed in Barro (1977) on the grounds that efficient contracts would not permit variables like employment to be influenced by perceived, purely nominal disturbances.

A direct comparison of next period's expected nominal price with currently observed prices is appropriate only if stores of value earn a zero nominal rate of return; that is, if fiat money is the only available asset. More generally, as noted in Lucas and Rapping (1969), McCallum (1978), Barro (1980a), and King (1978), the anticipated future prices would effectively be discounted by the available nominal interest rate over the applicable horizon. Instead of specifying a supply response to $P_t(z)$ relative to E_zP_{t+1}, which is a measure of the anticipated one-period real rate of return on money from the perspective of market z, the pertinent variable would be the expected real rate of return based on the holding of assets that earn a nominal interest rate R_t.

Equilibrium business cycle models typically incorporate a positive speculative response of supply to perceived excesses of observed prices over anticipated (future) normal values; that is, to unusual real rate of return opportunities. An analogous type of speculation implies a negative effect of the same type of relative price variable on the demand side (Barro, 1976, p. 5;

B. Friedman, 1978, p. 76). In a specification that employs an anticipated real rate of return measure as the relative price variable, the aggregate demand equation when considered as an average over the markets would exhibit the conventional negative substitution effect of expected real interest rates on consumption and investment.

Suppose that aggregate supply and demand are influenced by the same relative price variable; for example, by an anticipated real rate of return with comparable information on prices, etc., on both sides of each local market. If the other right-hand side variables for supply and demand are exogenous real variables, then an equilibrium solution would involve a dichotomy between monetary variables and the real sector. The equation of supply to demand would determine output and the anticipated real rate of return in each local market as functions of the exogenous real variables. Therefore, in this type of model it is essential for obtaining a link between nominal disturbances and real variables that the monetary shocks impact directly on excess commodity demand.[1] One possibility would be a real balance-type effect on commodity demand or supply. In Lucas's (1972, p. 106) overlapping-generations model in which money is the only store of value, a positive real balance effect on aggregate demand corresponds to the older generation's incentive to spend all of its savings from the previous period.[2] For the context of households that have access to interest-bearing assets and that effectively plan over an infinite horizon (perhaps because they have an operative bequest motive), it is argued in Barro (1980a, pp.) that the principal direct monetary effect on excess commodity demand would involve the discrepancy between the money stock and its contemporaneously perceived value. Essentially, this setup ignores the wealth effect corresponding to changes in the excess burden due to anticipated inflation. The formulation implies, in particular, that equal increases in total money and in the desired money stock have no direct effect on excess commodity demand. The distinction between this type of specification of the monetary wealth effect and the real balance type specification arises primarily in analyses of anticipated inflation, which involve changes in real balances but no changes in money relative to perceived money. If last period's money stock is viewed as observable, the latter variable becomes the unperceived part of current money growth, denoted by $m_t - E_z m_t$.

A simple log-linear model of local commodity markets that reflects the above discussion is (Barro, 1980a, p.):

$$(1) \quad y_t^s(z) = \alpha_s r_t(z) - \beta_s(m_t - E_z m_t) + \varepsilon_t^s(z),$$

$$(2) \quad y_t^d(z) = -\alpha_d r_t(z) + \beta_d(m_t - E_z m_t) + \varepsilon_t^d(z),$$

where y(z) is the log of local output, $r_t(z) \equiv P_t(z) - E_z P_{t+1} + R_t$ is the anticipated one-period[3] real rate of return from the perspective of market z (neglecting effects associated with the variance of future prices), P(z) is the log of the local price, P is the log of the average of prices across markets, R is a one-period nominal interest rate on an asset that is assumed to be traded economy-wide, $(\alpha_s,\alpha_d) > 0$ are relative price elasticities, $(\beta_s,\beta_d) > 0$ are "wealth" elasticities, and the $\varepsilon(z)$'s are local disturbance terms that add to zero in summations across the markets. In the present setup there is only one form of interest-bearing asset--notably, the model does not encompass imperfect substitutability between bonds and equity claims. Further, some of the results depend on a setup that allows individuals to observe an economy-wide nominal interest rate, rather than a pre-set global real rate of return. Constants, economy-wide real shocks, or systematic effects on natural outputs could readily be added to equations (1) and (2).

The assumptions that goods not travel across markets during a period and that local prices are completely flexible generate the equilibrium condition for each commodity market, $y_t^s(z) = y_t^d(z)$. Equations (1) and (2) then imply conditions for local output and expected real rate of return, which can be written as

$$(3) \quad y_t(z) = (1/\alpha)(\alpha_s\beta_d-\alpha_d\beta_s)(m_t-E_z m_t) + (\alpha_s/\alpha)\varepsilon_t^d(z) + (\alpha_d/\alpha)\varepsilon_t^s(z),$$

$$(4) \quad r_t(z) = (1/\alpha)[\beta(m_t-E_z m_t) + \varepsilon_t(z)],$$

where $\alpha \equiv \alpha_s + \alpha_d$, $\beta \equiv \beta_s + \beta_d$, $\varepsilon_t(z) \equiv \varepsilon_t^d(z) - \varepsilon_t^s(z)$.

B. Some Properties of the Model

Equations (3) and (4) are not final solutions for $y_t(z)$ and $r_t(z)$ because they contain the endogenous expectation $E_z m_t$. Further, the model would have to be closed to determine R_t and the array of $P_t(z)$'s by specifying some sort of portfolio balance condition. However, for present purposes, the main results can be obtained by studying the intermediate equations (3) and (4).[4]

Association Between Money Shocks and Output

The direction of association of output with money shocks in equation (3) depends on the relative magnitudes of some elasticities. The speculative supply coefficient α_s, which is stressed in these types of models, entails a positive relation, but the demand coefficient α_d has an opposite implication. A sufficient condition for obtaining the "normal" net positive relation is that money shocks impact directly mostly on the demand side; that is, $\beta_d >> \beta_s$. The direct monetary effect on supply--which can be viewed as reflecting a wealth effect on demand for leisure--is, in fact, typically assumed to be negligible in macroanalysis.

Behavior of Rates of Return

As stressed by Sargent (1973, pp. 442-44), there is a direct tie between departures of output from its natural value (which is itself treated as constant on average across markets in the present setting) and departures of the anticipated real rate of return from the natural rate. Since money shocks impact positively on excess commodity demand, the relative price variable $r_t(z)$ moves positively with $m_t - E_z m_t$ in equation (4) in order to maintain clearing of the local commodity market.

