Asymmetric Effects of Government Spending: Does the Level of Real Interest Rates Matter?

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Abstract

This paper examines empirical issues on asymmetric effects of government spending. Increases in government spending under low real interest rates are not associated with the same increases in future tax liabilities as those under high real interest rates. Consequently, the negative impact from the Ricardian effect is smaller with lower real rates. Our empirical work on US data, using threshold regression models, provides new evidence that an expansionary government spending is more conducive to real activities when real rates are low. We also find asymmetric effects on interest rates and threshold effects associated with substitution between financing methods.

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I. INTRODUCTION

Fiscal policy would attract more attention if the conduct of monetary policy is limited in its scope of boosting economic activities while an economy proves to have a low and steady inflation.[2] In the face of the increased attention to fiscal policy, it will be of special interest to see whether the effectiveness of fiscal policy depends on circumstances. Consideration on the financing consequence of fiscal policy in particular may suggest that fiscal policy can gain its potential momentum as low real interest rates put less burden on the degree of fiscal consolidation. This paper empirically explores whether fiscal policy (represented by increases in government spending) involves asymmetric effects depending on the level of real interest rates.

Why might the effectiveness of fiscal policy depend on the level of the real interest rate? In standard dynamic general equilibrium models, the government spending multiplier depends quite sensitively on the assumptions about labor supply, the persistence of the spending shock, and other features of the environment. Fiscal policy shocks have positive effects on output and investment, through various channels, principally related to intertemporal substitution and wealth effects on labor supply. These models, however, typically examine the local effects of fiscal policy shocks approximated around a steady state where the real interest rate is constant. In general, therefore, these models abstract away from the financing consequences of fiscal policy shocks, assuming that the question of whether spending is financed by taxes or debt does not principally affect the size of the multipliers. Even in dynamic models that do not satisfy Ricardian equivalence, the fiscal policy multipliers are normally quite close to those in the usual infinite horizon dynamic general equilibrium model (see Barry and Devereux, 2003).

Nevertheless, recent researchers have emphasized that the financing consequences of fiscal policy may be of key importance. In particular, a large literature on the possibility of contractionary effects of fiscal policy has argued that in times of high deficits and growing public debt, government spending can have weak or even pathological effects, by affecting expectations about future tax rates. If government spending and public debt is already at a high enough level, then further spending may cause a precipitous fall in consumption as triggers expectations of a fiscal crisis in the future. A number of papers have modelled the way in which fiscal policy can have counterproductive outcomes through this mechanism: for example, there is a strand of studies proposing the "expansionary fiscal contraction" hypothesis (Barry and Devereux, 1995, 2003; Sutherland, 1997; Perotti, 1999).

Standard debt sustainability analysis (for example, Reinhart, Rogoff, and Savastano, 2003), as applied to a country's government debt, suggests that real interest rates should be lower than output growth for fiscal sustainability; otherwise the debt dynamics may lead to an untenable situation and require a fiscal consolidation. Data analysis suggests that real interest rates and output growth shift over time. Thus, there could be a "virtuous cycle" in which low real interest rates and rapid growth take the economy's fiscal debt burden to a safe region. Ball, Elmedorf, and Mankiw (1998) suggest that the future effects of government spending can be benign, depending on real interest rates and output growth. If the average return on government debt is

[2] When economic growth is weak despite very low interest rates, monetary expansions through typical channels of open market operations will not be effective, because of little difference between money and government securities (see Koenig and Dolmas, 2003).

sufficiently lower than the average output growth for a sufficiently long period, the government can most likely roll over the debt and accumulated interest without raising taxes since the economy's output will likely to grow faster than the debt will accumulate. Conversely if future economic growth turns out to be low relative to the return on government debt, the debt-output ratio will increase and the government eventually will be forced to raise taxes.

The post-war US real interest rate involves persistent deviations from its whole-sample mean. Garcia and Perron (1996) provide evidence on shifts in real interest rates. Shifts in real interest rates can be associated with shifts in productivity or time preference. They can also be caused by exogenous structural events, such as monetary regime shifts and deregulation on interest rates. Canzoneri and Dellas (1998) show that operating target procedures affect the real interest rate in a stochastic general equilibrium: that is, interest rate targeting results in higher real rates than monetary aggregate targeting. They conjecture that higher real interest rates make the existing public debt more costly to finance and, ultimately, more taxes have to be raised.

In this paper, we find that empirically, the effectiveness of government spending tends to be critically related to the level of real interest rates. In times of low real interest rates, fiscal policy tends to be expansionary, raising output and its components, investment and consumption. Conversely, in times of higher real interest rates, the effect of fiscal policy on the same aggregates tends to be weaker or even negative. The intuition behind this result can be described as follows. Suppose that Ricardian equivalence fails, so that the financing implications of government spending are important. Also suppose that there is an upper limit—set by political economy considerations—on the debt-output ratio that a government can endure. If the debt ratio is expected to reach this upper limit, which happens when real interest rates are substantially high relative to output growth, then agents perceive that the government must undergo a fiscal consolidation, raising tax rates on wages and capital income. Therefore, the impact of government spending will be very different, depending on whether real interest rates are high enough for the economy to exceed tolerable debt burden during agents' time horizon.

A key determinant of the impact of government spending will be the level of real interest rates. A persistent shock to government spending—which reflects the characteristic of the actual data—affects the risk of hitting the upper limit on the debt ratio and thus future fiscal adjustment, depending on the level of real interest rates. Decisions on private consumption and investment in response to fiscal expansions, therefore, depend on whether the real interest rate is high or low (relative to output growth).When real interest rates are low, then a fiscal expansion, financed by deficits rather than current taxes, raises the outstanding stock of public debt, but this does not generate a significant risk of hitting the upper limit on the debt-output ratio. In times of high real interest rates, however, the fiscal expansion is more likely to push the government debt towards the critical debt-output ratio during agents' time horizon. As a result, the fiscal expansion tends to have a strongly negative effect on aggregate consumption and investment. The overall magnitude of the expansion on output is then much smaller than would be the case of a similar size spending expansion, in times of low interest rates. Therefore, the size of the Ricardian effect will (positively) depend on the level of real interest rates.

We focus exclusively on government spending, which is not much reactive to the current state of the economy, in assessing the effect of fiscal policy. Changes in government spending are associated with changes typically in government debt, if sustainable, rather than in the tax rate, since government debt has typically been managed to maintain a pattern of reasonably stable tax rates over time. However, there could be situations in which government debt and its associated interest payment shift priorities toward budget by raising taxes (see Davig, Leeper and Chung, 2004).[3] Many recent studies have examined the effect of fiscal policy shocks based on government spending (for example, Blanchard and Perotti, 2002; Alesina et al., 2002; Fatás and Mihov 2003). Also, we search for asymmetric effects of government spending. Recent studies on fiscal policy effects have searched for nonlinear effects of fiscal policy based on (i) different characteristics of fiscal impetus that have different impacts on the economy because they have different implications for future tax liabilities (Giavazzi, Jappelli, and Pagano, 2000; Alesina et al., 2002; Bayoumi and Masson 1998); and (ii) the consumers' expectations about fiscal adjustment for government debt sustainability (Bertola and Drazen, 1993; Sutherland, 1997; Perotti 1999). In searching for nonlinear effects, this paper takes a slightly different approach.

To account for nonlinearity in the effect of government spending, which arises from shifts in the finance cost of government spending, we employ threshold regression methods (Tong, 1983, 1990; Hansen, 1999, 2000), as applied to threshold vector autoregression analysis by Choi (1999). Our empirical model allows government spending shocks to have differential impacts across regimes on economic activities including consumption, investment, and output. Our empirical findings from US time series data suggest that asymmetry in fiscal policy effects is associated with nonlinearity in the behaviour of investment growth, output growth, and interest rates across different levels of real interest rates. Linearity testing supports the existence of double threshold (that is, three regimes), and impulse response analysis provides pronounced asymmetries in the dynamic responses of the economy to a government spending shock.

We provide new evidence that an expansionary government spending is more effective when real interest rates are low than when they are high. We also find notable asymmetric effects of government spending on nominal and real rates of interest, which can be explained by taking into account regime shifts in the context of earlier studies on the effect of government spending on interest rates (Evans, 1985, 1987; Mankiw, 1987). In addition, we find some threshold effects associated with substitution between government debt and money for financing government spending in the face of different real interest rates, while we find no evidence on asymmetry in the government spending behaviour itself. Further, we provide evidence on asymmetry in the link between government spending and inflation, which somewhat reconciles earlier cross-country data analyses (Koelln, Rush, and Waldo, 1996; Fischer, Sahay, and Végh, 2000; Catão and Terrones, 2003). Our empirical findings suggest that fiscal policy be conducive to spurring growth when an economy faces comparatively low real interest rates.

The remainder of this paper is organized as follows. Section II contains a brief description on related studies. Section III presents specifications of empirical models and estimation methodology including nonlinearity testing and impulse response analysis. Section IV describes empirical results for asymmetric effects of government spending and provides robustness checks and discussions. Section V concludes the paper.

[3] Davig, Leeper, and Chung (2004) suggest that tax policy reactions can shift between periods when taxes are adjusted in response to the government indebtedness and those when other priorities drive tax decisions. Our paper focuses on government spending and its implication for future tax liabilities but not the tax policy behavior itself.

II. CONTACTS WITH THE LITERATURE ON FISCAL POLICY EFFECTS

In a simple Keynesian framework that assumes price rigidity and excess capacity, a fiscal expansion has a multiplier effect on output. If government spending increases interest rates, it reduces private spending through the crowding-out effect and thus dampens the multiplier effect.[4] While fiscal policy analysis traditionally focuses on its demand-side effects, there could be supply-side effects that add to the effectiveness of fiscal policy.[5] Government spending on investment-type goods helps augment the production capacity and thus tends to increase fiscal multipliers by ameliorating the crowding-out effect.

Contrary to the conventional Keynesian view, the "expansionary fiscal contraction" hypothesis suggests that fiscal contractions can, through their impact on expectations, lead to growth in consumption and investment since large or persistent fiscal contractions, after a prevailing expansionary fiscal stance, signal the government's adjustment that has been delayed (Barry and Devereux, 1995; Sutherland, 1997; Perotti, 1999). Such episodic fiscal contractions are more likely to happen in the economies that need a fiscal adjustment (see, for the listing of related studies with cross-country data, Alesina and Perotti 1997; Giavazzi, Jappelli, and Pagano, 2000; Hemming, Kell, and Mahfouz, 2002; Alesina et al., 2002).

A neoclassical approach suggests that the effects of government spending stem mainly from its crowding-out effect and a wealth effect (Barro, 1981; Aiyagari, Christiano and Eichenbaum, 1992; Christiano and Eichenbaum, 1992; Baxter and King, 1993). The wealth effect is operative as long as increases in government spending call for increases in future taxes. The resulting fall in wealth reduces consumer demand, increases labor supply, and lowers interest rates (Devereux and Love, 1995; Barry and Devereux, 1995), and the increase in labor supply in turn increases the marginal productivity of capital and spurs investment (Ramey and Shapiro, 1998; Burnside, Eichenbaum, and Fisher, 2003). The size of the wealth effect depends on whether changes in government spending are purely transitory or persistent affects.

In the extreme case of complete Ricardian equivalence (Barro, 1974; Evans, 1988), an increase in government spending, regardless of whether it is financed by tax or debt, will be fully offset by higher private saving. However, the practical significance of complete Ricardian equivalence is questionable, since it relies on strong assumptions. The empirical literature has provided mixed results for Ricardian equivalence (for the listing of studies, see Evans, 1988; Hemming, Kell, and Mahfouz, 2002). The non- or partial Ricardian equivalence case arises, when agents have a short-time horizon, less than perfect foresight, or binding borrowing constraints (for example, Blanchard, 1985; Mankiw, 2000). In the more realistic case where the private sector does not fully account for or discount future taxes implied by government spending, Ricardian effects are only partial. In the face of partial Ricardian equivalence, the stabilization role of fiscal policy would retain, and the issue of its effectiveness would remain.

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[4] For an open economy, higher interest rates induce capital inflows and real exchange rate appreciations which result in deteriorating current account and offsetting the increase in domestic demand arising from a fiscal expansion.

[5] Public service can be considered as an input to private production, government spending on public goods and infrastructure can lead to higher growth (Aschauer, 1989; Barro and Sala-i-Martin, 1992; Tanzi and Zee, 1997). Such supply-side effects of fiscal policy are seen more important over the longer term.

