Relative Prices and the Business Cycle

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Introduction

Evaluations of business cycle models often have been critical of assigning a major role to capital stock, macroeconomic relative prices, or distributional effects of the cycle. For example, in a discussion of the relation between money and income, Blanchard presented Lucas= 1975 model. It included lagged output to represent the role of capital in the propagation mechanism of the cycle, though it considered only the aggregate level of the capital stock and not the composition. Blanchard concluded that Acapital accumulation appears to be an unlikely channel for cyclical persistence@ (1990, p.797), on the expectation that firms would be able to reduce the excess capital to the previous level. If that does not happen quickly and at little cost, then the cycle would have permanent effects; the altered capital accumulation affects marginal products of specific capital, and the losses of liquidation are not temporary as are those of lost output.

Relative prices between money and goods, domestic and international goods, present and future goods are integral to macroeconomic analysis. However, interest rates are commonly characterized as Aacyclical@ and uninvolved in the nature of business cycle effects. Only relative price changes between broad macroeconomic aggregates are considered, and in short run analysis, relative price changes are minimized by sticky-price assumptions. Business cycle analyses often have ignored relative price changes and changes in the allocation of resources because there is a presumption that the magnitude of the effects is not large enough to account for the cycle. Blanchard expresses the view that Athe [long-run money] neutrality proposition is only an approximation. Any anticipated change in the nominal money supply ... is likely to affect capital accumulation. Even unanticipated changes ... have distributional effects. But, except for the effects of steady inflation, which may be substantial (especially when the non-neutrality of the tax system is taken in to account), these effects are mere intellectual curiosities; they can account neither for the size nor the shape of the effect of money on output (Blanchard, 1990, p.780). This paper offers a model of the business cycle which does permit changes in relative prices and the composition of capital stock. The behavior of the model in simulating the business cycle can provide a test of the assumptions that macroeconomic relative prices or capital composition are unrelated to the cyclical pattern of income, or empirically unimportant.

There has been extensive empirical analysis of the existence, magnitude and persistence of the liquidity effect; that a money supply shock would have a negative effect on short term interest rates. The notion that monetary shocks may cause business cycle behavior, and the general question of how monetary shocks affect income have been the focus of much recent work, as suggested by several symposia (St. Louis Federal Reserve Bank *Review*, 1995 and 2001; *Journal of Economic Perspectives*, Fall 1995). The Austrian theory of the business cycle provides a framework for considering these issues, since it is distinctive in considering the composition of capital, macroeconomic relative prices, and it relies on the existence of a liquidity effect.

The purpose of this paper is to offer an empirical model of the business cycle which specifies relative prices as the endogenous propagation mechanism for the cycle, and to explore whether the model can simulate and account for observed business cycle behavior. A structural VAR model is estimated which includes measures of the monetary policy shock, relative price responses to changes in interest rates, resource allocation as the propagation mechanism, and aggregate income as the cyclical behavior. The method provides a calculation of the magnitude of effect of such a shock, which will reflect on whether the Austrian theory can account for business cycle variations. The main results of the paper are that interest rates, resource allocation and income exhibit the expected behavior, and that the empirical model is capable of simulating the cycle. Estimates of the extent to which the behavior of the income aggregate is directly due to monetary shock indicate a substantial magnitude. The ability to account for variations in business cycle process is not limited to the direct influence of money, but including the combined influences of relative prices and resource use, the proportion suggests that the Austrian process is empirically important.

I. Review of the Austrian Business Cycle Theory

The Austrian theory of the business cycle has been presented elsewhere (for example, Garrison, 2001) and so only a brief summary is presented here. In general equilibrium, the interest rate will equal the rate of marginal productivity of capital as well as other of extending the capital stock. The interest rate should also correspond to the rate of price margin between resources, goods in process and final goods considering the time dimension of production processes. If that equilibrium is disturbed by a nominal monetary shock, market interest rates would diverge in level and proportion from Anatural@ rates of marginal productivity or time preference. Adopting Wicksell=s concept of the difference between market and natural interest rates, a monetary shock which creates that wedge represents the impulse that generates the business cycle. Because the shock may have origins in policy or banking system behavior, it may be difficult to classify the Austrian theory as either exogenous or endogenous.

An unexpected monetary expansion increases the supply of loanable funds in the credit market, lowering the market interest rate below the rate of return on capital. Short term interest rates decrease with the liquidity effect of the monetary shock. The expectations hypothesis of the term structure of interest rates expresses long term interest rates as an average of short term rates during the period, and so long term rates decline with the monetary shock also, but to a lesser degree. The yield curve, which arrays interest rates by the term of the loan, shifts down as all rates decrease, and becomes steeper as short term rates fall relative to long term rates.

Resource allocation responds to the change in relative prices expressed by the interest rate levels and term structure. At lower interest rates, firms will increase demand for capital, capital asset prices increase and firms producing new capital goods increase quantity supplied. Common to many business cycle theories, aggregate investment increases when interest rates fall and that drives the expansion. But in addition, firms respond differently to the changes in interest rates, according to their stage of production, and the allocation of investment flows is altered from that during general equilibrium. Early stage production processes that are more distant in time from the consumer good experience a larger effect on the demand for capital than later stage processes. Capital asset prices rise more, and both investment and output increase relatively more for capital intensive industries that are further removed in time from the final product. As investment responds to the change in asset prices, the composition of the capital stock is changed. Given the long life of capital goods, the specific design that limits substitutability among capital types, and the irreversibility of investment decisions, the expansion has long lasting effects on the economy, and consequently money is not considered neutral in the long run.

The dedication of resources to investment and future production has not been matched by a permanent increase in the supply of saving; in fact, the monetary shock which lowered interest rates reduces the real flow of saving. The shock has temporary effects on the real money supply and the supply of loanable funds. As the aggregate economy expands and firms progress in building capital and expanding output, shortages of resources occur which raise resource prices. Short term interest rates are increased toward long term rates and the yield curve flattens or may invert. The primary mechanism in this endogenous market process is the intertemporal disequilibrium between sources and uses of income; at low interest rates, consumers and investors increase spending, and need to finance an increase in both consumption and investment, but savers decrease the quantity supplied of funds. The recession phase begins as resource prices and short term interest rates rise, reducing demands of consumption and investment goods. The development from expansion to recession is a result of the altered relative prices that initiated the expansion, and no further monetary shock, specifically a change in monetary policy, is specified by the theory to induce recession.

The Austrian theory of the business cycle offers several hypotheses about interest rates, relative prices and resource use through the cycle.

1) The liquidity effect of a monetary shock will lower interest rates in general and lower short term rates relative to long term rates. The yield curve will shift down and become steeper in slope, with consistent expression in relative prices of goods at different stages of production. Thus the liquidity effect generates systematic macroeconomic relative price changes.

2) Resource allocation will respond to relative price changes by allocating more resources toward industries which are distant in time from final goods production. Asset prices, investment flow, capacity utilization, labor employment and output will increase more for early

stage production than late stage production. Through the course of the business cycle, the cumulative effects of the altered allocation of investment cause the composition of the capital stock to change.