It should be stressed that the pertinent variable above is the anticipated real rate of return, rather than the realized value. In models with an economy-wide nominal interest rate where monetary aggregates are not observed contemporaneously, the realized and anticipated returns tend to move in opposite directions in response to a money shock. For example, consider a setting where nominal aggregates are observed with a one-period lag, where money growth rates are serially uncorrelated, and where no elements of persistence in output are introduced (see below). Under these conditions, a change in this period's money stock would be reflected one-to-one in next period's price level. Because of incomplete current information about nominal aggregates,[5] equilibrium expected future prices end up rising by less than the actual (full current information) mean value of future prices; that is, by less than one-to-one with the current monetary disturbance. The full equilibrium then involves current prices rising relative to the "sluggish" expected future prices, but by less than one-to-one with the current money stock. Portfolio balance typically requires the implied increase in current real money balances to be accompanied by a decrease in the current economy-wide nominal interest rate.[6] The rise in the anticipated real rate of return is consistent with these results because the decline in the nominal interest rate is smaller in magnitude than the rise in current prices relative to expected future prices (that is, than the magnitude of decline in locally expected inflation rates). Note, however, that the mean (full current information) realized real rate of return must have fallen, since nominal interest rates have declined and the rise in the mean of actual future prices is greater than that of current prices.

The inverse effect of money shocks on current nominal interest rates is not a central element in the above story. Positive serial correlation in the money growth process can reverse this effect, essentially by introducing the feature that the perceived parts of current money shocks signal future money creation and general inflation, which lead to increases in the current economy-wide nominal interest rate. This change leaves unaltered the conclusions regarding anticipated real rates of return. Unperceived monetary injections continue to raise anticipated real rates of return as indicated in equation (4). (The rise in the nominal interest rate cancels the effects of anticipated general inflation in the formula for expected real rates of return.)

The effects on realized real rates of return in models with an economy-wide market that sets a nominal interest rate are generally dependent on the nature of the serial dependence in the money growth process. Positive serial correlation--which characterizes the post-World War II U.S. experience--implies that a current money shock has an even larger effect on the actual (full current information) mean value of future prices relative to the effect on currently anticipated (partial current information) future prices. The mechanism involves the inverse effect on next period's money demand of the inflationary expectations that arise after the current money shock has been fully perceived. Because of this effect, the presence of positive serial correlation in the money growth process reinforces the inverse effect of money shocks on realized real rates of return.

The preceding story applies to the effects of unperceived monetary movements on contemporaneously expected real rates of return and on subsequently realized returns. If nominal aggregates are observed with a one-period lag, the present type of model would not account for effects of money shocks on output or expected real returns that last beyond the initial "period." Persisting effects of monetary and other disturbances have been explained in a number of models, such as Lucas (1975) and Sargent (1979, Ch. XVI), from consideration of stock adjustment effects. A key element in these models is the existence of "excess capacity" in periods following the positive shock to aggregate demand. For example, the initial monetary-induced response of investment, production and employment is reflected later in increased stocks of capital, inventories, employees, etc. Because of stock adjustment costs in a generalized sense, these high levels of stocks boost commodity supply[7] beyond the time at which nominal disturbances are fully understood. However, the spur to aggregate demand--which was provided initially by the direct impact of the nominal shock--must now be generated by a reduction in expected real rates of return (that is, by a decline in prices relative to expected discounted future prices).[8] Since incomplete information is not a part of this excess capacity effect, the reduction in expected real returns would now coincide with a decline in the (full current information) mean value of subsequently realized returns.

To summarize, unperceived monetary disturbances would induce a contemporaneous increase in expected real returns, to be followed (when information on nominal aggregates becomes available and when the excess capacity effect becomes important) by a drop in expected returns. Realized real rates of return would be reduced throughout the period subsequent to a monetary shock.

C. Effects of Government Purchases

Intertemporal substitution effects associated with movements in government purchases have been stressed in papers by Hall (1979) and Barro (1979). These effects arise in the context of temporary purchases, such as wartime expenditures, which have a strongly positive impact on aggregate demand.[9]

Long-run changes in the share of gross national product absorbed by government purchases have a corresponding inverse effect on households' permanent disposable income, which tends to eliminate the net impact of these purchases on aggregate demand.[10]

The positive effect of temporary government purchases on aggregate demand induces a rise in current commodity prices relative to expected, discounted future prices; that is, an increase in expected real rates of return. This price movement restores commodity market clearing through a combination of reduced private demand and increased aggregate supply. The positive supply response reflects the intertemporal substitution of factor services and final products toward periods with relatively high (discounted) values of wages and prices, which signal unusual rewards for intensive work effort and production. This behavior implies that periods with high values of government purchases relative to "normal," such as wartime, will also be periods with relatively high values of output. The substitution effects set off by temporary government purchases have been stressed by Hall (1979, section 2), who points out also that this mechanism differs in some important respects from the response of supply to monetary misperceptions that occurs in some business cycle theories that stress intertemporal substitution effects, as discussed above. The effect of temporary government purchases on the time arrangement of work and production does not rely on elements of misperception with respect to the general price level or other variables. In particular, the hypothesized positive effect of temporary government purchases on anticipated real rates of return carries over in this case to a positive effect on the (full current information) mean of subsequently realized returns.

Lagged effects of temporary government purchases on output and real rates of return are ambiguous. If the private plant and personnel that produce to government order were entirely non-specific for this purpose, then the persistence effects of shifts in government purchases would parallel those of monetary shocks. In particular, the excess capacity prevailing in future periods would tend to maintain high levels of output. Future real rates of return would be depressed in this case. However, the opposite conclusions emerge when factors are specific to government-ordered work. Therefore, the primary theoretical hypothesis is for a positive effect on real rates of return (and output) of the contemporaneous value of temporary government purchases.

For empirical purposes I utilize a series for the "normal" ratio of government purchases to GNP that was constructed in Barro (1979, part II). A time series analysis of total government purchases was used to relate the expected value of future purchases to currently observed variables. Shifts in the ratio of federal plus state and local non-defense purchases to GNP appeared to be permanent, in the sense that the most recent observation of this variable provides the best prediction for future values.[11] Similar behavior characterizes movements in the defense purchases ratio when these changes do not accompany wars. The only temporary movements that were isolated were the shifts in defense purchases that were associated with wars. This behavior is exhibited for the period since 1941 by the series labeled $(g^w - \overline{g^w})$ in table 1, where g^w is the ratio of real defense purchases to real GNP and $\overline{g^w}$ is the constructed expected long-run average value of this ratio. Because the $(g^w - \overline{g^w})$ variable corresponds to a gap between the current and "normal" values of the purchases ratio, rather than to a spread between actual and "anticipated" amounts, it should not be surprising that this variable exhibits a substantial amount of positive serial correlation. In particular, the large number of peacetime years with small negative values of $(g^w - \overline{g^w})$ are offset by a smaller number of wartime years with larger excesses of g^w over $\overline{g^w}$. (However, war years cannot be deemed special, since they constitute 42 per cent of the years since 1941 and 33 per cent of those since 1946.[12]) The present analysis does not encompass any effects of war that are not proxied by the temporary purchases variable. For example, the investigation does not deal with separate effects of patriotism, conscription, or changing probabilities of victory, which could influence future property rights.