A fiscal expansion may have effects on interest rates and inflation. As opposed to the crowding-out effect caused by higher interest rates with the fiscal expansion, Evans (1987) find no positive association between budget deficits and real and nominal rates of interest, consistent with Ricardian equivalence. Mankiw (1987) argues that an increase in government spending depresses the real rate since it reduces private consumption (through a wealth effect) and increase marginal utility of consumption, which lowers the marginal rate of substitution and thus marginal productivity of capital (through capital accumulation). Government spending can alternatively be financed with money creation especially by governments running persistent deficits, producing inflation. However, Dwyer (1982) find no evidence that increasing current or past budget deficits raises the price level. Recent studies, using cross-country data analysis, suggest that the positive association between fiscal deficits and inflation are strong among high-inflation and developing countries but not among low-inflation and advanced economies (Fischer, Sahay, and Végh, 2000; Catão and Terrones, 2003).

Many empirical studies have examined the effect of changes in government spending, which is not related to the current state of the economy and thus is less prone to simultaneity problems. The empirical results on the effect of government spending are rather mixed. Ramey and Shapiro (1998) find that a military buildup decreases consumption (on durables) and increases (non-residential) investment—consistent with neoclassical models—for the post-war US data. Blanchard and Perotti (2002), using a general framework, shows that (positive) government spending shocks have a positive effect on output and consumption but a negative effect on investment. Alesina et al. (2002), using a panel of OECD counties, find that spending shocks have a negative effect on investment, consistent with non-Keynesian effects of fiscal adjustment. Perotti (2002) provides evidence on the decline in the potency of government spending over last twenty years for OECD countries. Fatás and Mihov (2003) find that discretionary fiscal policy induces macroeconomic instability using a panel of a large set of countries.

Importantly, there are two strands of studies that emphasize nonlinearity in the effect of fiscal policy. One strand is associated with different characteristics of fiscal impetus. Giavazzi, Jappelli, and Pagano (2000) suggest that nonlinear effects (on national saving) tend to be associated with large and persistent fiscal impetus for both industrial and developing countries, whereas Alesina et al. (2002) find little evidence that government spending has different impacts (on investment) during large fiscal adjustments than in normal times. Bayoumi and Masson (1998), using Canadian data, show that national vs. local fiscal stabilizers have different impacts on the economy because they have different implications for future tax liabilities.

The other strand pertains to the expectations view of fiscal policy that emphasizes consumers' expectations about fiscal adjustment for government debt sustainability. Bertola and Drazen (1993) suggest that as government spending approaches a critically high level, there appears a nonlinear relationship between government spending and private consumption, which is consistent with expansionary effects of large cuts in government spending as part of stabilization programs. Sutherland (1997) theoretically and Perotti (1999) empirically examine how the effect of fiscal policy depends on the level of public debt, extreme values of which trigger consumers' expectation for extra burden on their future tax liability.

In this paper, we take a regime switching approach for government spending effects to reflect that no single approach of traditional Keynesian, neoclassical, or Ricardian equivalence can fit all the time the actual data that involve regime shifts. Our empirical model is designed to capture different effects of government spending on economic activities across different regimes.

III. Empirical Model Specification and Estimation Methodology

A. Asymmetric Effects of Government Spending

We consider that (complete) Ricardian equivalence fails but that agents are *partially* Ricardian: agents reduce their spending in the face of an expansionary government spending to the extent that government spending affects agents' expectation for future tax liabilities during their time horizon. Since partial Ricardian does not fully account for the effect of government debt on future taxes, government debt is included as part of the stock of their private wealth. Thus government spending financed by debt can increase consumption through a wealth effect. Also, government spending on public goods and infrastructure can lead to higher productivity and thus higher investment (a productivity-enhancing effect). The wealth and the productivity-enhancing effects will be offset partially or fully—depending on the underlying regime—by the adverse impact of the Ricardian effect.

Debt sustainability critically depends on whether real interest rates are sufficiently lower than output growth. Since the processes of real interest rates and output growth evolve over time with uncertainty, the debt-output ratio, which averages out past transitory movements of deficits and entails persistence, can be an indicator for debt sustainability. When interest rates are sufficiently high relative to output growth so that the economy is likely to reach at or near the upper limit on the debt-output ratio, government spending may have negative effects on the economy, because of the high probability of precipitating a fiscal consolidation during agents' time horizon of interest. Since shifts in real interest rates will be exogenously given, agents will perceive the underlying regime to prevail for a sufficiently long period. The impact of government spending will be very different depending on whether real interest rates are high enough for the economy to exceed tolerable debt burden during agents' time horizon.

Our regime switching approach allows the behaviour of key variables in the economic system and the net effect of government spending to vary over regimes. We classify the underlying states into three regimes based on the level of real interest rates: a "high-rate" regime, a "moderate-rate" regime, and a "low-rate" regime. We estimate a multiple equation system—threshold vector autoregression models—comprising regime-dependent, reduced-form equations, especially for government spending, consumption (or investment), output, and interest rates.

B. Threshold Vector Autoregression (TVAR) Model

Assuming that all variables are endogenous and that government spending depends on other variables as well as its own past values, we estimate the TVAR of a simple, piecewise-linear form. We consider a TVAR model with three regimes as follows:

$$\boldsymbol{Y}_t = \boldsymbol{A}_1 + \boldsymbol{B}_1(\boldsymbol{L})\boldsymbol{Y}_{t-1} + \boldsymbol{V}_{1,t} \qquad \text{if } s_t \leq \tau_L, \tag{1}$$

$$= \boldsymbol{A}_2 + \boldsymbol{B}_2(\boldsymbol{L})\boldsymbol{Y}_{t-1} + \boldsymbol{V}_{2,t} \qquad \text{if } \tau_L < s_t \le \tau_U ,$$
$$= \boldsymbol{A}_3 + \boldsymbol{B}_3(\boldsymbol{L})\boldsymbol{Y}_{t-1} + \boldsymbol{V}_{3,t} \qquad \text{if } s_t > \tau_U ,$$

where $\boldsymbol{Y}_t = (Y_t^1, \cdots, Y_t^k)'$ is the vector of k variables, $\boldsymbol{L}$ is the lag operator, $\boldsymbol{V}_{i,t} = (\varepsilon_{i,t}^1, \varepsilon_{i,t}^2, \cdots \varepsilon_{i,t}^k)'$ is a $k \times 1$ vector of error terms with $\boldsymbol{V}_{i,t} \sim N(0, \Sigma_{V_i})$ for i=1,2,3, s_t is the switching index, and the thresholds are ordered ($\tau_L < \tau_U$). Errors are assumed to be heteroskedastic across regimes. Threshold parameters, τ_L and τ_U, are assumed to be fixed and should be estimated.

C. Nonlinearity Testing and Number of Thresholds

If one or some of individual equations in the system involve threshold effects, such threshold effects can feed in the responses of the whole system. Especially if a transmission variable of government expenditures to private spending involves nonlinearity, then government expenditures can have differential impacts on aggregate demand. For this reason, our test of nonlinearity is based on an individual equation rather than for the whole system.

This study tests nonlinearity for a single equation. It is well known that classical tests have nonstandard distributions when the threshold parameter is unknown a priori and not identified under the null hypothesis of linearity. This nuisance parameter problem is the so-called “Davies” problem (Davies, 1987). Following Hansen (1999, 2000) to control for the Davies problem, we obtain a consistent estimate of threshold parameter(s) by minimizing the sum of squared residuals of the equation over a grid set. In the context of TVAR model (1), there are either no thresholds, one threshold, or two thresholds. To determine the number of thresholds (regimes), we perform the likelihood-ratio test, which is nonstandard but free of nuisance parameters, using *p*-values constructed from a bootstrap procedure. Hansen’s approach also helps us to obtain the confidence interval for threshold parameters by forming the no-rejection region using the likelihood-ratio statistic for tests on thresholds.

In the single threshold case, we set the bounded grid set for $\tau \in [\underline{\tau}, \overline{\tau}]$ so that each regime has at least 20 percent of the whole sample. The grid set is comprised of 100 grids that evenly divide the range from the 20th to the 80th percentile of the empirical distribution of the switching index. In the two thresholds case, given the first-stage threshold obtained from the estimation of the single threshold model, the grid set for the second threshold is comprised of 50 grids, which evenly divide the range of the empirical distribution of the switching index. As suggested by Bai (1997) and Hansen (1999), we use the refinement estimator to improve the efficiency of the threshold parameters by estimating threshold parameters in three stages.[6]

[6] In stage 1, we estimate a single threshold (τ_1). In stage 2, the first-stage threshold is taken as the upper (lower) threshold, if it is above the 65 percentile (below the 35 percentile) of the switching index. The grid set for the other threshold (τ_2) is comprised of 50 grids on one side with the longer leg of the τ_1 estimate. If it is between the 35 and 65 percentiles, the grid set for τ_2 is comprised of 25 grids on each of both sides of the τ_1 estimate. In stage 3, taking the τ_2 estimate as its refinement estimator (τ_2^r) and repeat stage 2 to obtain the refinement estimator of τ_1 (τ_1^r).

D. Specification Tests for Asymmetry across Regimes

We test the null hypothesis that the coefficients in each equation are equal across three regimes. To deal with the Davies problem, we employ the procedure that approximates the unknown asymptotic distribution by simulation for testing the presence of asymmetry in an individual equation across regimes, following Hansen (1996).

Following Hansen's procedure, we calculate three test statistics and use simulated realizations of chi-squared empirical processes underlying these statistics, assuming that the error term is heteroskedastic across regimes but homoskedastic within each regime. The three statistics are functionals of the collection of Wald test statistics over the grid space: the supremum (*SupW*), the average (*AveW*), and the exponential average (*ExpW*) of all Wald statistics.[7] Their significance levels are calculated using simulated empirical distributions of these statistics.[8] In addition, we perform specification tests which take symmetry across *given subgroups* in the equation as the null hypothesis as in Durlauf and Johnson (1995). We do this by splitting the data into subgroups based on the assumed τ and examining whether the coefficients are equal across the subgroups. The $\hat{\tau}$ obtained by grid search is taken as the assumed τ.

E. Analysis of a TVAR Model

To find the threshold values of a TVAR model, we employ a grid search, which is useful since our regime switching approach is based on perfect discrimination among regimes and the likelihood function is not differentiable in threshold parameters. For the minimization of the criterion function, the threshold parameter is assumed to be restricted to a bounded set.

In a similar way to the procedure described in Pesaran and Potter (1997), the grid search for a TVAR model (1) works as follows. Compared to the refinement estimator of double threshold, this approach *jointly* estimates the two threshold parameters, which are assumed to be the same across individual equations in the system. We set grids by generating a g length row vector of grid for τ_L and τ_U for its bounded set, respectively. The pairwise combinations in τ form a $g \times g$ grid. Then estimate the TVAR model by least squares for each point in the grid to find the estimate $\hat{\tau}$ that maximizes the conditional log-likelihood and implies estimates $\hat{\boldsymbol{A}}, \hat{\boldsymbol{B}}$, and $\hat{\Sigma}_V$. The estimate $\hat{\tau}$ will be consistent, as suggested in Pesaran and Potter (1997) and Hansen (1996).[9] Let $\tau = (\tau_L, \tau_U)'$ and $I_t(i\colon \tau)$'s are indicator functions with $I_t(1\colon \tau) = I_t(s_t \leq \tau_L)$,

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[7] Davies (1987) and Granger and Teräsvirta (1993) suggest using the supremum of statistics over a grid set, whereas Andrews and Ploberger (1994) suggest using the average and the exponential average of statistics.

[8] We generate J (=1,000) realizations of the Wald statistics, $\chi_T^{2j}(\tau)$ (j=1,2,...,J), under the null of symmetry for each grid and then construct empirical distributions for three functionals of the collection of the statistics over the grid space Γ: $SupW = \sup_{\tau \in \Gamma} \chi_T^2(\tau)$, $AveW = \frac{1}{\#\Gamma} \sum_{\tau \in \Gamma} \chi_T^2(\tau)$, $ExpW = \ln\{\frac{1}{\#\Gamma} \sum_{\tau \in \Gamma} \exp(\chi_T^2(\tau)/2)\}$, where $\#\Gamma$ is the number of grid points in the set Γ.

[9] Hansen's (1999) procedure, by minimizing the sum of squared errors in the threshold autoregressive model, enables one to compute the confidence intervals of thresholds for a *single* equation. Hansen's procedure for computing confidence intervals, however, is not readily applicable to the thresholds that are obtained by the maximization of the conditional log-likelihood for *multiple* equations.