3) As the expansion phase continues and real income rises relative to potential income, short term interest rates will rise relative to long term rates (the yield curve flattens or inverts) and final goods prices rise relative to resource prices. In the recession phase, the investment incentives are reversed and unsustainable investment will be liquidated or converted to alternative uses.

4) A monetary shock has real effects on the level of real interest rates, the term structure of interest rates and the level of real income.

II. The Cyclical Patterns of Aggregate Economic Activity

To explore these hypotheses, data are examined for the U.S. for the time period 1959:1 through 2001:2. Strongin (1995) and others have noted that although federal funds interest rates existed at the beginning of this period, the federal funds market, with its role in monetary policy, did not begin to develop until 1966. The time period 1979:4 - 1982:4, during which the Fed altered its monetary policy procedure, has often shown structural change in econometric models (Bernanke and Mihiv, 1998).

Figure 1 presents the cyclical behavior of income, expressed as the ratio of actual real GDP to natural real GDP. This ratio displays the pattern of expansion to a peak and then decline in recession to the trough of the cycle, on dates defined by the NBER. Clearly cycles vary greatly in length as well as in amplitude. The time profile varies also in the rate of increase to the peak and the rate of decline of income in recession. It is necessary to allow for this variation, rather than to impose a single stylized shape on the cycle, as in the NBER Acycle relative@ methodology. More recently, Harding and Pagan (2001) appear to identify business cycle facts in an aggregated manner. Even after noting that the observed Acycles@ are not true cycles since they vary in period and volatility, the characteristics they use for comparison of models are the mean duration, amplitude and cumulates losses of output across cycles. By using an output gap measure of actual relative to potential income, different trend rates of growth are permitted, reducing the constraints of comparison across cycles.

Macroeconomic relative prices in Austrian theory emphasize the time dimension of production. That is often modeled as a point-input point-output process, from resources used at early stages to the final good at later stages of production, expressed in terms of the time length until the good is available to consumers. As with a Hotelling Rule, the value of resources must rise over the time of the production process at the rate of interest from early to later stages, given the price of the final good. A relative price ratio of the Producer Price Index for all commodities to the GDP deflator or the Consumer Price Index exhibits little if any cyclical behavior. Commodities prices rise relatively with oil prices during the decade of the 1970s but otherwise there is something of a downward trend of commodity prices relative to final goods prices over the time period. However, at a disaggregated level, there is evidence of cyclical behavior. Clark used several data bases of industry level input and output prices, and found that Aat most early stages of production, an exogenous monetary tightening causes input prices to fall more rapidly and by a larger amount than output prices@ (1999, 430). This pattern of relative price changes is that suggested by Austrian business cycle theory, using Hayek=s concept that the response of input demand to interest rates is related to time and stage of production.

A liquidity effect of a monetary shock is the necessary event to generate these relative price changes. Figure 2 shows the yield curve during the most recent Federal Reserve policy episode of lowering interest rates. While the policy was widely announced and the Fed=s behavior is consistent and credible, these data exhibit a liquidity effect. Short term rates fell from about 6.5% in January 2001 to 2.5% in October, and long term rates fell more slightly. The yield curve became steeper and also shifted down in response to policy. (An earlier example is discussed in Campbell, 1995). A large literature has explored the existence and magnitude of the liquidity effect through a variety of econometric techniques. Bernanke and Mihov (1998) present persuasive evidence that estimates which show a Avanishing@ liquidity effect in recent time periods do so because of bias in the measures of monetary policy variables. They find a strong liquidity effect, as do Strongin (1995), Pagan and Robertson (1995), Leeper and Gordon (1992) and others.

Figure 3 displays four interest rates in term structure for 1954:3 - 1999:4. The effects of inflation on these nominal interest rates is apparent in the high rates of the 1970s. While variation in interest rates is also apparent, there is also association with the aggregate income cycles. Correlations are -.2 between long term interest rates and the income ratio, and -.01 to -.02 between short term rates and income over the full sample. Cross correlations between long term rates and income are negative and significant contemporaneously and for about nine quarters, becoming negative but not significant for about six quarters and returning to negative and significant. Various definitions of real long term interest rates show little if any systematic cyclical pattern, as Mishan (1981) and others have suggested. Cross correlations between income and short term interest rates are negative and highly significant for quarters 2 - 12, otherwise negative but not significant. The level of the yield curve responds as expected during the cycle, with high interest rates associated with low actual real income and low interest rates associated with expansion. Across the four rates, from short term to long term, the term structure also appears cyclical. Especially at cycle peaks, short term rates are high relative to long term rates as the yield curve is frequently inverted between the peak and trough.

Figure 4 further characterizes the cyclical behavior of the term structure. The slope of the yield curve, measured with the 3 month Treasury bill rate and the 10 year government bond rate is graphed for each cycle. Several studies using more precise measures of the yield curve slope, which include the full range of maturities, found that a wide interest rate spread captures most of the characteristics of the yield curve. All the cycles (except 1980-82) begin with a steep yield curve, with slopes ranging from 0.014 to .025, and the slopes decline during the expansion phase. At the peak all of the cycles have flat yield curves, and four become inverted at the peak or within three quarters. Just after the peak, all the cycles show a rapid increase in slope. In both the level the term structure, interest rates exhibit the expected cyclical patterns.

Figure 5 illustrates resource allocation relative to income. Two measures are intended to represent the allocation of investment resources between production processes with a long time process of point-input, point output, and those processes that are shorter in time until the final consumer. NRSRS is the ratio of quarterly investment in Non-Residential Structures to investment in Residential Structures. Together these regularly account for about 60% of total Private Fixed investment. IETE is the ratio of investment in Industrial Equipment to investment in Transportation Equipment, and non-residential Equipment accounts for about 38% of

Investment. For both ratios, the numerator represents early stages of production and the denominator represents later stages. The data show a distinct procyclical pattern, much more pronounced than that of income.

If resource allocation matters to business cycles, in addition to the level of aggregate resource use, investment flows and resource use by sector should have systematic co-movement with aggregate income. The literature in sectoral shifts has examined cyclical behavior of disaggregated data. Romer (1991) found an important influence of an Aaggregate factor@ in the comovement of output of many commodities. Norrbin and Schlagenhauf (1991) similarly suggested both Aaggregate and industry-group@ factors of largest importance in comovements, and also that the aggregate factor was correlated with monetary shocks. An implication is that a single aggregate factor accounts for a large proportion of output variation, rather than specific industry factors. Cross correlations between the income and capacity utilization ratios reverse in sign and are significant for long periods.

Evidence of cyclical patterns exist for the interest rate term structure, prices by stage of production, capacity utilization and output by sector. These disaggregated data series are cyclically correlated with aggregate economic activity, suggesting that macroeconomic relative prices and the composition of capital may be important to the transmission of monetary shocks to aggregate economic activity. The graphs and correlations offer a basis for the hypotheses of the Austrian business cycle theory in Section I. A model of the business cycle which incorporates these characteristics should exhibit a liquidity effect on the interest rate term structure, relative price changes and systematic resource allocation across stages of production.