II. Previous Empirical Findings on the Business Cycle Role of Intertemporal Substitution Variables

Sargent (1976) estimates a model from quarterly U.S. data over the 1951 to 1973 period. The analysis includes a price-surprise term, $P_t - E_{t-1}P_t$, as a key explanatory variable. (Recall that P_t represents the log of the price level, which is measured in this case by the GNP deflator.) A major finding is the minor explanatory role for the unemployment rate of this price surprise variable, which has an estimated coefficient that is negative, but with a t-value of only 2.0. When the model is reestimated by Fair (1979, pp. 703-08) with a second-order autoregressive error term and with a constraint that the expectation $E_{t-1}P_t$ be formed in an internally consistent manner, the estimated coefficient becomes insignificant.

It seems likely that the Sargent and Fair estimates are confounded by simultaneity problems; clearly, in an OLS regression with the unemployment rate as a dependent variable, the sign of the estimated coefficient on the price-surprise term would depend on whether demand or supply shocks were dominant over the sample. Fair (1979, p. 704) uses only the nominal money stock and population as exogenous variables for carrying out two-stage least squares; deleting Sargent's (1976, p. 234) government purchases, employment and surplus variables because they were absent from the structural model. (The treatment of the surplus as exogenous is surprising in any case.) Since the contemporaneous realizations of the two exogenous variables and of the long-term nominal interest rate (which is treated by Fair as predetermined) are the main basis for distinguishing supply effects of the current price level from those of the expected price level, $E_{t-1}P_t$,[13] it is unclear that the estimates can be interpreted as supply parameters. For example, one would question the independence of the interest rate from supply disturbances. These doubts are reinforced by the dramatic reversal in sign for the price-surprise coefficient that arises when Fair (p. 706) adds the years 1974-77 to the sample. The natural interpretation is that adverse supply shocks were important since 1974, with these shocks producing a positive correlation between the unemployment rate and price movements (and nominal interest rate changes).

The price-surprise term, $P_t - E_{t-1}P_t$, is also not an appropriate representation of the intertermporal substitution variable in business cycle models, as discussed above.[14] The relevant comparison is between current prices (or wages) and expected future values, so the $E_{t-1}P_t$ would be replaced by a variable like E_tP_{t+1}. The introduction of (partial) contemporaneous information into the expectational calculation substantially complicates any empirical analysis. In some cases (see below) it is possible to avoid the problem of explicity constructing expectations by studying the behavior or realized real rates of return. Finally, a nominal interest rate would appear also in the intertermporal substitution variable; that is, E_tP_{t+1} would enter in discounted form for a comparison with P_t.

The empirical analyses of annual U.S. data since World War II that are summarized in Barro (1980c) deal primarily with reduced form effects of money shocks on the unemployment rate, output and the price level. The investigation is extended to quarterly data in Barro and Rush (1980). The major finding is the statistically significant and quantitatively important expansionary influence on real economic activity of a constructed money shock variable. The positive response of output to a monetary disturbance is estimated to peak with a 3-4 quarter lag, then gradually diminish to become insignificant after about 7 quarters. The negative response of the unemployment rate is similar, although possibly revealing a slightly longer lag relative to that of output. The empirical evidence did not indicate any periods of contractionary response following the roughly two-year interval of above normal real activity following a money shock. Given the relatively minor role played by price surprises in the results of Sargent (1976) and Fair (1979) discussed above, it appears that these monetary influences on output and the unemployment rate involve channels that have yet to be isolated.

The results in Barro (1979) document positive output effects of government purchases for annual U.S. data since 1946. There is some indication that the largest expansionary influence applies to temporary movements in purchases; but, as noted above, the only temporary variations that have been isolated are parts of the defense expenditures associated with wars. Long-run changes in defense spending are estimated to have a significantly positive, but smaller, effect on output. The output effect of non-defense federal plus state and local purchases is imprecisely determined. The relatively small amount of sampling variation in this explanatory variable and the necessity of using an instrument for estimation purposes imply a large standard error for the estimated coefficient.[15] Lagged effects of governemnt purchases on output are unimportant in the annual data. As in the case of the reduced form monetary studies, the results on government purchases lack a description of the relative price variables that stimulate an increase in supply.

Bortz (1979) uses quarterly post-World War II U.S. data to explore the reduced form effects of money shocks on the realized real rate of return from 3-month Treasury Bills. The study uses the money shock series constructed by Barro and Rush (1980) and measures real returns on Treasury Bills by netting out changes in the consumer price index. The principal finding (Bortz, 1979, table 3) is a significantly negative effect of the contemporaneous and three quarterly lagged values of money shocks on the realized real return. The t-values for the estimated coefficients from lags zero to three are in a range from 2.4 to 2.7. Some statistical tests indicate a preference for a form that utilizes money shock variables over an alternative that employs actual growth rates of the money supply. Overall, these results support the theoretical implications of business cycle models that stress intertemporal substitution variables.

Hall (1979, p. 16) uses quarterly, post-World War II U.S. data to estimate a "labor supply" function with an intertemporal substitution measure as a right-side variable. He finds a significantly positive effect (t-value = 2.4) of this price variable on total employment when military purchases and military employment are used as instruments. The implied elasticity of labor supply with respect to the current real wage rate is about one-half. Hall's basic inference (p. 17) is that increases in military purchases and employment induce an increase in aggregate employment via a rise in the intertemporal substitution variable. This finding accords with Hall's theoretical arguments and with the analysis of government purchases that was presented above. However, there is some difference between Hall's intertemporal substitution variable and the previously discussed real rate of return variables. Hall's variable (pp. 15, 16) is the real rate of return--measured as a one-year commercial paper rate net of the annual inflation rate as indicated by changes in the GNP deflator--plus the log of the current real wage rate. This price variable can be viewed as governing the substitution between today's leisure and future consumption of commodities. If current leisure is an especially close substitute for future leisure, it may be preferable to rewrite the substitution variable in terms of current nominal wage rates relative to discounted expected future nominal wage rates; that is, as an expected real rate of return with the rate of nominal wage rate change substituting for the rate of price change.

However, if cyclical movements in real wage rates are relatively unimportant, the distinction between this form of the intertemporal substitution variable and Hall's construct will be minor.

III. New Reduced Form Evidence on Realized Rates of Return

This section presents some evidence from annual, post-World War II U.S. data on the effects of monetary and government purchases variables on realized real rates of return. The focus on realized returns avoids a serious empirical problem concerning the formation of price expectations. As the theoretical section makes clear, for the interval where movements in monetary aggregates are not directly observed, the sign of the effect of monetary disturbances on anticipated real returns depends on whether conditioning is done on partial or complete current information. Perceived real returns based on partial information rise with money shocks, while those that could have been calculated based on full information decline. Not surprisingly, the empirical results are highly sensitive to the choice of which current information to use in forming expectations. Some of these problems are avoided by completely neglecting current observations in these calculations, but issues are then raised concerning the timing of receipt of lagged information. Further, this procedure incorrectly ignores some contemporaneous information, such as war prospects, that should be included in determining expectations of future prices.