$I_t(2:\tau) = I_t(\tau_L < s_t \le \tau_U)$, and $I_t(3:\tau) = I_t(s_t > \tau_U)$. The conditional log-likelihood up to a constant term is given by:

$$\ln l(\boldsymbol{A}, \boldsymbol{B}, \Sigma_V, t) = -\frac{1}{2}\sum_{t=1}^{T}[\sum_{i}^{3} I_t(i:\tau)\ln\left|\Sigma_{V_i}\right|] \\ -\frac{1}{2}\sum_{i=1}^{3}\{I(i:\tau)(\boldsymbol{Y}^i - \boldsymbol{A}_i - \boldsymbol{B}_i(\boldsymbol{L})\boldsymbol{Y}_{-1}^i)\}'[I_{Ni} \otimes \Sigma_{V_i}]^{-1}\{I(i:\tau)(\boldsymbol{Y}^i - \boldsymbol{A}_i - \boldsymbol{B}_i(\boldsymbol{L})\boldsymbol{Y}_{-1}^i)\} \quad (2)$$

where $\Sigma_{V_i} = \frac{1}{N_i}(\boldsymbol{Y}^i - \boldsymbol{A}_i - \boldsymbol{B}_i(\boldsymbol{L})\boldsymbol{Y}_{-1}^i)(\boldsymbol{Y}^i - \boldsymbol{A}_i - \boldsymbol{B}_i(\boldsymbol{L})\boldsymbol{Y}_{-1}^i)'$, $\boldsymbol{Y}^i$ is the selected sample vector for regime *i*, N_i is the number of observations in regime *i*, and I_{N_i} is an $N_i \times N_i$ identity matrix.

We construct a total of 1,600 grid sets for $\tau = (\tau_L, \tau_U)'$, allowing for 40 grids for each threshold: the lower (upper) threshold ranges from the 20th (60th) to 40th (80th) percentile of the empirical distribution of s_t. We estimate TVARs with the same lag order in all regimes by the least squares method. Then we obtain the impulse response function of the variables of interest to the orthogonal fiscal shock obtained through the Choleski decomposition of Σ_{V_i}, assuming that the economy stays at a certain regime. Empirical standard error bounds for the response function are obtained using the bootstrap method (Runkle, 1987) with 1,000 replications.

IV. Empirical Results

A. The Data and Constructing Variable Sets for TVARs

We use the U.S. quarterly time series data taken from Federal Reserve Economic Data (FRED) over the period 1959:1–2001:4 (see Appendix I). The switching index in period *t* is the lagged *ex-post* real interest rate defined as $rr_{t-1} \equiv R_{t-1} - 400(P_t / P_{t-1} - 1)$, where R_t and P_t are the nominal interest rate and the price level, respectively, in period *t.* The three-month Treasury bill rate is used as the nominal interest rate. To measure inflation, we use the GDP deflator.

Figure 1 (panel A) depicts the *ex-post* real rate of return on three-month Treasury bills along with the *ex-ante* real rate for comparison. The quarterly expected inflation is interpolated from the semi-annual inflation forecast from the Livingston Survey, and the ex-ante real rate is defined by the three-month Treasury bill rate minus the expected inflation rate. The ex-post real rate dipped in the 1970s with inflation, while the ex-ante real rate did less so—perhaps reflecting that the survey inflation forecast was much smoother than actual inflation during the high and volatile inflation era. The downward movement in inflation and financial deregulation in the early 1980s may have led to a sharp rise in the real rate: the ex-ant and the ex-post rates show a common drift, which is not much related to the inflation process. After the mid-1980s the movement in the real rate became rather steady but remained moderately high. The ex-ante real rate is smoother than the ex-post real rate but tends to overshoot before 1980 when inflation was high and somewhat undershoot afterwards. Garcia and Perron (1996) suggest that three different regimes are associated with drifts in the real interest rate. Choi (2002) suggests that the real interest rate may vary with shifts in the inflation process and shows that the real rate is negatively correlated with inflation when inflation persistence or inflation is below a threshold.[10]

Figure 1.B depicts the debt-output ratio that shows a different time-varying pattern, in contrast with the real interest rate: the ratio has a downward trend in the 1960s and an upward trend in the 1980s and the first half of the 1990s.[11] Figure 1.C displays (total) government spending growth along with national defence spending growth. Government spending growth shows rather high growth in the 1960s and the mid-1980s. National defence growth is highly correlated with (correlation coefficient=0.70), but more volatile than total government spending growth: it is high during the war periods (especially, in the late 1960s due to the Vietnam War) and moderately high in 1980s (due to the Carter-Regan defence buildup); it is often negative in 1970s and 1990s, contributing to a downward trend in the ratio of national defence to government spending.

We now construct several variable sets for alternative models of TVARs. In the baseline model (Model 1), the vector $\boldsymbol{Y}_t$ includes four variables: the growth rate of government real expenditures ($\Delta \ln G_t$), the growth of private real spending ($\Delta \ln Z_t$), the growth rate of real GDP ($\Delta \ln X_t$), and the three-month Treasury bill rate (R_t). The private real spending, $\Delta \ln Z_t$, is measured by either the growth rate of private real investment ($\Delta \ln I_t$) or the growth rate of private real consumption ($\Delta \ln C_t$). Thus, the baseline model consists of four variables as follows:

Model 1: TVAR with the ordering of $\{\Delta \ln G_t,\ \Delta \ln Z_t,\ \Delta \ln X_t,\ R_t\}$.

To account for financing of government expenditures and for inflation, we also consider extended models as follows:

Model 2: TVAR with the ordering of $\{\Delta \ln G_t,\ \Delta \ln D_t,\ \Delta \ln Z_t,\ \Delta \ln X_t,\ R_t\}$
Model 3: TVAR with the ordering of $\{\Delta \ln G_t,\ \Delta \ln M_t,\ \Delta \ln Z_t,\ \Delta \ln X_t,\ \Delta \ln P_t,\ R_t\}$,

where $\Delta \ln D_t$, $\Delta \ln M_t$, and $\Delta \ln P_t$, respectively, are the growth rate of real government debt, the growth rate of money, and inflation.[12] The money stock is measured by the monetary base, and the price level is measured by the GDP deflator. The (annualized) growth rate is measured by multiplying the log difference of a variable by 400. We estimate Models 1 and 2 with four lags and Model 3 with 3 lags of quarterly data.[13]

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[10] Inflation persistence tends to be associated with inflation in US. Inflation was rather persistent in the late 1960s, and high and highly persistent after the 1973 oil shock. Volcker's anti-inflation policy kept inflation in check in 1982 and, thereafter, policy has consistently aimed at keeping inflation low (see Choi, 2002).

[11] The regime classification according to the level of government debt (Sutherland, 1997; Perotti, 2003) is associated with the "accumulation" of government spending that has been financed by government bond issuance, reflecting the level of "fiscal stress" of the economy.

[12] The law of motion of government debt in a simple form can be written as: $D_{t+1} = AG_t^{\alpha} D_t^{\beta}$. This can be rewritten in a log-differenced form: $\Delta \ln D_{t+1} = \alpha \Delta \ln G_t + \beta \Delta \ln D_t$, which can be extended to a more general form in a VAR.

[13] For the VAR with the whole sample, the Akaike information criterion suggests four lags for most of Models 1 and 2 and three lags for Model 3, while the Schwarz criterion suggests 1 lag for all models.

The Choleski ordering that places government spending first is based on the identifying assumption that fiscal shocks have contemporaneous impacts on, but do not respond contemporaneously to, aggregate spending and other variables (Bernanke and Blinder, 1992; Christiano et al., 1996). This assumption is likely to be a reasonable approximation, since spending is discussed and approved before implementation (Alesina et al., 2002) and is not much reactive to changes in macroeconomic conditions (Fatás and Mihov, 2003).[14]

B. Tests for Threshold Effects

Linearity Testing and Number of Regimes

To begin with, we perform linearity testing to determine whether there exists a threshold effect. If a single regime is rejected, we also determine whether there are two or there regimes using Hansen's (1999, 2000) approach. In each equation, errors are assumed to be homoskedastic within a regime but heteroskedastic across regimes.

Table 1 summarizes the results of linearity testing for the four key variables along with inflation, assuming single threshold as alternative hypothesis. The test results tend to indicate that the null hypothesis of linearity is rejected against nonlinearity with single threshold: the likelihood-ratio test statistic for a threshold effect, F_1, is highly significant, as shown by *p*-values, for the interest rate equation and the inflation equation (*p*-value <0.01), and mildly significant for the investment growth equation (*p*-value <0.15) and the output growth equation (in most cases, *p*-value <0.10). The test results, however, suggest little evidence for a threshold effect in the consumption growth regression (*p*-value > 0.10). The least square estimate of threshold (τ) involves some degree of uncertainty as indicated by a confidence interval (90 percent) that is not very tight and, in some cases, half-open possibly owing to small samples of regimes. The observation number for the low- and the high-rate regime, for example, on the basis of output growth equation, is 65 and 98, respectively, which is classified by the threshold value of 1.542.

Although not reported, it is noteworthy that from the same testing procedure we find no evidence of nonlinearity for the equation of government spending growth (*p*-value is mostly greater than 0.30). In addition, for Models 2 and 3, we find little evidence of nonlinearity for money growth and government debt growth. The threshold estimate substantially varies across models for consumption growth, investment growth, and output growth equations and differs across equations (the interest rate equation versus others), suggesting the possibility of double threshold. Since F_1 rejects the null of no threshold effect for investment growth, output growth, interest rate, and inflation equations, we proceed with a further test to discriminate one and two thresholds for these equations.

Table 2 reports the likelihood-ratio test statistic of one versus two thresholds, F_2, and the refinement estimator (Bai, 1997; Hansen, 1999) of double threshold, (τ_L^r, τ_U^r), for investment

[14] Alesina et al. (2002) note that the yearly budget is discussed and approved during the second half of the preceding year and that additional small fiscal measures are sometimes decided during the year but, most of the time, they become effective by the end of the year. Fatás and Mihov (2003) suggest that spending is less prone to simultaneity problems in the determination of output and fiscal policy, compared to budget deficit, since spending is acyclical (not related to the current state of the economy) but budget deficit is largely affected by the cycle.

growth, output growth, and interest rate equations in each model. The F_2 statistic rejects the null of one threshold against two thresholds at the 5 percent significant level for the investment equation in Models 1 and 3 and at the 5 percent level or less for the interest rate equation in all models. However, the F_2 statistic is largely insignificant for the output equation (except that it is significant at the 10 percent for Model 3 with $\Delta \ln C_t$) and insignificant for the investment equation Models 2 and 3. The 90 percent confidence intervals for two thresholds are calculated based on the refinement estimator. Again, the confidence intervals of threshold estimates are not very tight and, in several cases, half-open possibly owing to small samples of regimes. The moderate regime tends to have more observations than the other two regimes for the equations of investment growth, interest rate, and inflation. Since F_2 statistic indicates strong evidence on double threshold for the interest rate and inflation equations, we hereafter consider a three-regime model that involves double threshold.

Specification Tests for Asymmetry across Regimes

Table 3 summarizes the specification test results for individual equations in TVARs with double threshold. Following Hansen (1996), we compute three test statistics—*SupW*, *AveW*, and *ExpW*. All the test statistics indicate that linearity is strongly rejected (at the 1 percent level) in most cases for investment growth, interest rate, and inflation equations. Mild evidence of nonlinearity is found for the equations of consumption growth and output growth. Linearity in the consumption growth equation is not rejected by all the statistics at the 10 percent level for Model 1, but often rejected at the 5 percent level for Models 2 and 3. Linearity in the output growth equation is mostly rejected at the 10 percent level with one exception: the exception is that linearity for Model 2 with consumption growth is not rejected by *ExpW*. Also performed is a specification test for parameter constancy across given subsamples as if the threshold estimate (τ reported in notes to Figures 3-5) were the true value as in Durlauf and Johnson (1995) and Choi (1999, 2002). The last column of the table provides strong evidence against parameter constancy across the subsamples except for consumption growth and output growth equations in Models 1 and 2 (p-values are greater than 0.10). Although not reported, we find no evidence of asymmetry in government spending growth (insignificant at the 10 percent level in all models). Taken together, these results give credence to threshold effects in investment growth, interest rates, and inflation (but only mildly to those in consumption growth and output growth).

The symmetry test results provide evidence on the coefficient shifts in most of the key regressions, consistent with the proposed switching mechanism with three regimes. An increase in government spending affects not only aggregate demand directly but also consumption and investment via, for example, its impact on interest rates. In addition, it involves the negative impact from the Ricardian effect via anticipated increases in future tax liabilities. Weak evidence on asymmetry in consumption may reflect that shifts in one parameter could be offset by changes in others, leaving the coefficients largely intact. However, asymmetry in other equations in the system can feed in the dynamic properties of consumption through the lagged values of other variables in the system. Thus, more importantly, we need to explore whether the dynamic responses of the economy to a government spending shock exhibit asymmetry across regimes.