III. Empirical Model

The Vector Autoregression (VAR) method estimates how a system of endogenous variables dynamically responds to an error shock, and is a particularly appropriate method for exploring the Austrian business cycle theory. The real money supply, prices, interest rates, sectoral resource use and aggregate income are interdependent through the cycle in this theory. The movement of the system from equilibrium through expansion and recession is an endogenous process and requires a dynamic simultaneous equations model to account for the development of the recession from the expansion phase. No further shocks to monetary policy, consumer confidence, business profit expectations, the government budget or exports are required to induce recession after an expansion phase is initiated by a shock. The source of the cycle, a nominal shock to the money supply, may be modeled as an error in the monetary policy equation, and the VAR estimate then illustrates the time profile of the responses of relative prices, resource use and aggregate income.

The VAR estimate in moving average representation allows the variance of forecasted endogenous variables at each time period to be decomposed into a component that is attributable to the shock and components due to changes in other endogenous variables. That provides a measure of the proportion of change in the endogenous variables that can be explained by a shock, and a means of evaluating hypotheses. In this paper, a VAR is designed to represent the market process of the Austrian business cycle theory, by modeling the aggregate economic activity as interdependent with relative prices and resource allocation. From that estimate, the variance decomposition will provide one approach to measuring the extent to which a monetary shock, in an Austrian model, can account for changes in aggregate economic activity.

The VAR method is a Abackward-looking autoregressive structure@ (Bagliano and Favero, 1998), and still subject to the Lucas Critique; that the estimated responses within the system are specific to the policy regime. Over the period of this sample, there certainly were developments and changes in monetary policy, from reliance on lending at the discount rate, to a free reserves target without specific goals, to interest rate or monetary aggregate targeting with specific goals (Strongin, 1995). Even though other researchers have found that a Federal Funds rate target is appropriate for most of this sample period, with the exception of 1979-82 (Bernanke and Mihov, 1998), the design of that policy has evolved and so may the estimate. An advantage of the VAR is that the restrictions that must be imposed for identification of equations involve fewer assumptions about the equation structure. A Choleski factorization for example, orders the variables in the system=s causal sequence, but does not add further constraints on the coefficients. The flexibility of the VAR method permits modeling a changeable process, as well as structure in terms of the choice of variables and identification.

A dynamic structural simultaneous equations model of k endogenous variables yk as function of lags of endogenous variables, current exogenous variables, and error can be presented as (Bagliano and Favero, 1998; Keating, 1992):

$$A\begin{bmatrix} Y_t \\ P_t \end{bmatrix} = B(L)\begin{bmatrix} Y_{t-1} \\ P_{t-1} \end{bmatrix} + C\begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^P \end{bmatrix} \tag{1}$$

where Y is a vector of endogenous, non-policy variables, P is a vector of policy variables and ε is a vector of structural errors. Elements of the A matrix express the contemporaneous relations among policy and non-policy variables, for example whether policy variables have a current effect on macroeconomic variables or whether policy responds to current economic conditions. B(L) is a matrix of coefficients on lagged endogenous variables and C is a matrix of the effects of shocks on current endogenous variables. For two endogenous variables, yi and pi, two lags, the structural equations for the VAR model are:

a11 yt + a12 pt = b11 yt-1 + b12 yt-2 + b13 pt-1 + b14 pt-2 + c11 ε1t + c12 ε2t (2)

a21 yt + a22 pt = b21 yt-1 + b22 yt-2 + b23 pt-1 + b24 pt-2 + c21 ε1t + c22 ε2t

Premultiplying (1) by A^{-1} provides the reduced form of the VAR:

$$\begin{bmatrix} Y_t \\ P_t \end{bmatrix} = A^{-1}B(L)\begin{bmatrix} Y_{t-1} \\ P_{t-1} \end{bmatrix} + A^{-1}C\begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^P \end{bmatrix} \quad (3)$$

Estimation of (3) provides coefficients for D = A^{-1}B(L), and the VAR residuals, $A^{-1}C\varepsilon$.

The distinctive characteristics of the Austrian business cycle theory can be presented more formally in a simple model which summarizes aggregate economic activity with a credit market, a production function and a money supply policy rule. The A matrix is:

a11 y1(t) + a12 y2(t) + a13 y3(t) + a14 y4(t) (4)

a21 y1(t) + a22 y2(t) + a23 y3(t) + a24 y4(t) (5)

a31 y1(t) + a32 y2(t) + a33 y3(t) + a34 y4(t) (6)

a41 y1(t) + a42 y2(t) + a43 y3(t) + a44 y4(t) (7)

where y1 is real income, y2 is the monetary policy target, y3 expresses the interest rate term structure (the interest rate spread or slope of the yield curve), y4 expresses resource allocation (capacity utilization rate or investment flows), and εi are mutually uncorrelated disturbances. Equation (4) is an aggregate supply relation which expresses the value of real income as a function of relative prices and resource allocation. Suppliers make decisions about how much to produce in the current time period based on the relative price of current goods compared to future goods, as represented by the level and term structure of interest rates. They are also constrained by past choices of investment decisions and the structure of the capital stock. Equation (5) is the monetary policy rule, expressing the endogenous real money supply as dependent on the interest rate and on the level of income. Equation (6) represents the interest rate term structure which is affected by changes in the money supply through a liquidity effect, and by income through the Wicksellian process of interest rate adjustment. When the market rate, measured by a short-term interest rate, differs from the natural rate, correction forces embodied in the growth of income return the level and slope of the term structure to equilibrium. The long-term interest rate is assumed here to represent the exogenously determined natural rate, or the rate of marginal productivity of capital. Finally, equation (7) resource allocation is a function of interest rates, as the use of capital and investment resources respond to relative prices. For each of these equation, the B(L) specifies the current value of the variable as a function also of lagged values of all endogenous variables.

The production function is an Austrian concept of the propagation mechanism of the cycle process. When choices are made in the current time period about the allocation of capital and other resources, and about the allocation of new investment, the capital stock is altered in a manner that cannot easily be reversed within a few time periods. The structure of capital is a constraint on the level and composition of real goods and services that can be produced. The monetary shock has a liquidity effect on interest rates, and systematically changes asset demands and investment. That becomes a mechanism for perpetuating the cycle through long-lasting changes in the capital stock and production capabilities.

Relative prices, expressed in the term structure of interest rates, play a key role in the propagation mechanism. Investment and Capacity Utilization depend on both short-term and long-term interest rates, as producers make decisions about the allocation of capital resources based on the relative prices of current and future goods. When the interest rate term structure is disturbed by a monetary shock, capacity utilization is increased for, and investment re-allocated toward capital in early stages, assuming that coefficient a43 is positive in Equation (7), and lagged coefficients on the term structure are positive. Income begins the expansion phase as resource supplies increase. However, the divergence of the market and natural rates, and the growth of income act to return the short-term rate toward the level of the long-term, the natural rate. That adjustment process reverses the previous expansionary effects and results in the recession phase of the cycle.