The theory does have several clear implications concerning the behavior of realized returns, as is clear from the earlier discussion. These propositions can be tested in a reasonably straightforward manner. A drawback of this procedure is that it fails to test directly a key hypothesis that is associated with equilibrium business cycle theory--namely, the positive effect of monetary disturbances on contemporaneously (and incorrectly) percieved real returns. The concluding section contains some additional discussion of this gap in the analysis.

Nominal rates of return are measured empirically in two ways: first, as the annualized return to maturity on 3-month Treasury Bills sold on secondary markets; and second, as the total return on a value-weighted portfolio of all New York Stock Exchange (NYSE) stocks. The latter series is reported by the Center for Research in Security Prices of the University of Chicago. In interpreting the results it should be recalled that the theory applies to a setting of an economy-wide nominal bond market. The implications posed by the existence of equity shares has not been examined in the theoretical framework.

For the Treasury Bill series the return for year t, $(RT)_t$, is the annual average of the 3-month bill returns. For the NYSE, the return $(RMV)_t$ applies to the period from Janaury 1 to December 31 of year t. Realized real returns have been constructed by subtracting either the annual rate of change of the seasonally-unadjusted wholesale price index (WPI) measured from January of year t to January of year t+1, or the change of the seasonally-adjusted GNP deflator (PGNP) measured from the first quarter of year t to the first quarter of year t+1.[16] There is a minor discrepancy in the timing between the inflation rates and the nominal returns, but the results were insensitive to some alterations in this dating.[17]

I have examined also the behavior of constructed "after-tax" real returns variables. The tax rate applied to the nominal returns is the one implicit in the relation between the nominal yield to maturity on Moody's Aaa rated corporate bonds and that on Standard & Poor's high grade municipal bonds. The tax rate is determined in table 1 from the formula, $\tau = 1 - (R_{municipal}/R_{Aaa})$, where the R variables represent nominal yields. This calculation assumes that corporate and municipal bonds are equivalent except for the (federal) income tax exemption on municipals. I have used the same tax rate variable to adjust Treasury Bill and equity returns, although this procedure neglects various differences in the tax treatment of these two types of returns. Because of this and other problems, the constructed after-tax returns series should be regarded as subject to considerable measurement error. However, the tax rate variable that was used may capture the major secular changes in the true average marginal tax rates on the two forms of asset returns.

For the case of monetary shocks, I focus on the current and lagged effects of the annual money shock variable DMR (table 1), which was derived from the analysis in Barro (1980c,). Essentially, the values for annual average M1 growth appear relative to the growth that is associated typically with current real federal spending relative to "normal," the lagged unemployment rate, and two annual lag values of money growth. The series for g_t^w, the ratio of real defense purchases to real GNP, expressed relative to its "normal" value, $\overline{g}_t^w$, was discussed above and is contained also in table 1.

The Treasury Bill variables correspond roughly to the average annual real spot returns. Therefore, these returns should exhibit the theoretical relationships, which predict a negative effect of contemporaneous and lagged money shocks, and a positive effect of the contemporaneous value of government purchases relative to normal.

The NYSE returns reflect both average spot discount rates and the effects of innovations on asset values. For example--with the expected time path of real share earnings held fixed--an inverse effect of a money shock on real discount rates would imply an upward adjustment to contemporaneous real asset prices. Realized returns up to the date that includes the shock would be moved upward, while subsequent returns would be pushed downward. The "contemporaneous" effects revealed by the present time-aggregated annual data would be ambiguous, since they involve the offset of these two forces. The analysis of contemporaneous effects is complicated further if the shocks alter projections of real share earnings. These difficulties do not pertain to the analysis of lagged effects, which would presumably be incorporated into asset prices before the start of year t. Therefore, lagged monetary shocks would be expected to exert a negative effect on realized real NYSE returns.[18]

The current value of the temporary government purchases variable would be expected to have a positive effect on realized NYSE returns if the principal movements in the $(g^w - \overline{g^w})_t$ variable, which are almost exclusively war-related, were anticipated by the start of year t. I examine also the effect of the lagged value, $(g^w - \overline{g^w})_{t-1}$, which is presumably fully understood during year t.[19]

The basic empirical results appear in table 2. All regressions apply to annual data for the 1949-77 period. The starting date was dictated by the strong effect of World War II controls on the reported price data from 1943 to 1947. Some of the data after 1977 were unavailable at the time of this study. I consider first the behavior of the stock returns, RMV. The findings are similar for these returns whether inflation rates are measured by the WPI or by the GNP deflator. For convenience, I discuss only the results that use the WPI.

The estimated effects of the temporary government purchases variable on realized real returns, RMV - D(WPI), are positive throughout. For specifications that include also the money shock variable DMR, the t-values of the estimated government purchases coefficients are in the neighborhood of 2. For example, with DMR_{t-1} as the only additional explanatory variable, the estimated coefficient on the $(g^w - \overline{g^w})_t$ variable is 5.1, s.e. = 2.6 (line 1 of the table) for the pre-tax real rate of return regression; and 3.8, s.e. = 2.1, for the case of after-tax returns (line 5). The results are basically similar except for a small deterioration of the fit if the lagged value of the $(g^w - \overline{g^w})$ variable replaces the current value. With the DMR_{t-1} variable as the other explanatory variable, the estimated coefficient of the temporary government purchases variable is then 4.7, s.e. = 2.6, for the pre-tax returns case; and 3.9, s.e. = 2.1, for the after-tax returns. When the contemporaneous and lagged values of the $(g^w - \overline{g^w})$ variable are entered simultaneously, the estimated coefficients are both positive[20] but, because of the high degree of intercorrelation between these variables, the estimated coefficients are individually insignificantly different from zero.

There is some indication that permanent movements in government purchases do not have the real rate of return influences that are produced by temporary shifts. The variables $\overline{g^w}_{t-1}$ and g^p_{t-1} (g^p is the ratio of real non-defense government purchases to real GNP) are insignificant in an equation that includes also the variables DMR_{t-1} and $(g^w - \overline{g^w})_{t-1}$. For the pre-tax returns case, the estimated coefficient on $\overline{g}^w_{t-1}$ is -0.1, s.e. = 1.7, while that on g^p_{t-1} is -2.7, s.e. = 2.7. For the after-tax returns, the corresponding estimates are -0.1, s.e. = 1.4, and -2.4, s.e. = 2.2.[21]

The one-year lagged monetary movements have significantly negative effects on the real stock returns. For example, the estimated effect of the DMR_{t-1} variable on the pre-tax real returns is -8.2, s.e. = 2.6 (line 1); while that for the after-tax case is -6.6, s.e. = 2.2 (line 5). The effect of the contemporaneous variable DMR_t is insignificant (lines 2 and 6), as is also the case for a second lag value DMR_{t-2}.[22]

The negative effect of one-year lagged monetary movements appears also when actual money growth substitutes for the shock portion, DMR. The estimated coefficient of DM_{t-1} is -5.3, s.e. = 1.5 for the pre-tax returns (line 3); and -4.4, s.e. = 1.2, for the after-tax values (line 7). (The estimated coefficients of DM_t (lines 4 and 8) and DM_{t-2} turn out to be insignificant.) The fit of the equations that contain actual values of money growth are actually superior to those based on the DMR values, which differs sharply from comparisons of estimated equations for output and the unemployment rate (Barro, 1980c,).