Before examining different impacts of a spending shock across regimes, we look at how the regime type and the relation between real rates and output growth evolve over time. Figure 2 (panel A) displays the regime type index based on the estimated thresholds for Model 1 with investment growth—it consists of the low- and moderate-rate regimes before 1980 but the high- and moderate-rate regimes after 1980 (with one exception in 1993:1). Figure 2.B depicts output growth (annualized, quarter-to-quarter growth) along with real interest rates: output growth is more volatile (especially before the mid 1980s) than real interest rates. Figure 2.C shows that the regime mean of real rates is negatively related to that of output growth: the mean of real rates (output growth) is −0.90 (3.75) for the low-rate regime; 2.06 (3.49) for the moderate-rate regime; and 5.16 (2.43) for the high-rate regime. The relationship between real rates and growth reconciles the debt-output ratio transition in Figure 1.B: for example, the dominance of the low-rate regime before 1980—characterized by periods when on average real rates are smaller than output growth—is associated with a downward trend in the debt-output ratio.

C. TVAR Models and Impulse Responses to a Government Spending Shock

We consider a positive shock of one-percentage point to government spending growth (annualized) and its dynamic effects on the variables in TVARs. Our impulse-response analysis focuses on the case where the real rate is around its mean under each regime so that its small changes after the shock do not entail a shift to another regime.

The self (government spending growth) response shows a similar pattern across regimes: it entails, if there exist any differences, more persistence under the low-rate regime than under other regimes. In this section, we focus on whether the impulse responses of real activities (consumption, investment, and output) to the shock confirm empirically the anticipated larger impacts of the government spending that creates less future liabilities, compared to the spending that creates more future liabilities. Along the line of this evidence, we also examine the associated responses of interest rates, inflation, and financing methods.

Responses of Real Activities

Figures 3-5 depict the responses of consumption or investment growth and output growth in Models 1-3. The shock increases initially consumption growth (panel A.1 of each figure). In contrast with the responses in the whole sample (last column of each panel), consumption responses differ across regimes. In Model 1 (Figure 3.A.1), consumption growth responses are the strongest under the low-rate regime, followed by those under the moderate-rate regime. In Model 3 (Figure 5.A.1), however, consumption growth initially increases under the high-rate regime, perhaps because lower responses in real interest rate, under that regime, temper the adverse impact of the Ricardian effect.

The investment growth (panel B.1 in each figure) responses of the whole sample, if significant, are negative for all models—being attributed to crowding-out effects in the whole sample analysis. In contrast, the initial impacts of the spending shock on investment growth are significantly positive under the low-rate regime while (significantly or insignificantly) negative under other regimes. This asymmetry may be explained as follows. The productivity-enhancing effect induces a higher investment, on the one hand. On the other hand, when real rates are sufficiently high, a possible future increase in taxes has two opposing effects on investment: corporate taxes discourage investment, but income taxes will decrease consumption (a wealth effect), increase labor supply, and thus increase investment. Under the low-rate regime, investment growth initially increases (a dominating, productivity-enhancing effect) but declines after a few quarters as interest rates rise (a crowding-out effect). Under the high-rate regime, the spending shock has no boosting effect on investment growth and, if any, results in lower investment growth (a negative net effect of future taxes on investment).

Output responses (second and fourth rows in Figures 3-5) are initially positive under the low- and the moderate-rate regimes in all models but often not under the high-rate regime—consistent with the responses of consumption and investment growth under the corresponding regime. Under the low-rate regime of Model 2, output growth responses show a trough around the fourth-fifth quarter with significantly negative figures, reflecting a V-shape in investment growth responses. The moderate-rate regime somewhat mimics the whole sample responses that entail an initial positive response. Table 4 reports point estimates and standard errors of time averages of the impulses in the figures. Under the low-rate regime, the first-half year response is mostly significant (except for Model 1 with consumption growth and Model 3 with investment growth): for example, in Models 1 and 2 with investment growth, it is significantly positive (35.2 basis points) and three times as large as those in the whole sample (11.6–12.0 basis points). Under the moderate-rate regime, the first-half year response is in the range of 5 to 15 basis points and significant only in Models 1 and 2 with consumption growth. Under the high-rate regime, the output growth response is little or insignificantly negative in all models: the first-half year response is in the range of −8.8 to 14.1 basis points and mostly insignificant.

The whole sample analysis shows initial positive responses of consumption growth and output growth and initial negative responses of investment growth, which are consistent with earlier empirical findings that government spending shocks have a positive effect on consumption and output (Blanchard and Perotti, 2002) and a strong negative effect on investment (Blanchard and Perotti, 2002; Alesina et al., 2002).[15] In contrast, the TVAR analysis shows initial favorable effects on the growth of investment as well as consumption and output under the low-rate regime but less favorable or (significantly or insignificantly) adverse effects on them under other regimes. This asymmetry indicates that an expansionary government spending is more conducive to real activities when real rates are low than when they are high. Although no direct comparisons with existing studies are available, this result reconciles Perotti's (2002) finding that the effects of fiscal policy on output and its components have become substantially weaker over the last twenty years for US (and other OECD countries), considering that the post-1980 period largely consists of the high- and the moderate-rate regimes, whereas the pre-1980 period largely consists of the low- and the moderate-rate regimes (see Figure 2.C).

Responses of Interest Rates and Inflation

Figure 6.A shows the responses of nominal interest rates to the government spending shock in Model 3. The nominal interest rate shows a higher response under the low-rate regime than under other regimes. Nominal interest rate responses after 2-3 quarters of the shock are significantly positive under the low-rate regime but significantly or insignificantly negative

[15] Blanchard and Perotti (2002) estimate structural VAR models, which contain tax, government spending, output, and an individual GDP component (such as consumption or investment) in a level form controlling for trends, for the post-1960 US data. Alesina et al. (2002), using a simple structural model for a panel of OECD countries, find that government spending shocks lead to a decrease in the investment/GDP ratio.

under the high-rate regime (and the whole sample). Although not depicted, we find qualitatively similar nominal interest rate responses from Models 1 and 2 except that the responses are negative under the moderate-rate regime for Model 1 with investment growth.

Conventional macroeconomic theory suggests that an expansionary government spending raises interest rates, a consequence that one would expect if aggregate demand rises (an income effect). But why does the shock have positive impacts on the nominal interest rate only under the low-rate regime? The initial positive responses of output growth under the low-rate regime, which exert upward pressures on interest rates, partially explain this question. Nonetheless, a thorough answer requires a further look at the responses of inflation and real interest rates.

Figure 6.B depicts inflation responses under different regimes. The low-rate regime has significant positive inflation responses, but other regimes and the whole sample have no positive responses of inflation.[16] Hence, these asymmetric responses of inflation are consistent with positive responses of nominal interest rates under the low-rate regime and nonpositive responses of nominal interest rates under the high-rate regime (as implied by a Fisher effect). The inflation responses are also consistent with the output growth responses under different regimes, since the shock appears to contribute to aggregate demand only under the low-rate regime in most cases.

Nonpositive or negative responses of nominal rates under the high- and the moderate-rate regimes perhaps partly reflect that the Mankiw (1987) effect of government spending on real rates is regime-dependent. The Mankiw effect will be stronger under the high-rate regime, since government spending is more costly to finance and thus has stronger negative effects on consumption and real rates under that regime than under other regimes.

To support our conjecture that the Mankiw effect is partly responsible for the negative response of nominal interest rates to an expansionary government spending, we look at real interest rate responses. We put the ex-post real rate, rr_t, measured by the period-t nominal interest rate minus the period-t+1 inflation in place of R_t in Model 3 that accounts for the effect of government spending on interest rates through money growth and inflation responses. We term this modified version as Model 3′. Figure 7 shows real rate responses in Model 3′. The real rate is much higher under the low-rate regime than under other regimes, consistent with the Mankiw effect on real rates. Under the low-rate regime, insignificant initial responses are followed by significant positive responses, perhaps reflecting that the effect on real rates of the associated, lagged increase in aggregate demand dominates the Mankiw effect. Around 4-5 quarters, the positive responses of real rates are associated with negative responses in consumption and investment. Conversely, under the moderate- or the low-rate regime, brief negative or little responses are followed by insignificant negative responses. The whole sample, too, shows insignificant impacts of government spending on real rates.

To the extent that a positive shock to government spending leads to budget deficits given the current taxes, the nonpositive responses of interest rates in the whole sample and those under the high- and moderate-rate regimes reconcile earlier findings that budget deficits have little effect

[16] The commodity price inflation can be included in Model 3 to cope with the "price puzzle"–the finding that a monetary tightening leads to a rising rather than falling price level (Leeper, Sims, and Zha, 1996; Christiano et al., 1996). We find that the inclusion of the commodity price inflation does not alter our main results.

on prices (Dwyer, 1982) and on real and nominal rates of interest (Evans, 1987), supported by the Ricardian effects. In contrast, the positive responses of interest rates under the low-rate regime reconcile a Keynesian prediction. To the extent that high inflations tend to be associated with low real interest rates, our finding on positive inflation responses only under the low-rate regime reconciles Fischer, Sahay, and Végh's (2000) finding that a cross-country panel supports a significant positive association between inflation and fiscal balance for high inflations but not for low-inflation countries or low-inflation periods in high-inflation countries.

Responses of Financing Methods

Figure 8 depicts responses of government debt growth (in Model 2) and money growth (in Model 3) to the government spending shock. Under each regime, government spending is initially financed by government debt issuance (rows 1 and 3). The initial positive response of each financing method under the moderate-rate regime is similar to those in the whole sample analysis. Under the low-rate regime, debt finance declines significantly after two quarters after its initial increases, perhaps reflecting a rise in real returns on bonds whose level was initially low. It is remarkable that money growth responses (rows 2 and 4) rise significantly, after a short lag with a "hump shape," under the high-rate regime but not under the low-rate regime, while they show a brief initial increase under the moderate-rate regime. This indicates that government spending finance relies on money creation only when cost of debt financing is relatively high.

Under the low-rate regime, the (V-shape) responses of money growth, along with (inverted V-shape) responses of interest rates, seem to mirror the V-shape responses in investment and consumption growth. The hump-shape positive responses in money growth under the high-rate regime may be associated with downward pressures on the interest rate: thereby money finance, after a lag, may help reduce the crowding-out effect.[17] On the other hand, under the low-rate regime, positive inflation responses around 4-6 quarters largely reflect upward pressures of aggregate demand with a lag, as opposed to negative responses in money growth. Conversely, under the moderate- and high-rate regimes, there is no evidence of positive association between money growth and inflation responses. This asymmetry between money finance and inflation may reconcile earlier studies, noting that the low-rate (high-rate) regime tends to be associated with high (low) inflation periods. With higher inflation, agents adjust more frequently to keep with inflation, so sensitivity of inflation to aggregate demand shocks is high (Ball, Mankiw, and Romer, 1988; Choi, 2002)—implying a weaker trade-off between inflation and output and thus less effective monetary policy. The stronger effect of government spending for higher inflations reconciles Koelln, Rush, and Waldo's (1996) finding from cross-country data that the government spending multiplier increases with inflation if inflation is sufficiently high.

D. Robustness Checks and Discussion

We find that the use of alternative variable sets (real interest rates in place of nominal interest rates) and different ordering in TVARs (for example, the real money stock of M1 in place of the monetary base; placing money growth after output growth considering the money supply

[17] The effects of government spending on output through the interest rate channel or the exchange rate channel are known to be quite small (Hemming, Kell, and Mahfouz, 2002).

endogeneity) does not affect the main results qualitatively. Also, alternative lag length of one or two provides qualitatively similar results.

As an alterative switching index, we consider using the *ex-ante* real interest rate. With this index, we find similar results for the existence of double threshold but, overall, less pronounced asymmetries in dynamic responses to a government spending shock—perhaps because the overshooting in the ex-ante real rate before 1980 results in an obtuse discrimination of observations between the low- and the moderate-rate regime (see Figure 1.A). Table 5 reports the point estimates and standard errors of time average of the output growth responses with this switching index. Compared to those in Table 4, a similar pattern is observed, although asymmetric effects are less pronounced in all models with consumption growth and Model 1 with investment growth. As another alternative switching index, one may consider the government debt-output ratio, which, however, does not account for time-varying feature of the finance cost and sustainability of debt. We find that the use of this measure in place of the real interest rate provides no evidence on asymmetry in consumption (or investment) and output growth, although linearity testing suggests the existence of single threshold for interest rate and inflation equations, and no evidence on asymmetric responses to a government spending shock.