The hypotheses of the Austrian business cycle theory that were listed in Section II are implied by the interdependence of the income, money, interest rate and investment variables, and by the few structural restrictions that are imposed. Estimation of the VAR associated with the structural model will provide a test of the hypotheses in terms of the responses of the system to a monetary policy shock. The simple model of the Austrian business cycle theory that was specified earlier as equations (4) - (7) can be generalized to a VAR model in the reduced form of equation (3), in which each endogenous variable is a function of lagged values of all endogenous variables.

The reduced form model of the long-term relation between money, interest rates, resource allocation and output was estimated by a four-equation VAR. The variables for the model are income, monetary policy target, interest rate term structure, and resource allocation, and their data sources and definitions are presented in Table 1. All variables were tested for unit roots, and the results are presented in Table 2. The ADF tests reject the null hypothesis of a unit root for income, slope of the yield curve and resource allocation. The null hypothesis could not be rejected for Strongin=s measure of monetary policy, so several variations of were tested which also did not reject the unit root hypothesis. Most of the series exhibited autocorrelations that decreased to zero quickly, and had only one or two significant partial autocorrelations. Based on the ADF test and autocorrelations, the variables are assumed to be stationary in the forms specified for the empirical model.

The Austrian theory suggests several identification restrictions for the structural model. Monetary shocks are non-neutral in the long run as a result of their long lasting effects on the composition of the capital stock. I have defined the measure of aggregate economic activity as the ratio of actual real GDP to natural real GDP, however, which permits a long-run identifying restriction. The natural real GDP is calculated as if real GDP continued to increase at a constant growth rate from one cycle peak to the next. The growth rate varies by cycle, and that construction allows the measure to incorporate the long run real effects of the monetary shock. The monetary shock will have no long run effect on the INCOME variable, and so the sum of coefficients in that equation must be zero. This requires imposing restrictions on the matrix, D, which in turn implies restrictions on the A matrix. The monetary shock may have effects on real interest rates or the term structure of rates, and on resource allocation, so no restrictions exist for those equations.

The development of the money variable is the basis of an interpretation that identifies the money equation. The mix of borrowed and non-borrowed reserves in total reserves (NBRX) is the measure suggested by Strongin (1995), and has been interpreted by several researchers as providing a good measure of the effects of monetary policy (Bernanke and Mihov (1998); Bagliano and Favero (1998)). The VAR estimation of the money supply equation allows recovery of the residual as representing the monetary policy shock. It requires only the ordering of the income and money variables, with income prior to money in the model. By a Choleski ordering with the income equation prior to the monetary policy rule, a12 = 0, excluding money from the income equation, on the assumption that variations in the monetary policy measures have no contemporaneous effect on real income. That assumption is supported by Hafer and Kutan (1997) who explore VAR models of money, interest rates and income under a variety of assumptions. They find that Amoney shocks have no permanent, long-run impact on the output path@ and only the M2 version of money had significant transitory effects, but that the effect of changes in interest rates Ais statistically significant [and] may have both permanent and transitory impacts on the output path@ (1997, 57). While the monetary policy measure is excluded from the income equation, the measure of income is included in the NBRX equation, which permits an effect of income on the monetary policy as part of the policy rule. Considering only the income and money equations in the system, the exclusion allows identification of the error term in the NBRX equation of the VAR as the measure of monetary policy shock.

The lag length was explored with the Akaike and Schwarz criteria, which continued to decrease through 10 lags. Given the relatively small changes contributed by additional lags, the results for the estimate with 4 lags are presented. Estimates were robust to an alternative measure of the slope of the yield curve, the regression coefficient of the rate on the time in years of the maturity. The standard deviation of the ratio measure of the slope was 0.1 while that for the regression measure was 0.4, but the two measures were correlated at 0.93. Both measures used government securities interest rates, excluding the Federal Funds interest rate. Results are also robust to alternative measures of monetary policy, as described in Table 2.

Each of the four equations in the VAR estimate of the business cycle model had a relatively high R-squared value. For each equation, the lags of the dependent variable are significant. Lagged income is significant in the NBRX equation which suggests the endogenous nature of the money measure. Lagged income is significant for only one coefficient in the SLOPE equation, showing some evidence of the endogenous nature of the interest rate adjustment mechanism. One coefficient of INCOME is also significant in the RESOURCE equation, implying that the phase of the business cycle affects the resource allocation between primary and advanced production processes. One SLOPE coefficient is significant at the 10% level in the INCOME equation, providing only slight evidence that relative prices and resource use guide the cyclical behavior of aggregate income. The residual correlation matrix shows especially low correlations between the NBRX residual and other equation residuals, and generally low correlations.

IV. Discussion

Impulse Response Functions display the dynamic responses of the endogenous variables of the model to a one-standard-deviation shock to the error terms of system equations. Attention is restricted to a monetary shock to simulate the origin of a business cycle. The NBRX variable has been designed to permit identification of the error in that equation with the measure of monetary policy shocks. Graphs of the Impulse Response Functions are presented in Figure 6 (generated by the Eviews econometric program). A liquidity effect is evident at the beginning of the cycle as the yield curve becomes steeper, and increases the SLOPE, over two quarters. Through the rest of the cycle, during the expansion phase of income increase, the yield curve flattens, as expected, and returns toward its initial value. No restrictions of the model force that result, and time preferences, though unmeasured, are assumed constant.

Both income and resource allocation display procyclical patterns of persistent increase and then decline. The response of the resource allocation measure is as expected, with investment in non-residential structures rising relative to investment in residential structures after the shock, and then declining as the cycle progresses. The change is steady and consistent with the endogenous character of the turning points in the Austrian theory. The income ratio displays an expected pattern as actual real GDP rises relative to natural real GDP, then falls toward the original ratio. That matches the pattern of Figure 1 with the single peak or even sustained peak. Resource allocation and aggregate income clearly display the behavior that the Austrian theory predicts in response to a monetary shock, and aggregate economic activity is realistically tracked by the model simulation. The liquidity effect is significant but quite short in duration.

The variance of a forecasted value for an endogenous variable is a weighted average of the current and past errors, and the weights are the elements of the $A^{-1} C(L)$ matrix. For a given shock to the error term of one equation, it is possible to allocate part of the mean-squared forecast error to that source, especially when the residuals of the system equations are uncorrelated. The variance decomposition for each variable is presented in Figure 7. The monetary shock is expressed by a one-standard-deviation change in NBRX, and the graph traces the time path of the proportion of changes in endogenous variables due to the shock. The dashed line for the NBRX shock in the INCOME equation shows an increasing role for relative prices through the cycle, rising to about 30% of the variation in INCOME after 10 periods. The interest rate term structure and resource allocation are affected by the shock in the expected pattern, and the effects are Acumulative@ in the sense of constituting the market process of the business cycle. The contribution of the monetary shock to changes in GDP is thus a narrow measure of the empirical magnitude, or a minimum value. The full effect of the monetary shock may be considered the sum of the effects of the change in the money equation error and the subsequent changes in relative prices and resource utilization.