Regressions were run also with sets of DMR and DM variables included simultaneously, which permits tests for the significance of a set of DMR or DM variables, conditional on the inclusion of the other set. For example, for the case of pre-tax returns where a contemporaneous and one-year lag value of each variable is considered, the test for significance of the DMR values, given the inclusion of the DM's, corresponds to the statistic $F^2_{23} = 0.9$. The corresponding test for the significance of the DM values, given the inclusion of the DMR's, yields the statistic $F^2_{23} = 2.1$. Since both statistics are below the 5 per cent critical value of 3.4, the hypothesis of zero effect for either the set of DMR variables or the set of DM values, given the inclusion of the other set, would be accepted at the 5 per cent level. Nevertheless, the results can be viewed as suggesting (at a significance level below 95 per cent) some negative impact on subsequent real stock returns of the perceived growth rate of money (which would be closly related to anticipated future monetary growth rates), given the values of monetary shocks. In this respect the results are reminiscent of those of Fama and Schwert (1977, pp. 135, ff.), who have stressed the puzzling negative relation between anticipated inflation (as measured by the nominal interest rate on Treasury Bills with one-month maturity) and subsequently realized NYSE returns. Related results have been presented by Jaffe and Mandelker (1976) and Nelson (1976). These types of findings are elaborated and some explanations are offered in Fama (1980, pp. 21, ff.).

The results for realized real returns on 3-month Treasury Bills show much less explanatory power for the government purchases and monetary variables. A negative effect of the contemporaneous monetary shock does appear, which parallels the results from quarterly data that were reported by Bortz (1979) and discussed above. For example, for the pre-tax returns net of WPI inflation, the estimated coefficient on DMR_t is -1.4, s.e. = 0.6 (line 10 of table 2); while that for the after-tax returns is -1.5, s.e. = 0.7 (line 14). The result that the contemporaneous money shock effect is negative on the Treasury Bill returns and insignificant for the NYSE returns does accord with the theoretical discussion. The Treasury Bill regressions do not indicate a preference for the DM form of the equations, although the hypothesis of zero coefficients for either the set of DMR variables or the set of DM values would be accepted, given the inclusion of the other set. In either form of the equations, the contemporaneous (annual) value has the only significant monetary effect. One and two-year lagged values of the DMR or DM variables are insignificant (lines 10 and 14).

For the cases where the DMR_t variable is included, the temporary government purchases variable has a positive estimated effect on the Treasury Bill returns, with t-values close to 2. The estimated coefficient for the case of pre-tax returns (line 10) is 1.3, s.e. = 0.7; while that for the after-tax case is 1.4, s.e. = 0.7 (line 14). However, the government purchases variable becomes insignificant when the WPI is replaced by the GNP deflator to measure the inflation rate (lines 26 and 30). (The t-values for the contemporaneous monetary variables remain close to 2 in this case.)

I will consider now some details of the estimates for the equations based on the WPI that use the explanatory variables DMR_t, DMR_{t-1} and $(g^w - \overline{g^w})_t$. Although this equation form is more understandable on theoretical grounds than that expressed in terms of DM values, it should be recalled that the statistical results do not reinforce this choice of form. The actual values of the pre-tax realized real returns from the NYSE and from 3-month Treasury Bills are shown in table 3 along with estimated values and residuals from the regressions shown in lines 2 and 10 of table 2.

The estimated coefficient on DMR_{t-1} in the RMV equation (table 2, line 2) of -8.3 implies that a one percentage point money shock reduces the mean of next year's real NYSE returns by more than 8 percentage points! Since the estimated standard error from the money growth rate equation that generates the DMR values is .014, the results imply that monetary fluctuations have produced large movements in ex ante real returns on the NYSE. However, this relationship should be viewed in perspective to the sample standard deviation of the realized real returns on stocks, which was .195 from 1949 to 1977.[23] Since the estimated coefficient on DMR_{t-1} in the Treasury Bills equation (line 10) is negligible, the effect of DMR_{t-1} on the NYSE returns represents also a differential effect on the expected real returns from stocks and short-term government securities.

The estimated coefficient for the $(g^w - \overline{g^w})_t$ variable of 5.8 in line 2 implies a very large positive effect of war on real NYSE returns. For example, the Korean War values for $(g^w - \overline{g^w})$ of .026 imply that the realized real returns would be higher by .24 than those associated with the typical peacetime value for $(g^w - \overline{g^w})$ of -.015. It is clear that this magnitude of effect could not be extrapolated in a linear form to the World War II experience, where the values of $(g^w - \overline{g^w})$ are above 0.3.[24] These results should not be viewed as indicating that war is good for the stock market. Rather, the basic finding is that the high values of temporary government purchases associated with wartime imply an increase in the required real rate of return on equity--that is, a rise in the discount rate applied to anticipated earnings. In this context it is notable that the results remain similar if the lagged value for $(g^w - \overline{g^w})$--which is presumably known by the start of year t--replaces the contemporaneous value. However, the present results do not rule out a separate effect of new information about war conditions on equity prices, which could work through an effect on anticipated earnings flows.

There is, of course, no inconsistency between efficient capital markets and a predictable pattern either of overall real returns or of the return differential between stocks and Treasury Bills. The present results can be interpreted as showing a strong positive effect of war and (money-induced) recession on the return premium for stocks. It has, however, been argued (for example, in Nelson, 1976, p. 482; and Fama and Schwert, 1976, p. 136) that assets like common stocks should not exhibit lower expected returns than less risky assets like Treasury Bills.[25] For the estimated values shown in Table 3, this situation occurs for 7 of the 29 years of the sample (1956, 1960, 1969-70, 1972-74). All of these years except for 1960, but no other years in the sample, exhibit negative estimated real returns on stocks. These results apply to equations that include the contemporaneous values DMR_t and $(g^w - \overline{g^w})_t$. However, basically similar results obtain if only the lagged variables DMR_{t-1} and $(g^w - \overline{g^w})_{t-1}$ are used as regressors. In this case negative expected real returns on stocks apply for 1951, 1956, 1960, 1969, and 1972-74.