Expenditure composition may matter (Kormendi, 1983; Aschauer, 1989; Barro and Sala-i-Martin, 1992; Tanzi and Zee, 1997). For example, an increase in spending on government wages and salaries will have less favourable impacts on output than expenditures on goods and services and capital projects. Also, defence spending shocks may have a differential impact on the economy.[18] However, we consider total government spending rather than expenditure composition, because we emphasize the implication of financing cost of government expenditures for future tax liabilities as a whole—it will be difficult to take into account the implication of an individual expenditure component for the economy's tax liabilities since the individual expenditure component could be offset by others given the government budget constraint. Thus using national defence spending as a measure of fiscal policy has a limitation to serve our purpose. Nonetheless, we use this measure of fiscal policy for comparison and find that linearity testing supports threshold effects in the TVARs. In comparison with a total government spending shock, the national defense shock shows similar but less contrasting asymmetric effects across regimes, while it tends to have greater crowding-out effect on consumption and investment irrespective of regimes (not reported).

We have assumed no communication across regimes in the impulse-response analysis. This assumption will remain robust as a good approximation, because the one-percentage point shock does not affect much the real rate: it affects the real rate only about 10 basis points at its peak or trough as shown in Figure 7. Thus, the current regime at the *median* value of real rates is expected to prevail after the shock—the cumulative response of real rates is less than 80 basis points for eight quarters, so the switching index does not hit threshold values. Nonetheless, one may consider a more general case where a government spending shock affects the real rate enough to trigger switching back and forward across regimes. For example, suppose government

[18] Kormendi (1983) finds from US data that defense spending is in between government investment and government consumption in term of the size of crowding-out effect on private consumption. Evans and Karras (1998), using cross-country data analysis, suggest that private consumption and non-military government spending are substitutes, whereas private consumption and military spending are complements.

spending goes up in the low-real rate regime. Economic agents would anticipate low financing costs of this, and thus the crowding-out effects would be small, but in fact the regime has some probability of switching to higher real rate regimes.[19] In general, however, the (conditional and nonlinear) responses depend not only on the level of real rates (initial condition) but also on the *size* of shocks, rendering the summary of expected responses intractable.

In times of very low nominal interest rates, fiscal expansions—before deflation comes into its place with rising real interest rates—may prove conducive to boosting economic activities, whereas the activist monetary policy could rather be limited in its scope.[20] For an economy with pervasively high real interest rates and persistent government deficits, however, an expansionary fiscal policy could be less than effective. Further, as an aggressive fiscal policy induces macroeconomic volatility, which in turn lowers economic growth—as shown in Fatás and Mihov (2003)—fiscal policy entails a trade-off between volatility and efficacy.

V. Conclusion

Earlier studies have looked for nonlinear effects of fiscal policy on the basis of different characteristics of fiscal impetus or consumers' expectations about fiscal adjustment for government debt sustainability. Little evidence, however, has been provided from the viewpoint that the financing cost of government spending and its implication for debt sustainability affects the efficacy of fiscal policy. This paper examines empirical evidence concerning the relative effectiveness of government spending at different levels of real interest rates.

When real interest rates are sufficiently low relative to output growth, government spending can have expansionary effects on output and investment since the government can most likely roll over the debt and accumulated interest without raising taxes. When real interest rates are sufficiently high so that the economy is expected to exceed tolerable debt burden during agents' time horizon, then agents perceive that the government must undergo a fiscal consolidation, raising tax rates on wages and capital income—leading to a stronger Ricardian effect. Hence, government spending in times of low real interest rates will associated with smaller increases in future tax liabilities than those in times of high real interest rates.

Our empirical results confirm that the anticipated larger impact on aggregate spending holds when real interest rates are low. We find that government spending has significant positive impacts on aggregate spending under the regime with low financing cost of government spending, whereas we find less or no significant impacts, owing to a stronger Ricardian effect, under other regimes that entail comparatively high financing cost. Despite that government spending shocks involve strong threshold effects on the economy, the lack of evidence on asymmetry in government spending itself may indicate that the fiscal policy stance has not

[19] To allow for shifts to other regimes on the margin, one may consider the estimation averages over the actual histories of real rates conditional on each regime, given a *fixed* size of shocks. This approach will somewhat smooth out differences across regimes but will not affect our results qualitatively, given that the moderate-rate regime, as middle ground in the characteristics of responses, buffers a transition from one extreme regime to the other extreme unless the shock size is extremely large.

[20] Lessons from Japan's experience with the current prolonged recession suggest that there are limits to the Fed's activist aggression and suggest caution that cutting rates close to zero may introduce frictions in financial markets possibly outweighing the benefits of marginally cheaper money.

accounted for the threshold effects of fiscal policy to promote its effectiveness. In the face of different real interest rates, however, substitution between money creation and government debt issuance as financing method reflects an attempt to reduce the cost of government spending, which may temper asymmetry in fiscal policy effects across regimes.

We interpret this new evidence on asymmetric effects of fiscal policy as providing an argument that fiscal policy is likely to be more conducive to growth when real interest rates are low. However, ballooning government debt with a persistent, expansionary government spending is widely perceived as constraining fiscal policy—fiscal austerity indeed forms a stronger foundation for the fiscal stance in times of need. One also needs to acknowledge that an attempt to form an environment to promote the efficacy of fiscal policy may be associated with creating inflation shocks (through monetary expansions) to keep real interest rates low.

Data Appendix

Using the mnemonics in FRED at the Web site of the Federal Reserve Bank of St. Louis, the data series used in the paper are GDP (nominal GNP), GDPC1 (real GDP, chained 1996 dollars), GCEC1 (real government consumption expenditures & gross investment, chained 1996 dollars), FDEFX (national defence consumption expenditures & gross investment) deflated by the GDP deflator (=GDP/GDPC1), GPDIC1 (real gross private domestic investment), FPIC1 (real fixed private domestic investment, chained 1996 Dollars), BOGAMBSL (Board of Governors' adjusted monetary base), M1SL (money stock M1), TB3MS (three-month Treasury bill rate), and TB6MS (six-month Treasury bill rate). The semi-annual inflation forecast is 6-months ahead forecast of 'cpiz' inflation taken from the *Livingston Survey* and interpolated at quarterly frequency. The nominal government debt is taken from *International Financial Statistics* and seasonally adjusted.

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Table 1. Tests for Single Threshold and Threshold Estimates, 1960:1–2001:4

Eq. in TVAR	Test Statistic: F_1 [a]	Threshold Value: τ [b]	Number of Obs. [c]
Consumption Growth Eq. in			
Model 1 with $\Delta \ln C_t$	40.3 (0.205)	1.542 [1.523, 1.597]	[65, 98]
Model 2 with $\Delta \ln C_t$	55.6 (0.113)	1.542 [1.523, 1.597]	[65, 98]
Model 3 with $\Delta \ln C_t$	37.7 (0.490)	0.584 [– , 0.999]	[40, 125]
Investment Growth Eq. in			
Model 1 with $\Delta \ln I_t$	43.1 (0.124)	0.186 [– , 0.352]	[33, 130]
Model 2 with $\Delta \ln I_t$	54.6 (0.136)	1.139 [0.938, 1.194]	[53, 110]
Model 3 with $\Delta \ln I_t$	52.5 (0.072)	0.837 [– , 1.144]	[43, 122]
Output Growth Eq. in			
Model 1 with $\Delta \ln C_t$	46.1 (0.093)	1.542 [1.267, 1.560]	[65, 98]
with $\Delta \ln I_t$	43.2 (0.117)	1.542 [1.377, 1.560]	[65, 98]
Model 2 with $\Delta \ln C_t$	58.0 (0.084)	1.542 [1.450, 1.560]	[65, 98]
with $\Delta \ln I_t$	61.8 (0.053)	1.065 [0.864, 1.194]	[51, 112]
Model 3 with $\Delta \ln C_t$	52.7 (0.058)	1.126 [0.783, 1.180]	[52, 113]
with $\Delta \ln I_t$	64.6 (0.008)	0.223 [– , 0.891]	[34, 131]
Interest Rate Eq. in			
Model 1 with $\Delta \ln C_t$	131.1 (0.000)	3.629 [3.465, –]	[126, 37]
with $\Delta \ln I_t$	156.8 (0.000)	3.813 [3.611, –]	[129, 34]
Model 2 with $\Delta \ln C_t$	141.4 (0.000)	3.813 [3.465, –]	[129, 34]
with $\Delta \ln I_t$	158.4 (0.000)	3.776 [3.611, –]	[128, 35]
Model 3 with $\Delta \ln C_t$	91.0 (0.000)	3.509 [3.166, –]	[123, 42]
with $\Delta \ln I_t$	101.7 (0.000)	3.509 [3.318, –]	[123, 42]
Inflation Eq. in			
Model 3 with $\Delta \ln C_t$	147.8 (0.000)	0.801 [0.783, 0.927]	[42, 123]
with $\Delta \ln I_t$	165.8 (0.000)	0.801 [0.783, 0.927]	[42, 123]

Notes: [a] The likelihood-ratio test statistic, F_1, is for the null hypothesis of no threshold against the alternative hypothesis of single threshold, following Hansen (1999, 2000). The asymptotic *p*-values are reported in parentheses. The number of simulation replications for each grid was set at J=1,000. The lag length is set at 4 for models 1 and 2 and at 3 for Model 3.

[b] The grid set: Γ = {100 grids evenly dividing the range from the 20th to the 80th percentile of the switching index}. The 90 % confidence interval for τ is computed using the likelihood-ratio statistic following Hansen (1999).

[c] The number of observations is in the order of the low regime and the high regime.

Table 2. Tests for Double Threshold and Threshold Estimates, 1960:1–2001:4

Eq. in TVAR	Test Statistic: F_2 [a]	Threshold Parameters: (τ_L^r, τ_U^r) [b]	Number of Obs. [c]
Investment Growth Eq. in			
Model 1 with $\Delta \ln I_t$	54.3 (0.050)	{0.186, 3.205} [– , 0.340; 3.089, 3.509]	[32, 98, 33]
Model 2 with $\Delta \ln I_t$	54.1 (0.268)	{0.186, 2.019} [0.359, 0.782; – , 2.147]	[32, 51, 80]
Model 3 with $\Delta \ln I_t$	45.2 (0.299)	{0.359, 2.710} [0.345, 0.808; 2.297, 3.320]	[37, 63, 65]
Output Growth Eq. in			
Model 1 with $\Delta \ln C_t$	38,7 (0.320)	{0.223, 1.537} [– , – ; – , 1.560]	[34, 31, 98]
with $\Delta \ln I_t$	45.0 (0.179)	{0.339, 1.556} [– , 0.312; – , 1.579]	[36, 31, 96]
Model 2 with $\Delta \ln C_t$	49.3 (0.608)	{0.237, 1.537} [– , 0.377; – , 1.560]	[34, 31, 98]
with $\Delta \ln I_t$	45.4 (0.468)	{1.131, 3.733} [1.108, 1.155; 2.756, 3.394]	[32, 35, 96]
Model 3 with $\Delta \ln C_t$	64.9 (0.035)	{1.125, 3.217} [0.340, 0.808; 1.548, 1.594]	[52, 63, 50]
with $\Delta \ln I_t$	50.4 (0.184)	{0.360, 3.660} [0.337, 0.886; 3.498, –]	[37, 91, 37]
Interest Rate Eq. in			
Model 1 with $\Delta \ln C_t$	58.3 (0.045)	{0.186, 3.813} [– , 0.349; 3.783, –]	[32, 98, 33]
with $\Delta \ln I_t$	67.1 (0.007)	{0.186, 3.813} [– , 0.358; 3.743, –]	[32, 98, 33]
Model 2 with $\Delta \ln C_t$	78.7 (0.034)	{0.333, 3.813} [– , 0.358; 3.790, –]	[36, 94, 33]
with $\Delta \ln I_t$	95.2 (0.004)	{0.186, 3.813} [– , 0.308; 3.790, –]	[36, 94, 33]
Model 3 with $\Delta \ln C_t$	145.9 (0.000)	{0.186, 3.813} [– , 0.309; 3.790, –]	[32, 98, 33]
with $\Delta \ln I_t$	129.3 (0.000)	{0.186, 3.813} [– , 0.274; 3.416, –]	[32, 98, 33]
Inflation Eq. in			
Model 3 with $\Delta \ln C_t$	100.6 (0.035)	{0.845, 3.486} [0.779, 0.911; 3.233, 3.486]	[43, 78, 42]
with $\Delta \ln I_t$	102.4 (0.025)	{0.186, 3.396} [– , 0.568; 3.233, 3.486]	[32, 86, 45]

Notes: [a] The likelihood-ratio test statistic, F_2, is for the null hypothesis of single threshold against the alternative hypothesis of double threshold, following Hansen (1999). The asymptotic p-values are reported in parentheses. The number of simulation replications for each grid was set at J=1,000. The lag length is set at 4 for Models 1 and 2 and at 3 for Model 3.