Figure 8 graphs the residuals of the NBRX equation, which are identified as the measure of the monetary policy shock. A comparison to the VAR estimate by Christiano, Eichenbaum and Evans (1996, Figure 1A) indicates some similarity, but far from identical patterns. Large positive shocks occur in 1959, 1970-72, 1984 and 1989, with offsetting positive and negative shocks in 1974-75. These do not correspond well with the beginning of expansion phases of the business cycle, but many of the shocks do occur during the expansions.

V. Conclusions

Business cycle research has been oriented to the concepts of impulse and propagation mechanism, which are appropriate in some respects for the Austrian theory. In that view, monetary policy and banking system behavior create nominal shocks which are exogenous impulses to the economy. The asset prices and the structure of capital stock are the propagation mechanism that convey the effects of the shock to aggregate income, and also generate long lasting or permanent real effects. The changes in relative prices, such as the level and term structure of interest rates, occur within an endogenous process, where disequilibrium prices are aligned to a new general equilibrium. As prices adjust, aggregate economic activity moves through the phases of the business cycle. The theory suggests certain hypotheses about the direction and time path of commodity and final goods prices, interest rates and resource allocation through the cycle. Data on U.S. post-war business cycles show cyclical behavior for the term structure of interest rates and for resource allocation. A VAR model of dynamic simultaneous equations system for the Austrian business cycle theory was estimated to simulate and forecast the market process.

The findings of this research are limited in two ways. Strongin=s measure of the monetary policy may not be stationary, according to tests for this sample. Attempts to revise the measure to assure stationary were not successful, and that may have contributed to a monetary shock measure that does not appear very plausible. Also, the data on resource allocation are quite aggregated, are more disaggregated data should provide a better measure. Clark (1999) was able to work with price data measured by stage of production, and similar investment or resource use data would improve the ability to measure responses to relative prices.

Results of the estimate show a statistically significant liquidity effect of the monetary shock, a necessary event for this specification of the Austrian theory. The empirical model is able to simulate the business cycle pattern for aggregate income and for the allocation of investment funds. The variance decomposition indicates that the empirical model is able to account for a substantial proportion of the simulated cyclical behavior of interest rate term structure, resource allocation and aggregate income.

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Table 1
Data and Sources

Federal Funds interest rate, Three-month Treasury Bill interest rate, six-month Treasury Bill interest rate, one-year Treasury bond interest rate, 3-year Treasury bond interest rate, 5-year Treasury bond interest rate, 10-Year constant maturity Treasury Bond interest rate, 20-year constant maturity Treasury Bond interest rate and 30-year constant maturity Treasury Bond interest rate

Slope of the Yield Curve = SLOPE = ln[(1+long-term rate) / (1+short-term rate)]

Non-Borrowed Reserves plus Extended Credit of the banking system, $ billions

Total Reserves, $ billions

Monetary Policy = NBRX = $(NBR / TR)_t / TR_{t-1}$

Real GDP, billions chained $1996

Natural Real GDP (Potential real GDP), billions chained $1996

INCOME = Real GDP / Natural Real GDP

GDP chain type Price Index, 1996 = 100

Source: Federal Reserve Bank of St. Louis macroeconomic data base (FRED).

Investment Expenditures for Non-Residential Structures, Residential Structures, Industrial Equipment and Transportation Equipment, $billions

RESOURCE = Non-Residential Structures / Residential Structures
or Industrial Equipment / Transportation Equipment

Source: U.S. Department of Commerce, Bureau of Economic Analysis, National Income and Product Accounts, Table 5-4.

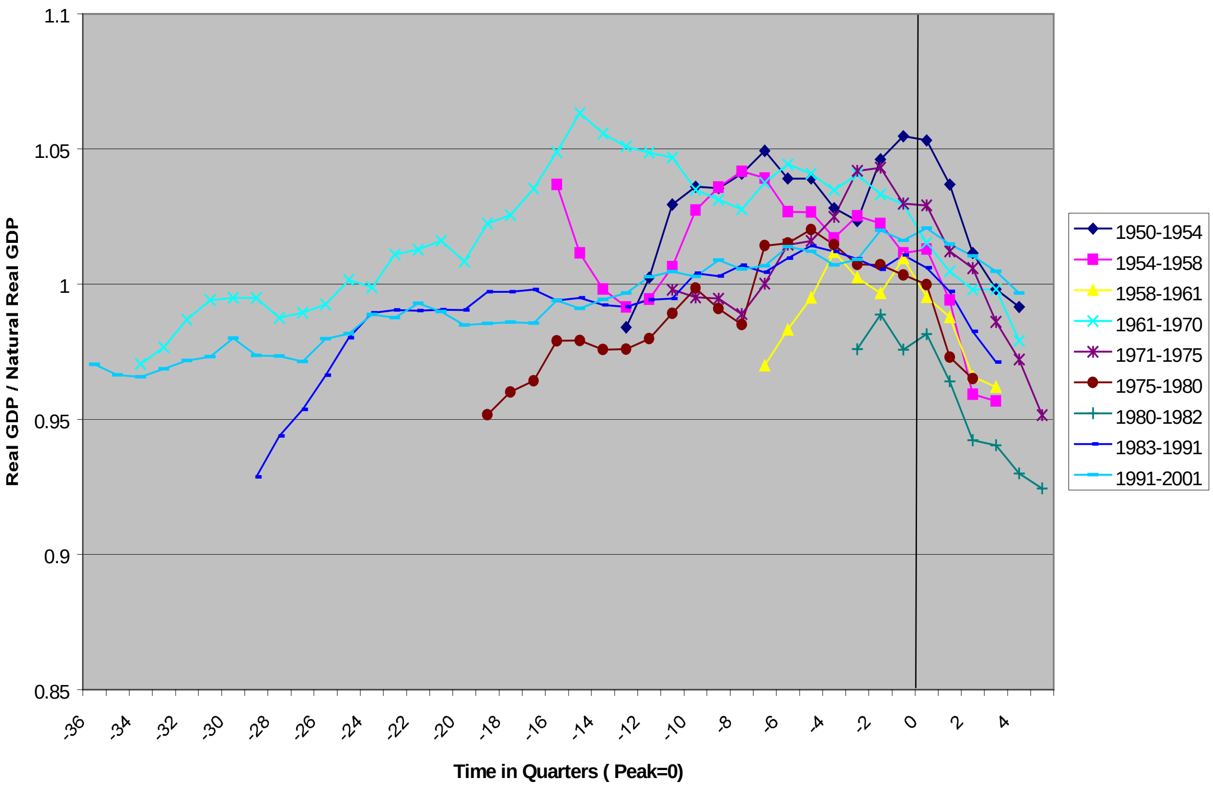
Table 2
Time Series Properties of the Variables