It is likely that the functional form could satisfactorily be restricted to confine the expected real NYSE returns to exceed either those on Treasury Bills or zero. For example, estimates of the functional form,

$$[RMV - D(WPI)]_t = \exp[a_0 + a_1 DMR_t + a_2 DMR_{t-1} + a_3(g^w - \overline{g^w})_t] + \text{error term},$$

which restricts the estimated values to be positive, yields a log likelihood that is only 1.1 below that of the linear form (table 2, line 2). Although the linear and non-linear forms of the return equations have not presently been set up to allow for a test of nested hypotheses, these results suggest that the appearance of negative estimated (or expected) real NYSE returns is not an important problem.

IV. Conclusions

In some respects the new empirical findings support the theoretical model--notably, in isolating realized real rate of return effects that are significantly positive for the temporary government purchases variable and significantly negative for the monetary variables. The statistical preference for actual monetary movements over the constructed money shock variable and the relatively weak effects on real Treasury Bill yields are less satisfactory features.

A different issue concerns the extent to which the present empirical analysis distinguishes hypotheses of equilibrium business cycle theory from those of more conventional macroanalysis. The usual IS/LM model predicts a positive effect of government purchases on rates of return, which should presumably be interpreted as an effect on real, rather than nominal, returns. In this respect the predictions parallel those of the equilibrium models. The IS/LM story involves crowding-out of private demands with no mention of positive supply effects, but the direction of interest rate response would still be positive. An important difference in the "equilibrium" approach is the stress on temporary government purchases, which does receive some support from the empirical results.

With respect to monetary movements, the IS/LM framework suggests a negative response of interest rates, although the distinction between real and nominal rates is less clear in this respect. The equilibrium analysis predicts a negative effect on realized real returns and an ambiguous impact on nominal returns (which involves an effect on generally anticipated inflation). The stress on monetary shocks, rather than perceived movements in money, in the equilibrium viewpoint was not borne out in the present results, as mentioned above.

The correspondence in some respects for the rate of return implications of the equilibrium approach and other macro theories does not, of course, rule out the present statistical results as valid tests of both types of theories. Although real rate of return effects that are positive for government purchases and negative for money growth may not be surprising, I cannot find much past empirical evidence that bears on these propositions.

One hypothesis that sharply distinguishes the equilibrium model with incomplete information on monetary aggregates from more standard macroanalyses is the prediction of a positive effect of money shocks on contemporaneously (and erroneously) perceived real rates of return. As discussed above, this hypothesis cannot be tested directly from observations on realized returns, precisely because the incomplete information structure predicts that monetary disturbances move *ex post* returns in a direction opposite to that of *ex ante* (partial information) returns. Satisfactory testing of this hypothesis seems to require an explicit calculation of price expectations conditional on partial current information. I am uncertain whether this analysis is feasible.

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Footnotes

[1]In Sargent (1973, p. 434) and Sargent and Wallace (1975, p. 242), supply depends on $P_t - E_{t-1}P_t$, while demand depends on an expected real interest rate. Therefore, a direct monetary effect on excess commodity demand is unnecessary. Similarly, in Lucas (1973, pp. 327-28), nominal income is exogenous and supply depends on $P_t(z) - E_z P_t$. Models where a separate form of relative price variable influences investment demand, as in Lucas (1975, p. 1124), do not require a direct real balance-type effect on aggregate demand. Although I regard this general route as promising, a fully satisfactory setup with different forms of relative price variables has not yet been constructed.

[2]This model assumes also (p. 105) that new money enters as governmental transfers that are proportional to individual money holdings. The implicit interest rate on holding money in this circumstance leads to neutral effects of changes in the anticipated monetary growth rate.

[3]The neglect of future anticipated real rates of return is satisfactory because these values are constant in the present setup. This type of model stresses departures of currently perceived returns from normal values, rather than changes in the normal rate of return.

[4]The absence of actual or expected price levels from the right side of equations (3) and (4) depends on some features of the specification in equations (1) and (2). For example, this absence would not obtain if commodity supply and demand depended on the level of real cash balances, with either the actual or expected price level used as a deflator for nominal

(continued)

([4] continued)

money. These changes would require an analysis of expectational equilibrium and portfolio balance before discussing any solution properties. Ultimately, the substantive differences would involve the real effects of anticipated inflation, as indicated in the text.

[5] Models where the current information set includes observations on a local commodity price and a global nominal interest rate are considered in Barro (1980a) and King (1978).

[6] This decrease may not occur if the induced rise in current output has a strong effect on current real money demand.

[7] Elements of adjustment costs on the demand side--for example, the planning costs for investment that are stressed by Kydland and Prescott (1980,   )--would imply maintenance of high levels of aggregate demand in periods subsequent to a shock (which would be followed by later periods of increased capacity). These effects reinforce the persistence of high output, but offset the inverse effect on real rates of return in some future periods. Similarly, an inverse effect of monetary shocks on producers' finished goods inventories (as opposed to inventories of goods-in-process and materials), which are stressed by Blinder and Fischer (1978), would tend to sustain high levels of demand. Overall, the excess capacity effect would be dominant in future periods if the principal initial effect of monetary disturbances is on work and production, rather than on consumption. In this circumstance the aggregate of future stocks--whether held by businesses or consumers--will end up higher than they otherwise would be.

[8]As above, changing expectations of future money growth and associated general inflation would not alter the conclusions about expected real rates of return.

[9]Direct substitution in utility or production functions of government purchases for private consumption or investment expenditures, as stressed by Bailey (1971, pp. 152-55), offsets the positive aggregate demand effect of temporary government purchases.

[10]This argument is independent of the method of public finance if households view deficits as equivalent to current taxation. The full direct offset of private for public demands arises when privately desired captial stocks are invariant with the level of government purchases.

[11]Neither this ratio nor the defense purchases ratio exhibited significant drift. A drift does appear since 1929 in the ratio of transfers to GNP.

[12]War years are classified as 1941-45, 1950-52, and 1965-72.

[13]Another distinction arises from the non-linear restrictions on the reduced form that are imposed in the calculation of $E_{t-1}P_t$.

[14]However, these models would predict a positive effect of contemporaneous money shocks on the variable $P_t - E_{t-1}P_t$.

[15]In the theoretical model long-run movements in government purchases would raise output, but not necessarily affect the real rate of return, if there were a direct positive influence of govenmental activities on aggregate supply.

[16]The January-to-January consumer price index (CPI) yields results that are very close to those obtained with the GNP deflator. The CPI's treatment of housing costs seems to impart meaningless sensitivity of the index to variations in nominal interest rates, which I had thought might particularly be a problem in the present context. However, the CPI probably provides a better measure than the WPI of true transactions prices. The WPI may be less sensitive than the other indices to problems of measuring quality change, which are likely to be most serious for services.

[17]For example, a shift to December-to-December or February-to-February values for the WPI had negligible effects on the results.