[b] The threshold parameters are based on the refinement estimator (Bai, 1997; Hansen 1999). The grid set: Γ = {50 grids for the refinement estimator, given the first- or the second-stage threshold estimate}.

[c] The number of observations is in the order of the low-rate regime, the moderate-rate regime, and the high-rate regime.

Table 3. Specification Tests for Asymmetry in TVARs, 1960:1–2001:4

Eq. in TVAR \ Type of Test Statistics	Across Regimes [a] *SupW*	*ExpW*	*AveW*	Across Subsamples [b] χ^2
<u>Consumption Growth Eq. in</u>				
Model 1 with $\Delta \ln C_t$	51.6 (0.171)	40.3 (0.176)	21.9 (0.212)	28.8 [*df*=34] (0.719)
Model 2 with $\Delta \ln C_t$	86.4 (0.001)	52.6 (0.111)	37.4 (0.002)	52.3 [*df*=42] (0.133)
Model 3 with $\Delta \ln C_t$	84.6 (0.000)	60.9 (0.006)	37.1 (0.000)	60.7 [*df*=38] (0.011)
<u>Investment Growth Eq. in</u>				
Model 1 with $\Delta \ln I_t$	73.7 (0.003)	55.7 (0.007)	32.4 (0.003)	61.0 [*df*=34] (0.003)
Model 2 with $\Delta \ln I_t$	89.3 (0.001)	71.7 (0.002)	40.7 (0.000)	81.8 [*df*=42] (0.000)
Model 3 with $\Delta \ln I_t$	80.3 (0.001)	60.6 (0.007)	36.2 (0.001)	62.4 [*df*=38] (0.008)
<u>Output Growth Eq. in</u>				
Model 1 with $\Delta \ln C_t$	67.9 (0.010)	46.5 (0.055)	29.1 (0.016)	39.8 [*df*=34] (0.226)
with $\Delta \ln I_t$	65.1 (0.016)	44.1 (0.099)	28.2 (0.026)	44.0 [*df*=34] (0.116)
Model 2 with $\Delta \ln C_t$	69.6 (0.054)	50.1 (0.159)	29.7 (0.090)	52.4 [*df*=42] (0.131)
with $\Delta \ln I_t$	82.3 (0.005)	54.6 (0.076)	36.9 (0.009)	50.3 [*df*=42] (0.178)
Model 3 with $\Delta \ln C_t$	90.9 (0.000)	65.0 (0.002)	40.5 (0.000)	67.7 [*df*=38] (0.002)
with $\Delta \ln I_t$	89.4 (0.000)	65.2 (0.001)	40.1 (0.000)	50.3 [*df*=38] (0.006)
<u>Interest Rate Eq. in</u>				
Model 1 with $\Delta \ln C_t$	305.6 (0.000)	81.7(0.000)	146.8 (0.000)	305.6 [*df*=34] (0.000)
with $\Delta \ln I_t$	155.1 (0.000)	104.5(0.000)	71.7 (0.000)	155.1 [*df*=34] (0.000)
Model 2 with $\Delta \ln C_t$	124.6 (0.000)	90.3 (0.000)	56.6 (0.000)	106.3 [*df*=42] (0.000)
with $\Delta \ln I_t$	156.9 (0.000)	116.7 (0.000)	72.5 (0.000)	156.9 [*df*=42] (0.000)
Model 3 with $\Delta \ln C_t$	110.0 (0.000)	81.3 (0.000)	50.8 (0.000)	100.4 [*df*=38] (0.000)
with $\Delta \ln I_t$	118.8 (0.000)	93.0 (0.001)	54.8 (0.000)	110.2 [*df*=38] (0.000)
<u>Inflation Eq. in</u>				
Model 3 with $\Delta \ln C_t$	216.7 (0.000)	173.5 (0.000)	102.4 (0.000)	154.1 [*df*=38] (0.000)
with $\Delta \ln I_t$	210.5 (0.000)	182.7 (0.001)	101.6 (0.000)	197.4 [*df*=38] (0.000)

<u>Notes:</u> [a] The result for testing the null hypothesis that the coefficients in the indicated equation are the same across regimes, following Hansen (1996). The asymptotic *p*-values are reported in parentheses. The number of simulation replications for each grid was set at *J*=1,000. The set of grid points for (τ_L, τ_U): Γ = {all the grids at grid search with 40 grids for each threshold} (# Γ=1,600).

[b] The result of the Wald tests of the null that the coefficients of the indicated equation are constant across the *indicated* subsamples grouped by $\hat{\tau}$, which is reported in the corresponding notes of Figures 3-5. The test statistics follow the chi-square distributions with degrees of freedom (*df*) in parentheses under the null. The *df* for the interest equation in a TVAR equals 2(1+number of variables×number of lags). The *p*-values are reported in parentheses.

Table 4. Output Growth Responses

Quarter	Model 1				Model 2				Model 3			
	L	M	H	W	L	M	H	W	L	M	H	W
	With $\Delta \ln C_t$											
1–2	59.4	11.0	−8.8	13.4	42.0	14.5	−6.1	13.9	23.9	5.9	2.9	11.1
	(36.0)	(4.9)	(10.8)	(4.0)	(13.1)	(5.5)	(10.0)	(3.5)	(11.7)	(5.6)	(12.5)	(4.7)
2–4	−3.5	1.2	−2.6	1.3	−6.7	0.8	−0.5	0.7	−14.2	0.7	−1.1	1.0
	(62.3)	(5.1)	(31.7)	(4.8)	(21.8)	(5.3)	(30.8)	(5.0)	(20.6)	(5.8)	(23.6)	(5.3)
5–8	−35.7	2.8	−28.8	3.1	−28.9	0.4	−21.8	4.0	−12.1	2.1	−39.7	0.9
	(174.0)	(4.2)	(100.6)	(3.6)	(25.6)	(4.1)	(97.9)	(3.7)	(22.0)	(3.0)	(71.7)	(3.1)
	With $\Delta \ln I_t$											
1–2	35.2	5.3	0.0	11.6	35.2	8.5	14.1	12.0	14.1	5.2	6.0	10.4
	(14.5)	(4.0)	(9.1)	(4.0)	(13.0)	(5.5)	(8.3)	(4.6)	(11.3)	(6.7)	(7.5)	(3.6)
2–4	−27.8	3.6	4.1	2.4	−14.9	9.7	8.3	2.3	−14.6	6.4	−8.4	1.9
	(19.9)	(5.4)	(16.9)	(4.7)	(16.9)	(5.9)	(12.0)	(4.8)	(18.6)	(6.4)	(14.3)	(5.0)
5–8	−5.9	4.9	−14.5	1.9	−14.8	1.7	−27.7	3.2	−15.9	−0.6	−16.6	−0.2
	(14.2)	(4.3)	(25.5)	(3.7)	(14.8)	(4.2)	(15.6)	(3.5)	(19.2)	(4.0)	(25.1)	(2.8)

Notes: The impulse responses (in basis points) were calculated for the first-half year (1-2 quarters), the second-half (3-4 quarters), and the second year (5-8 quarters) from TVARs or whole-sample VARs. The lag length is 4 for Models 1 and 2 and at 3 for Model 3. The {L, M, H, W} denotes {low, moderate, high regimes, whole sample}. The estimated grids for TVARs are reported in the corresponding notes to Figures 3-5. The top (bottom) panel pertains to the responses of output growth to a government spending shock in models with the consumption (investment) growth variable. Standard errors (in parentheses) are calculated from the bootstrapping with 1,000 replications.

Table 5. Output Growth Responses with Ex-Ante Real Rates as the Switching Index

Quarter	Model 1				Model 2				Model 3			
	L	M	H	W	L	M	H	W	L	M	H	W
	With $\Delta \ln C_t$											
1–2	20.0	9.5	5.0	13.4	14.1	14.9	7.2	13.9	31.7	5.6	7.1	11.1
	(8.0)	(5.5)	(9.0)	(3.6)	(8.3)	(4.4)	(5.0)	(4.3)	(12.1)	(5.0)	(6.9)	(4.2)
2–4	−12.0	−11.6	17.1	1.3	−10.4	−6.8	15.5	0.7	−12.8	−4.3	5.6	1.0
	(10.7)	(6.4)	(14.6)	(4.9)	(9.6)	(7.1)	(9.8)	(5.0)	(17.7)	(5.8)	(12.5)	(5.1)
5–8	−1.2	4.7	0.7	3.1	2.4	12.8	3.3	4.0	1.2	−2.1	−11.0	0.9
	(10.0)	(11.6)	(18.4)	(3.8)	(9.8)	(25.2)	(11.5)	(3.9)	(13.7)	(4.5)	(27.5)	(2.7)
	With $\Delta \ln I_t$											
1–2	17.8	13.1	12.9	11.6	70.4	7.8	15.9	12.0	31.8	−5.6	5.5	10.4
	(9.6)	(5.1)	(5.7)	(4.4)	(20.4)	(4.7)	(9.9)	(4.6)	(17.3)	(7.2)	(6.7)	(4.2)
2–4	−14.9	−6.9	23.9	2.4	30.4	−6.3	13.0	2.3	−14.3	−5.3	8.9	1.9
	(8.9)	(8.3)	(9.5)	(5.0)	(40.1)	(5.3)	(12.0)	(4.9)	(19.2)	(8.1)	(10.0)	(5.4)
5–8	−1.2	18.1	1.6	1.9	11.6	−4.2	−11.9	3.2	2.5	−2.3	3.0	−0.2
	(8.7)	(42.9)	(10.8)	(3.8)	(73.2)	(4.8)	(12.0)	(3.9)	(22.3)	(9.1)	(12.6)	(2.9)

Notes: See notes to Table 4. *Ex-ante* real rate are measured by the 3-month T-bill rate minus the expected inflation. To obtain a proxy for the expected inflation, the 6-months ahead forecast of inflation is taken from the *Livingston Survey* and interpolated at quarterly frequency