ADF tests, H0: $\rho=1$ for $\Delta y_t = \beta 0 + \beta 1$ trend $+ \beta 2\ y_{t-1} + \varepsilon_t$, $\beta 2 = \rho - 1$

			Significant lags	
Variable	ADF w/o trend	ADF w/trend	ACF	PACF
INCOME	-3.55*	-3.65*	10	3
NBRX	-1.69	-0.01	36	1
SLOPE	-3.82*	-3.82	7	7
RESOURCE	-2.52	-2.67	8	7
NBRTR	-3.74*	-3.92	22	3
NBRX1	-2.37	-2.40	18	2

Note:
NBRTR = Non-Borrowed Reserves / Total Reserves
NBRX1 = Predicted values from the regression of $(NBR/TR)_t$ on real TR_{t-1}
ACF = Autocorrelations
PACF = Partial Autocorrelations

Figure 1 - Business Cycles



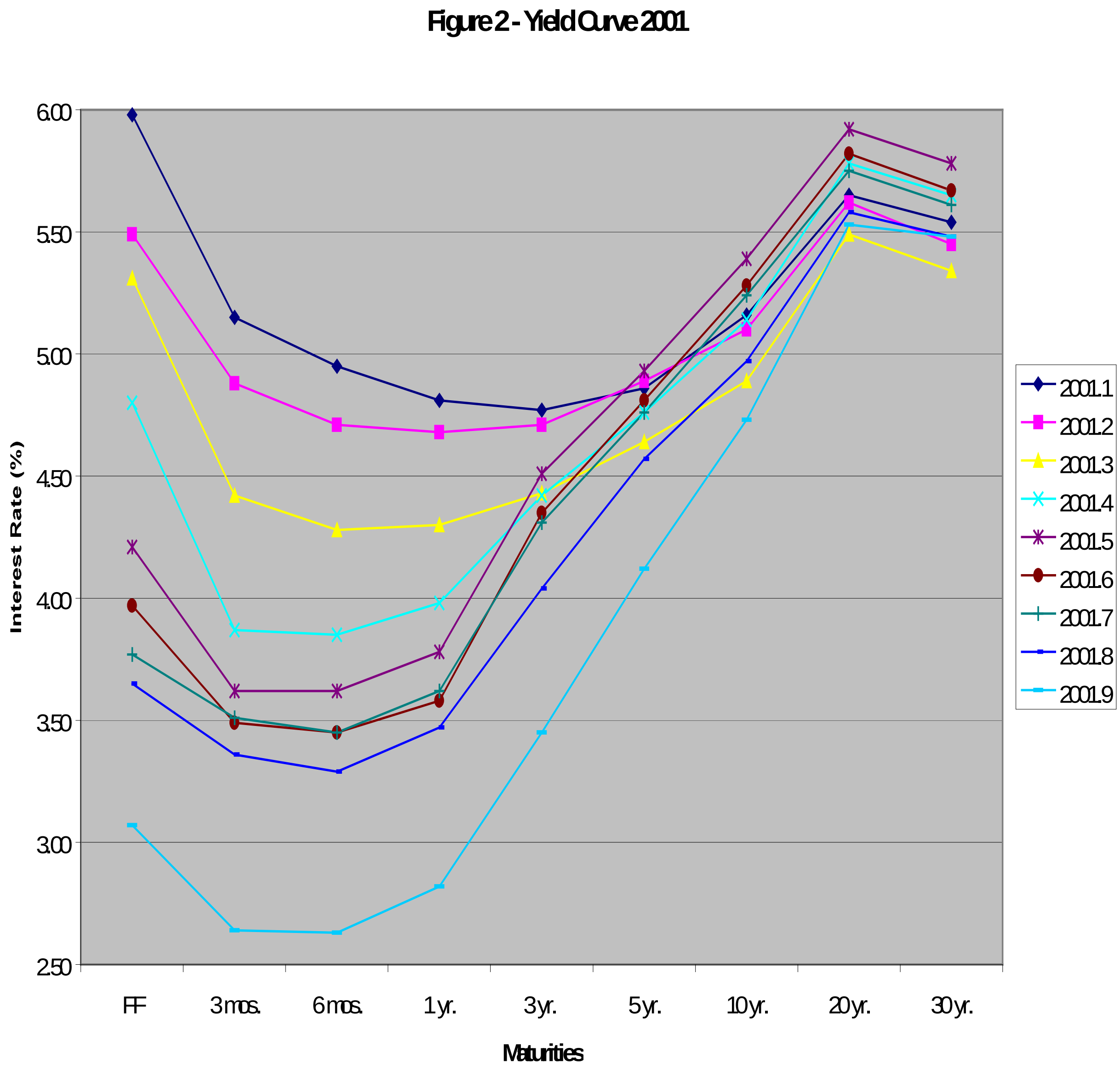


Figure 2 - Yield Curve 2001
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
Interest Rate (%)
FF
3 mos.
6 mos.
1 yr.
3 yr.
5 yr.
10 yr.
20 yr.
30 yr.
Maturities
2001.1
2001.2
2001.3
2001.4
2001.5
2001.6
2001.7
2001.8
2001.9