[18]This conclusion could be altered by two effects that I believe to be minor. First, there is a lag in obtaining initial reports on the money stock (which is now less than two weeks); and second there are subsequent revisions to the M1 data. (Only "final" reports are used in the present analysis.) A detailed study of money stock revisions in Barro and Hercowitz (1980) indicated only trivial implications for analyses of output and the unemployment rate.

[19]As constructed (Barro, 1979), the $\overline{g_t^w}$ variable incorporates some information about future war conditions. However, this element does not have a substantial effect on the $(g^w - \overline{g^w})_t$ series for the post-World War II period.

[20] For the pre-tax real rate of return equation with the DMR_t and DMR_{t-1} variables also included, the estimated coefficients are 4.1, s.e. = 4.2, for the current value of the temporary purchases variable; and 2.1, s.e. = 3.8, for the lagged value.

[21] The contemporaneous values of $\overline{g^w}$ and g^p are also insignificant, but the endogeneity of these variables (which include real GNP in the denominators) may cause some estimation problems, especially in the case of the g_t^p coefficient.

[22] For the pre-tax returns equation with the DMR_{t-1} and $(g^w - \overline{g^w})_t$ variables included also, the estimated coefficient on DMR_{t-2} is -2.4, s.e. = 2.5. For the after-tax returns case, the result is -2.2, s.e. = 2.1.

[23] The mean real return was .082. With the GNP deflator used to measure inflation, the mean real return was .077 with a standard deviation of .180.

[24] However, the nominal return on stocks, RMV, from 1942 to 1945 is quite high, averaging .24 per year (see table 1). The reported inflation rates are probably meaningless for this period.

[25] Treasury Bills do not provide a riskless real rate of return; for example, the sample mean return net of WPI inflation is .006 with a standard deviation of .045. With the GNP deflator used to measure inflation, the sample mean return is .002 with a standard deviation of only .019. The relative riskiness of stocks and Treasury Bills depends also on covariances with returns from other assets, such as human capital and real estate. Conceivably, the dependence of these covariances on money shocks, etc., could account for occasional negative risk premia on stocks.

Table 1

Values of Variables

Date	DM	DMR	$(g^w - \overline{g^w})$	RMV	RT	D(WPI)	D(PGNP)	τ
1941	.160	-.017	.054	-.095	.001	.171	--	.24
2	.179	-.030	.214	.163	.003	.059	--	.17
3	.265	.062	.349	.261	.004	.015	--	.25
4	.162	-.050	.392	.198	.004	.015	--	.32
1945	.150	.010	.341	.337	.004	.020	--	.36
6	.068	.003	.041	-.049	.004	.282	--	.35
7	.034	.001	-.011	.037	.006	.124	.075	.23
8	.004	-.005	-.009	.038	.010	-.016	.013	.15
9	-.010	-.012	-.021	.190	.011	-.050	-.013	.17
1950	.026	.022	-.002	.275	.012	.161	.084	.24
1	.044	.013	.026	.200	.016	-.017	.014	.30
2	.049	.011	.026	.132	.018	-.028	.017	.26
3	.024	-.016	.013	.007	.019	.009	.014	.15
4	.015	-.002	-.001	.427	.010	-.007	.015	.18
1955	.031	.006	-.017	.235	.018	.016	.026	.17
6	.012	-.012	-.017	.092	.027	.043	.040	.13
7	.005	-.013	-.017	-.106	.033	.017	.018	.07
8	.012	-.004	-.018	.374	.018	.005	.020	.06
9	.037	.006	-.020	.128	.034	-.001	.021	.10
1960	-.001	-.036	-.021	.015	.029	.005	.006	.15
1	.021	-.004	-.019	.246	.024	-.002	.020	.20
2	.022	-.015	-.020	-.078	.028	-.003	.016	.27
3	.029	-.003	-.019	.199	.032	.005	.014	.24
4	.039	.003	-.018	.154	.036	.000	.019	.27
1965	.042	.003	-.013	.134	.040	.035	.027	.27
6	.044	.002	.000	-.089	.049	.015	.032	.26
7	.039	-.002	.013	.248	.043	.010	.038	.28
8	.068	.029	.016	.129	.053	.031	.046	.27
9	.061	.015	.009	-.093	.067	.047	.055	.17
1970	.038	-.008	-.003	.035	.065	.023	.050	.19
1	.065	.021	-.011	.157	.044	.039	.046	.23
2	.068	.009	-.013	.168	.041	.068	.041	.27
3	.072	.009	-.017	-.173	.070	.163	.078	.30
4	.053	-.007	-.016	-.284	.079	.159	.110	.29
1975	.042	-.017	-.015	.340	.058	.043	.056	.22
6	.050	-.013	-.017	.245	.050	.047	.052	.23
7	.069	.008	-.015	-.046	.053	.061	.061	.31
8	.079	.011	-.015	.086	.072	.099	.086	.32

Notes: $DM_t \equiv \log(M_t/M_{t-1})$, where M_t is annual average of the M1 definition of money; $DMR \equiv DM - \hat{DM}$, where $\hat{DM}$ is an estimated value of money growth from Barro (1980c,); g^w is real defense purchases relative to real GNP; $\overline{g^w}$ is the estimated normal value of this ratio from Barro (1979,); RMV is the total nominal return on a value-weighted portfolio of all NYSE stocks; RT is the annual average of returns to maturity on 3-month

(continued)

Notes, continued

Treasury Bills sold on secondary markets; WPI is the seasonally-unadjusted January value of the wholesale price index (1967 base); $D(WPI)_t \equiv \log (WPI_{t+1}/WPI_t)$; PGNP is the seasonally-adjusted first quarter GNP deflator (1972 base); $D(PGNP)_t \equiv \log(PNGP_{t+1}/PGNP_t)$; τ is the tax rate variable, constructed as $\tau \equiv 1 - (R_{municipal}/R_{Aaa})$. $R_{municipal}$ is standard & Poor's yield on high-grade municipal bonds and R_{Aaa} is Moody's yield on Aaa rated corporate bonds. Interest rate data appear, for example, in Council of Economic Advisers, Economic Report of the President, January 1980, p. 278.