Figure 1. Real Interest Rates, Debt/GDP Ratio, and Government Spending Growth

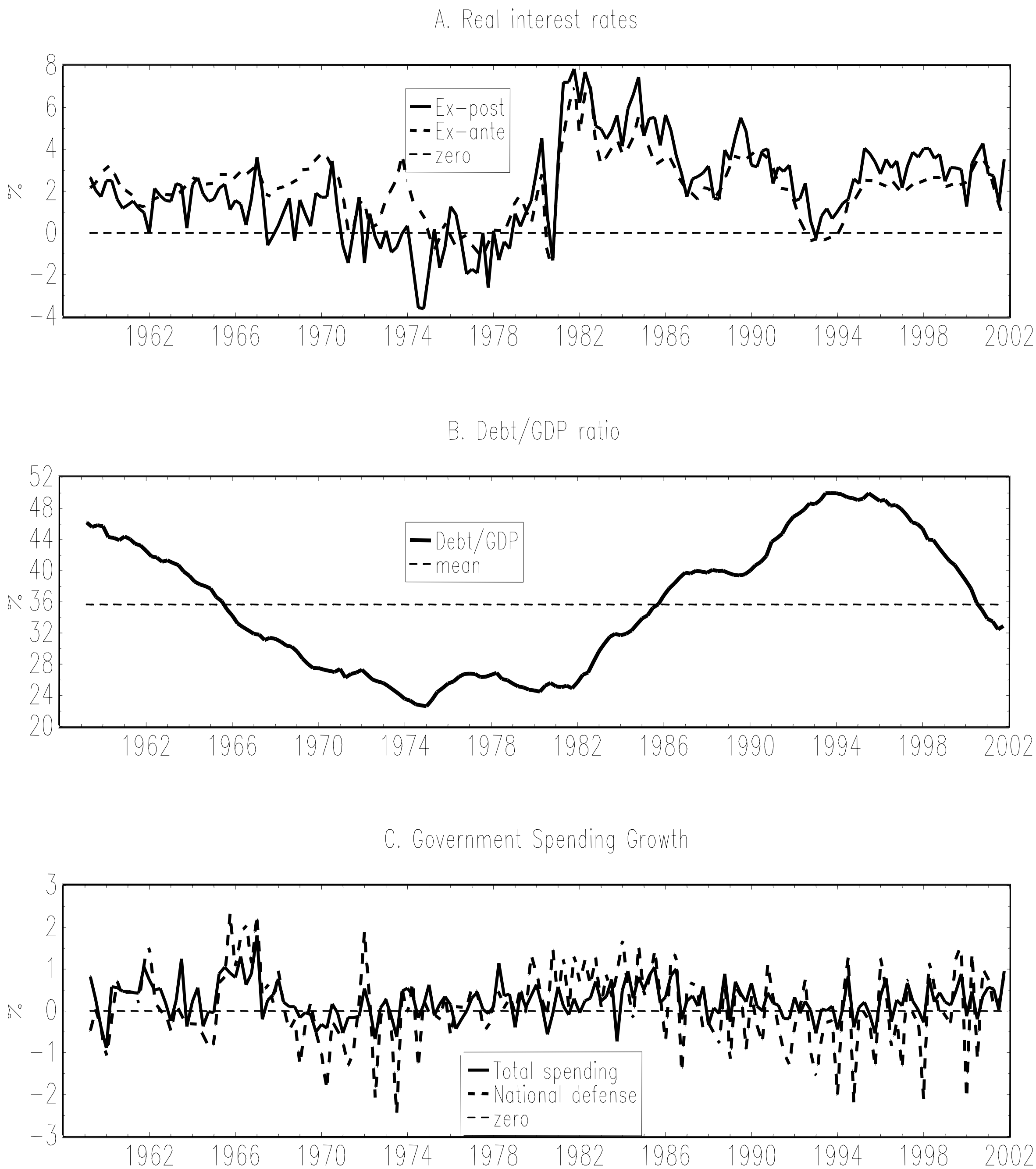
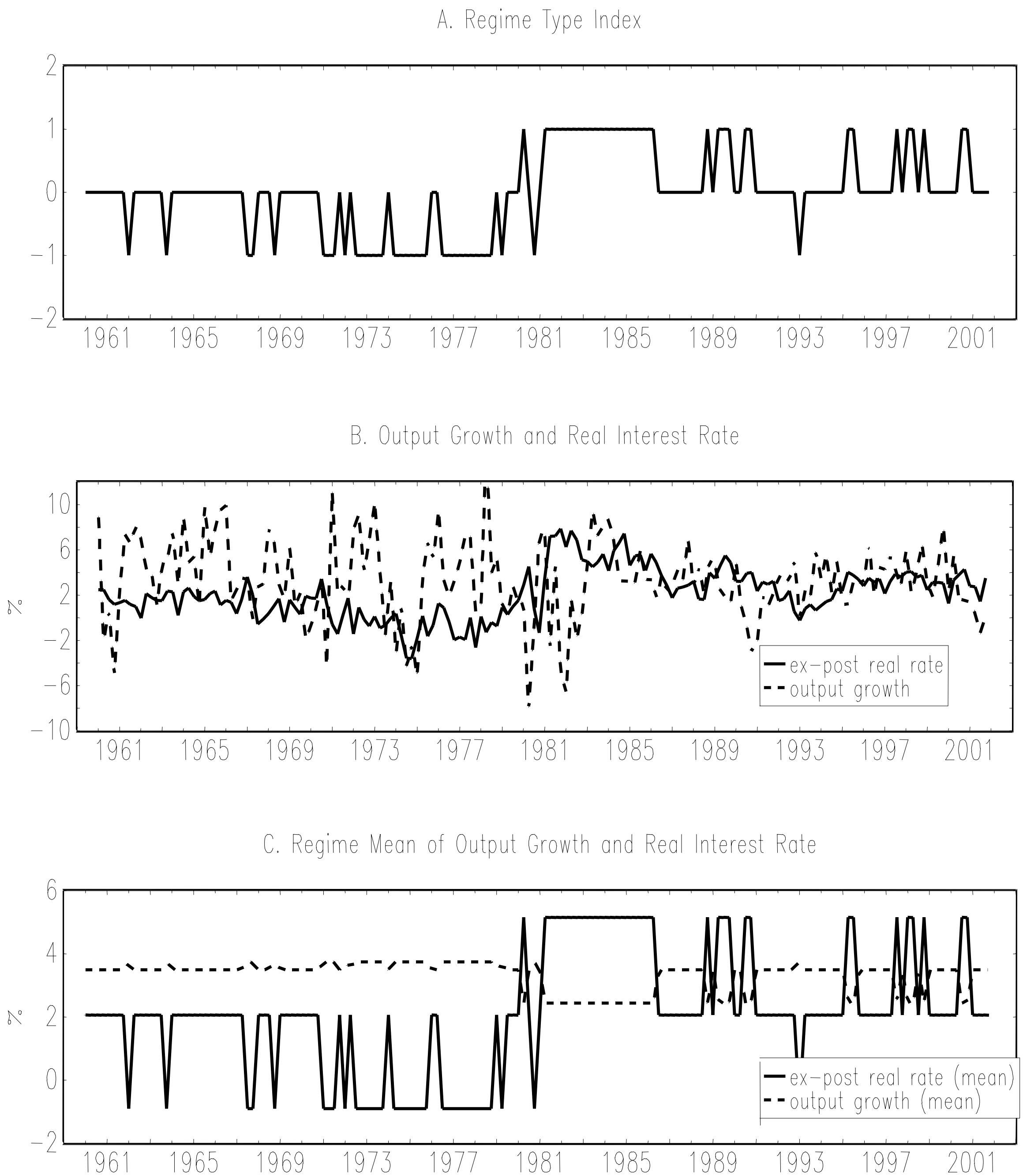


Figure 2. Regime Type Index, Real Interest Rates, and Output Growth

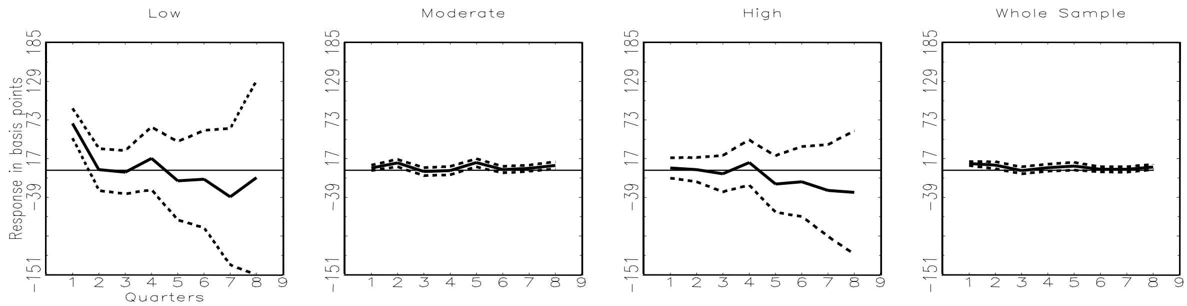


Notes: Regime type is determined on the basis of the estimated thresholds for Model 1 with investment growth (see notes to Figure 3): low-rate regime (-1), moderate-rate regime (0), and high-rate regime (1). Regime mean is the subsample mean of a variable for the corresponding regime.

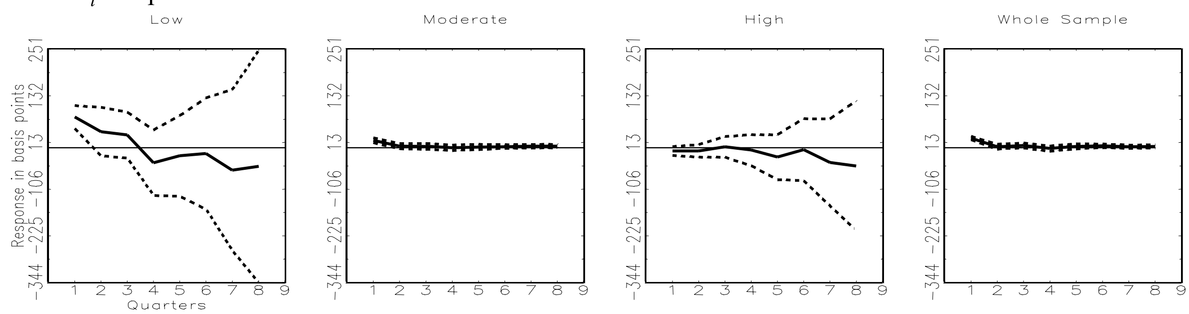
Figure 3. Responses of Real Activities in Model 1

A. With Consumption Growth

1. $\Delta \ln C_t$ Response

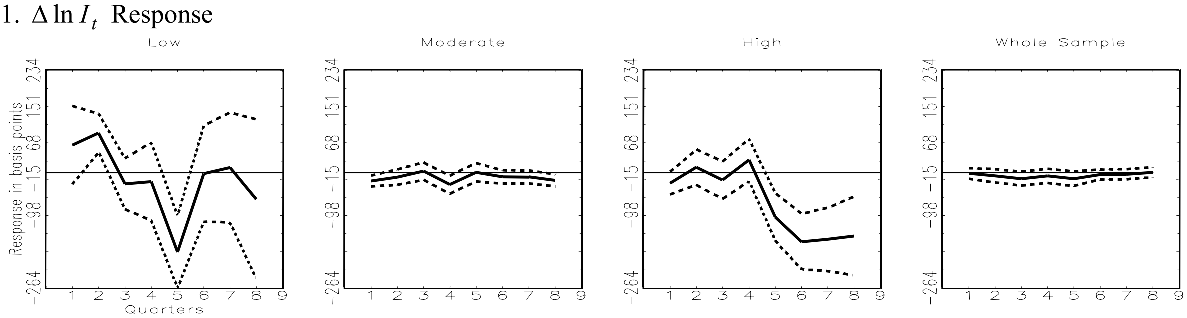


2. $\Delta \ln Y_t$ Response

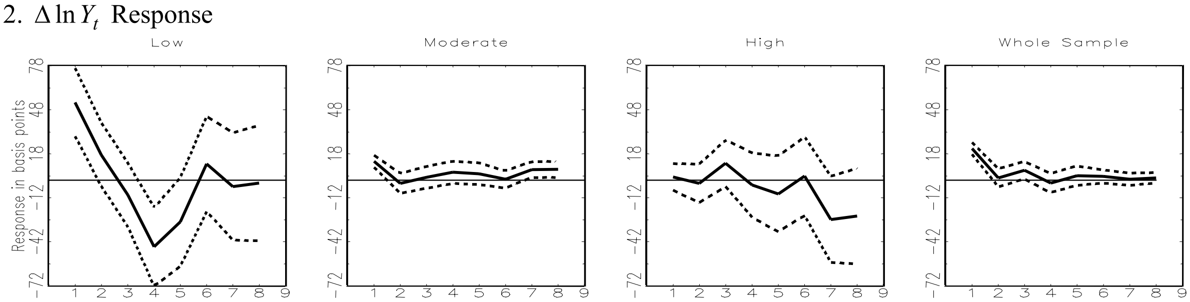


B. With Investment Growth

1. $\Delta \ln I_t$ Response



2. $\Delta \ln Y_t$ Response

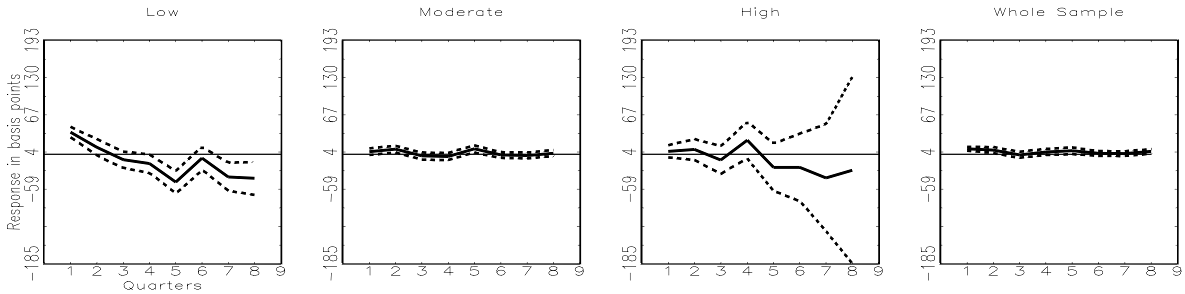


Notes: For Model 1 with consumption growth, estimated thresholds, (τ_L, τ_H), are (–0.144, 3.882), and the number of sample observations are (25, 106, 32). For Model 1 with investment growth, estimated thresholds, (τ_L, τ_H), are (0.325, 3.718), and the number of sample observations are (35, 92, 36). Dashed lines are one-standard error bands.