Figure 3
Term Structure of Interest Rates 1954:3-1999:4

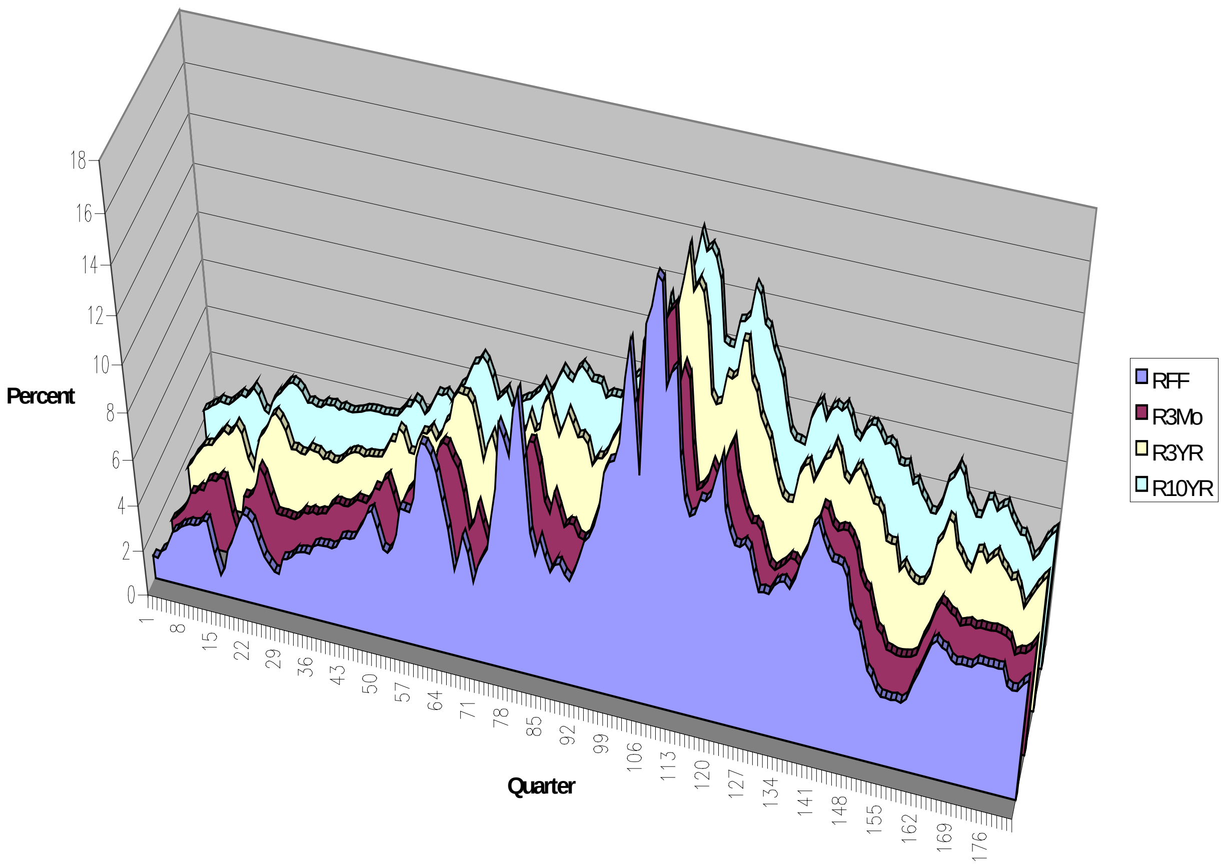


Figure 4 - Slope of the Yield Curve

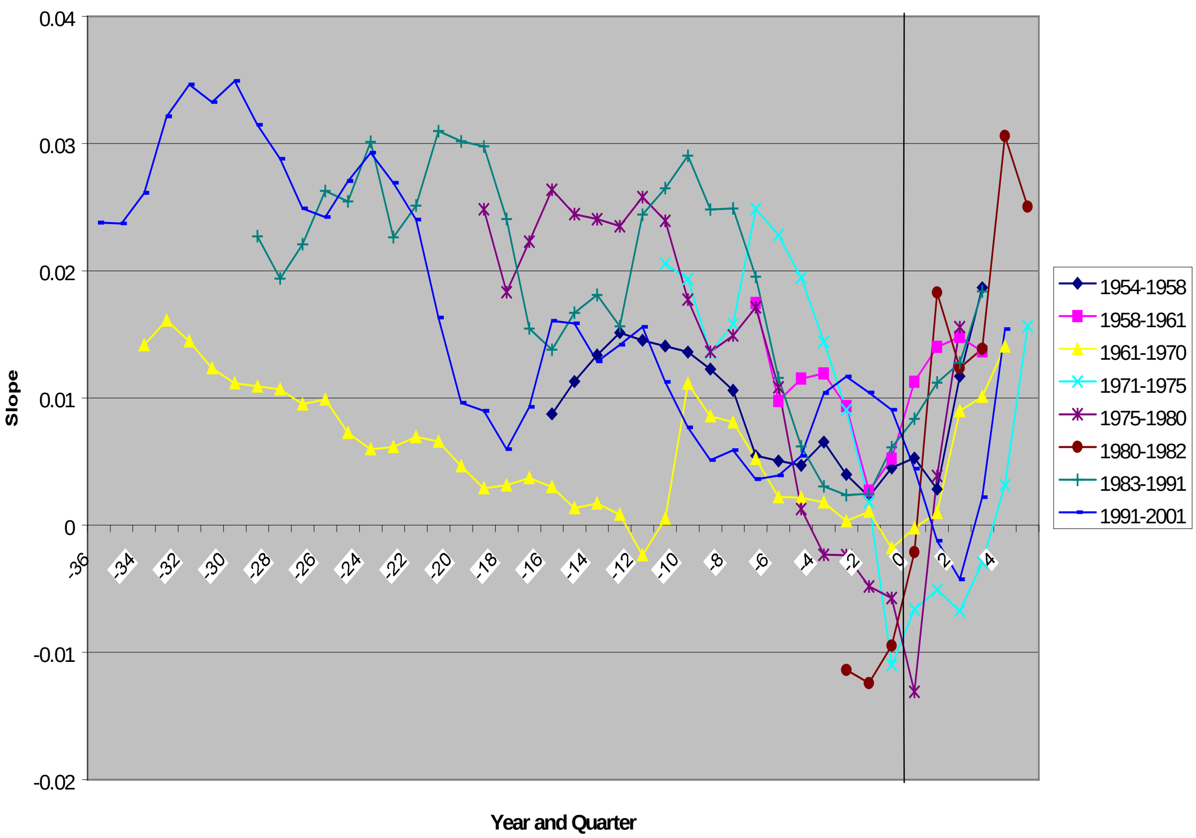


Figure 5 - Investment Components