Table 2

Equations for Realized Real Returns

Sample period: 1949-77

Dependent Variable	CONST.	DMR_t	DMR_{t-1}	DM_t	DM_{t-1}	$(g^w - \overline{g^w})_t$	R^2	D-W	$\hat{\sigma}$
RMV - D(WPI) (1)	.12 (.04)		-8.2 (2.6)			5.1 (2.6)	.27	2.1	.17
(2)	.12 (.04)	-1.4 (2.7)	-8.3 (2.8)			5.8 (2.9)	.27	2.1	.18
(3)	.29 (.06)				-5.3 (1.5)	3.0 (2.2)	.34	2.3	.16
(4)	.29 (.07)			-0.4 (2.0)	-5.0 (2.0)	3.1 (2.3)	.34	2.3	.17
RMV(1-τ)-D(WPI) (5)	.085 (.031)		-6.6 (2.2)			3.8 (2.1)	.25	2.1	.14
(6)	.090 (.032)	-1.5 (2.2)	-6.8 (2.3)			4.5 (2.4)	.27	2.1	.15
(7)	.23 (.05)				-4.4 (1.2)	2.2 (1.8)	.34	2.4	.14
(8)	.24 (.06)			-0.6 (1.6)	-4.0 (1.6)	2.3 (1.9)	.35	2.3	.14
RT - D(WPI) (9)	.011 (.010)		-0.3 (0.7)			0.6 (0.7)	.03	1.9	.046
(10)	.015 (.010)	-1.4 (0.6)	-0.5 (0.7)			1.3 (0.7)	.17	1.9	.043
(11)	.020 (.018)				-0.3 (0.4)	0.5 (0.6)	.04	1.9	.045
(12)	.034 (.019)			-0.8 (0.5)	0.3 (0.5)	0.7 (0.6)	.13	1.9	.044

Table 2, continued

Dependent Variable		CONST.	DMR_t	DMR_{t-1}	DM_t	DM_{t-1}	$(g^w - \overline{g^w})_t$	R^2	D-W	$\hat{\sigma}$
RT(1-τ) - D(WPI)	(13)	.003 (.010)		-0.5 (0.7)			0.7 (0.7)	.03	1.8	.048
	(14)	.008 (.010)	-1.5 (0.7)	-0.6 (0.7)			1.4 (0.7)	.19	1.8	.044
	(15)	.020 (.018)				-0.5 (0.4)	0.6 (0.6)	.07	1.9	.047
	(16)	.036 (.020)			-1.0 (0.5)	0.1 (0.5)	0.9 (0.6)	.18	1.9	.045
RMV - D(PGNP)	(17)	.10 (.03)		-7.2 (2.5)			3.7 (2.4)	.25	2.2	.16
	(18)	.11 (.04)	-0.6 (2.5)	-7.7 (2.6)			4.6 (2.7)	.27	2.1	.16
	(19)	.26 (.06)				-4.9 (1.4)	2.3 (2.0)	.34	2.4	.15
	(20)	.26 (.07)			0.1 (1.8)	-4.9 (1.8)	2.3 (2.1)	.34	2.4	.16
RMV(1-τ) - D(PGNP)	(21)	.075 (.028)		-6.1 (2.0)			3.0 (1.9)	.26	2.1	.13
	(22)	.077 (.030)	-0.6 (2.0)	-6.1 (2.1)			3.3 (2.2)	.26	2.1	.13
	(23)	.21 (.05)				-4.0 (1.1)	1.5 (1.6)	.34	2.4	.12
	(24)	.21 (.05)			-0.2 (1.5)	-3.9 (1.5)	1.5 (1.7)	.34	2.4	.12

Table 2, continued

Dependent Variable		CONST.	DMR_t	DMR_{t-1}	DM_t	DM_{t-1}	$(g^W - \overline{g^W})_t$	R^2	D-W	$\hat{\sigma}$
RT - D(PGNP)	(25)	.000 (.004)		0.3 (0.3)			-0.2 (0.3)	.03	1.9	.019
	(26)	.002 (.004)	-0.5 (0.3)	0.2 (0.3)			0.1 (0.3)	.16	1.8	.018
	(27)	-.003 (.007)				0.1 (0.2)	-0.1 (0.3)	.02	1.9	.019
	(28)	.003 (.008)			-0.4 (0.2)	0.3 (0.2)	0.0 (0.3)	.12	1.9	.018
RT(1-τ) - D(PGNP)	(29)	-.008 (.004)		0.1 (0.3)			-0.1 (0.3)	.01	1.7	.021
	(30)	-.005 (.004)	-0.7 (0.3)	0.0 (0.3)			0.2 (0.3)	.17	1.7	.019
	(31)	-.003 (.008)				-0.1 (0.2)	0.0 (0.3)	.02	1.9	.021
	(32)	.005 (.008)			-0.5 (0.2)	0.2 (0.2)	0.1 (0.3)	.17	1.9	.019

Notes: All data are annual. See tables 1 and 3 for definitions and tabulations of variables. Standard errors of coefficients are shown in parentheses. D-W is the Durbin-Watson Statistic. $\hat{\sigma}$ is the standard-error-of-estimate.

Table 3

Actual and Estimated Values for Realized Real Rates of Return

Date	(1) RMV - D(WPI)	(2) $\widehat{\text{RMV - D(WPI)}}$	(3) RESIDUAL	(4) RT - D(WPI)	(5) $\widehat{\text{RT - D(WPI)}}$	(6) RESIDUAL
1941	-.266			-.170		
2	.104			-.056		
3	.245			-.011		
4	.183			-.011		
1945	.317			-.016		
6	-.332			-.278		
7	-.087			-.119		
8	.054			.026		
9	.241	.065	.176	.061	.008	.053
1950	.113	.177	-.064	-.149	-.012	-.137
1	.217	.067	.149	.032	.020	.012
2	.160	.147	.014	.046	.027	.018
3	-.002	.126	-.128	.010	.048	-.037
4	.434	.249	.185	.016	.024	-.008
1955	.219	.031	.188	.002	-.014	.015
6	.049	-.009	.058	-.016	.008	-.024
7	-.124	.141	-.265	.016	.017	-.002
8	.368	.132	.237	.013	.004	.009
9	.129	.026	.103	.035	-.016	.052
1960	.010	.002	.008	.024	.036	-.012
1	.248	.318	-.070	.026	.013	.013
2	-.075	.059	-.134	.031	.013	.018
3	.194	.138	.056	.026	.003	.024
4	.154	.039	.116	.036	-.011	.046
1965	.099	.014	.085	.004	-.006	.011
6	-.104	.094	-.198	.034	.010	.023
7	.238	.176	.062	.033	.032	.001
8	.098	.184	-.086	.022	-.004	.026
9	-.140	-.089	-.052	.020	-.007	.027
1970	.013	-.013	.026	.042	.015	.027
1	.117	.096	.022	.004	-.023	.027
2	.100	-.141	.240	-.027	-.023	-.005
3	-.337	-.060	-.277	-.093	-.022	-.071
4	-.443	-.039	-.404	-.080	.000	-.080
1975	.297	.116	.181	.015	.023	-.008
6	.198	.189	.011	.003	.020	-.018
7	-.107	.132	-.239	-.009	-.008	-.001
8	-.013	(-.048)	(.035)	-.028	(-.022)	(-.006)

Notes: Definitions for RMV, RT and D(WPI) appear in the notes to table 1. The figures shown in columns 2 and 3 are the estimated values and residuals, respectively, for the regression shown in line 2 of table 2. Those in columns 5 and 6 are from the regression shown in line 10 of table 2.