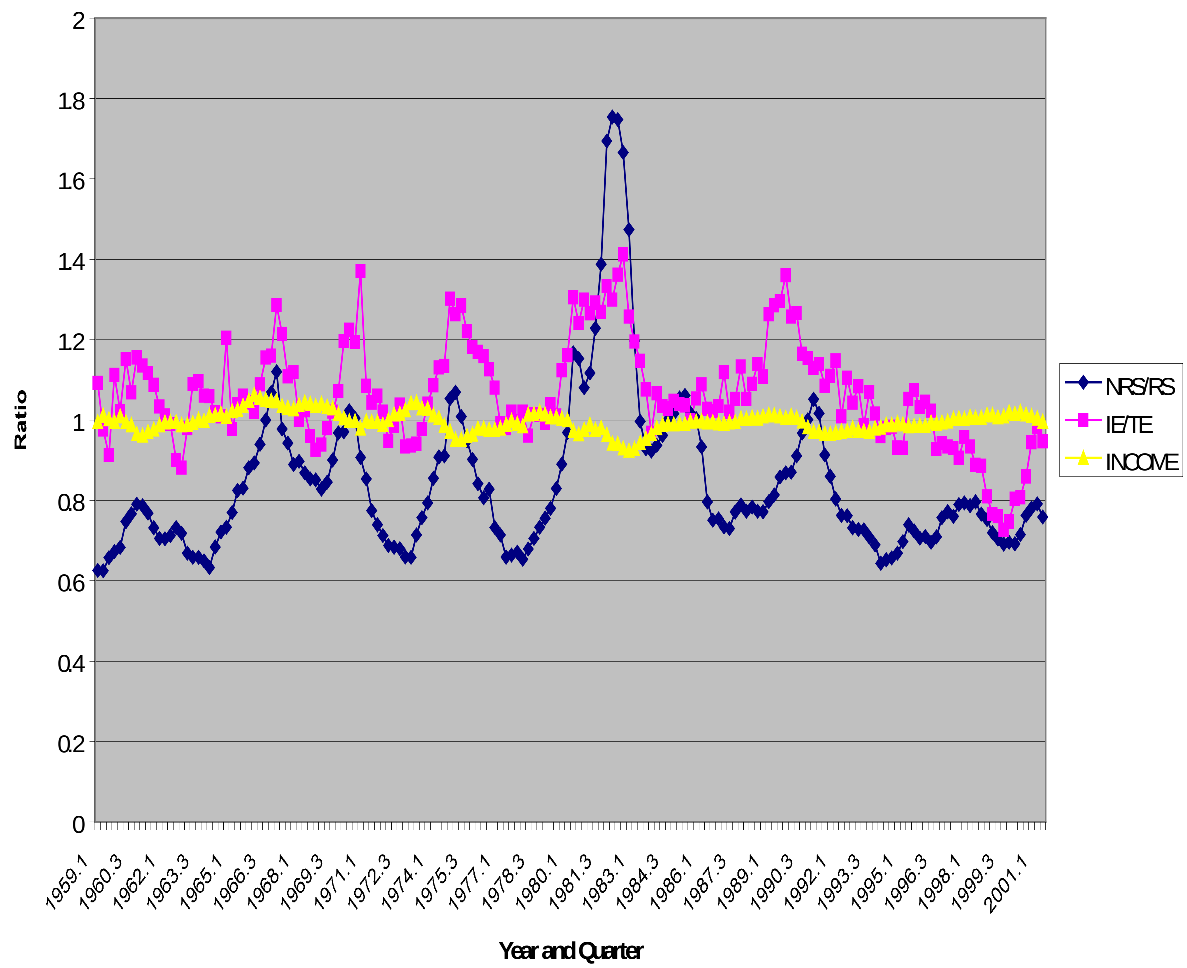


Figure 6
Impulse Response Function

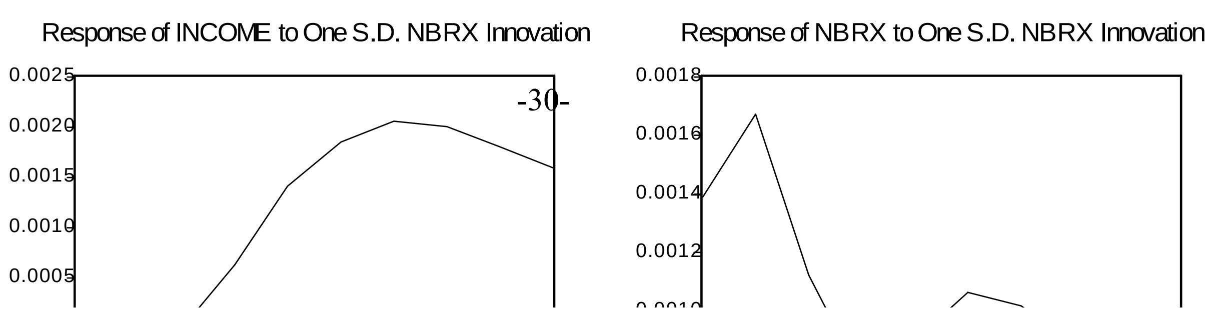


Figure 7
Variance Decomposition

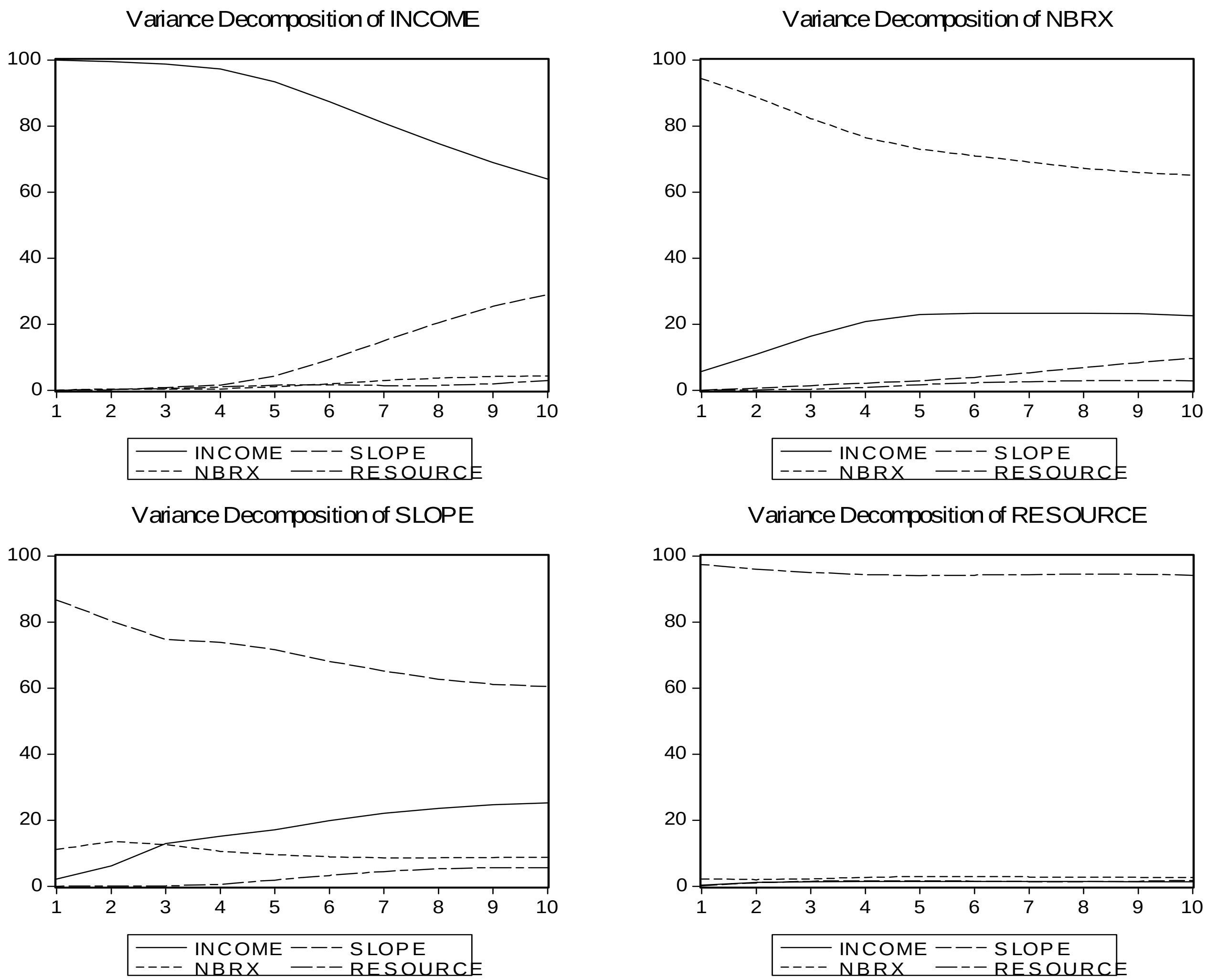


Figure 8
Monetary Policy Shock