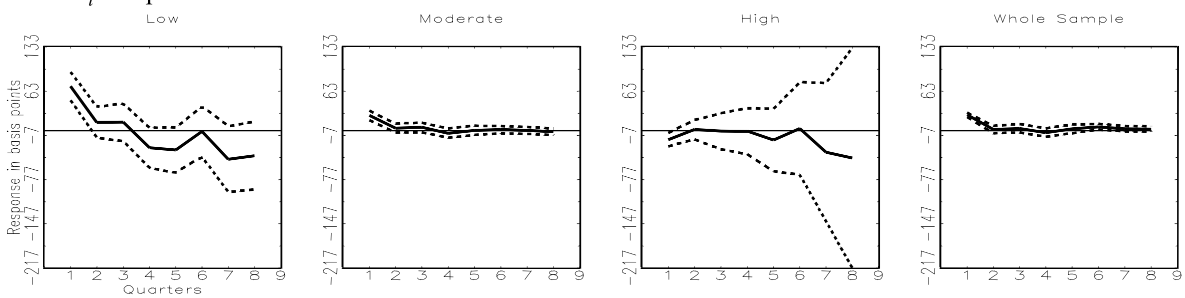
Figure 4. Responses of Real Activities in Model 2

A. With Consumption Growth

1. $\Delta \ln C_t$ Response

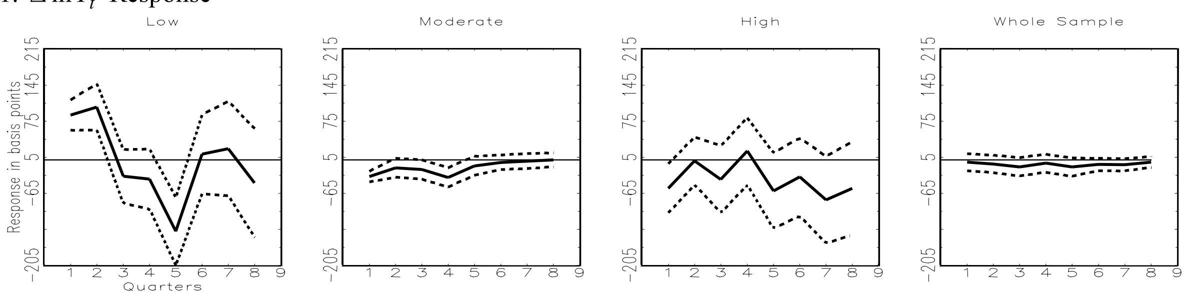


2. $\Delta \ln Y_t$ Response

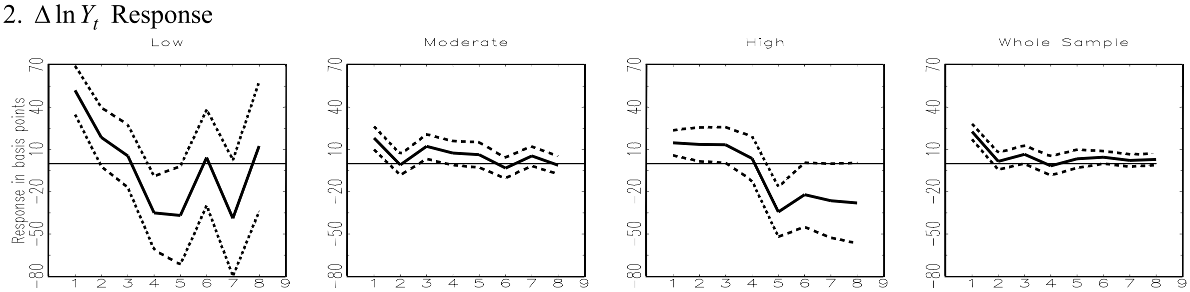


B. With Investment Growth

1. $\Delta \ln I_t$ Response



2. $\Delta \ln Y_t$ Response

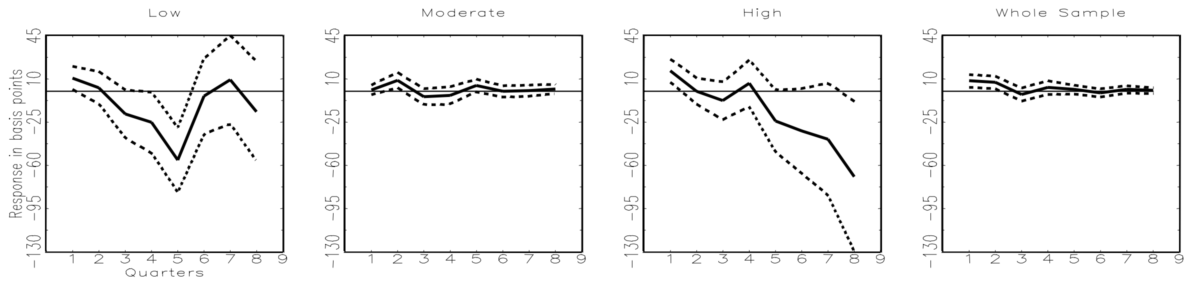


Notes: For Model 2 with consumption growth, estimated thresholds, (τ_L, τ_H), are (0.359, 3.813), and the number of sample observations are (37, 93, 33). For Model 2 with investment growth, estimated thresholds, (τ_L, τ_H), are (0.325, 3.499), and the number of sample observations are (35, 86, 42). Dashed lines are one-standard error bands.

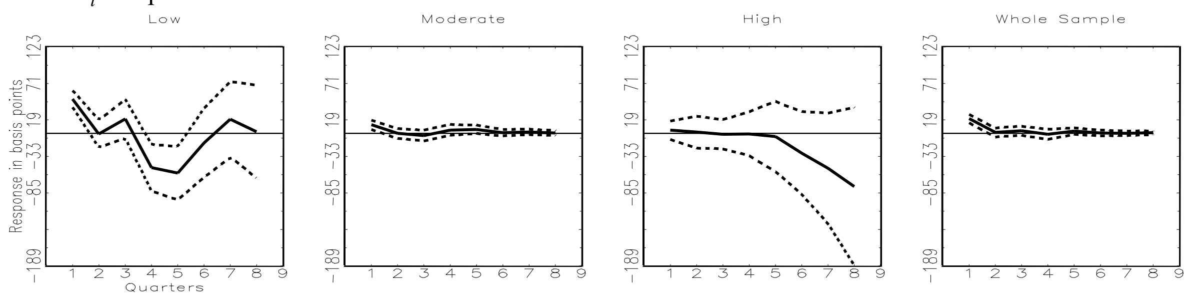
Figure 5. Responses of Real Activities in Model 3

A. With Consumption Growth

1. $\Delta \ln C_t$ Response

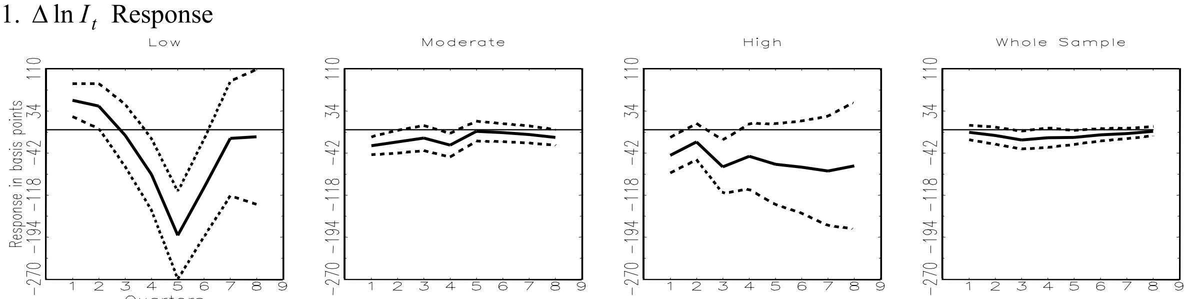


2. $\Delta \ln Y_t$ Response

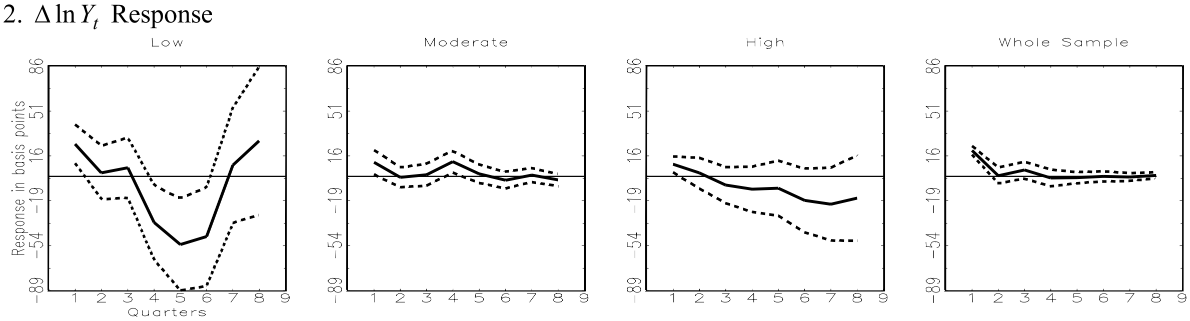


B. With Investment Growth

1. $\Delta \ln I_t$ Response



2. $\Delta \ln Y_t$ Response

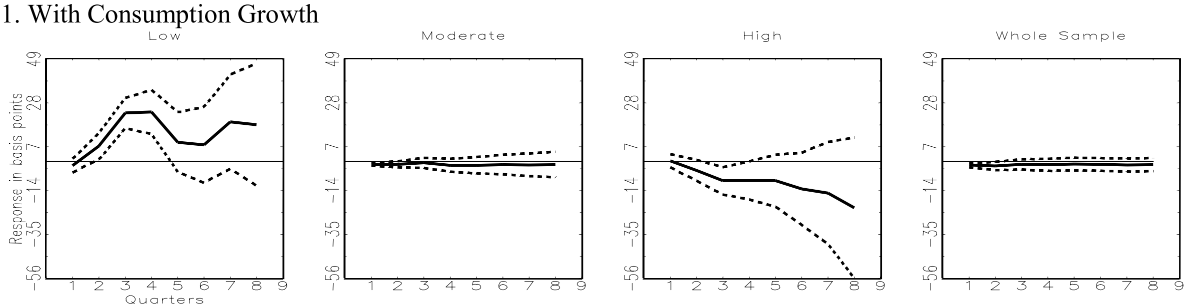


Notes: For Model 3 with consumption growth, estimated thresholds, (τ_L, τ_H), are (0.257, 3.705), and the number of sample observations are (34, 95, 36). For Model 3 with investment growth, estimated thresholds, (τ_L, τ_H), are (0.257, 3.395), and the number of sample observations are (34, 86, 45). Dashed lines are one-standard error bands.

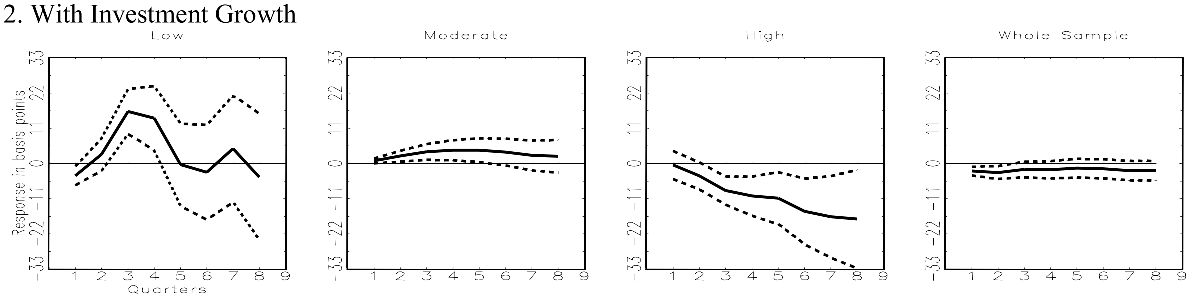
Figure 6. Responses of Nominal Interest Rates and Inflation

A. Nominal Interest Rates in Model 3

1. With Consumption Growth

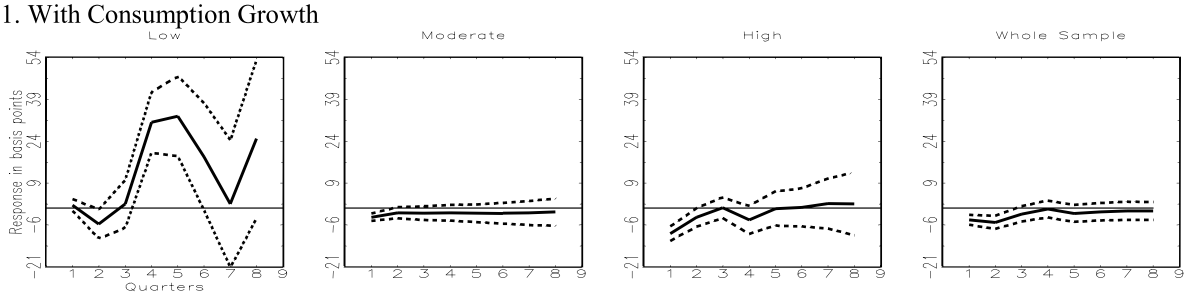


2. With Investment Growth

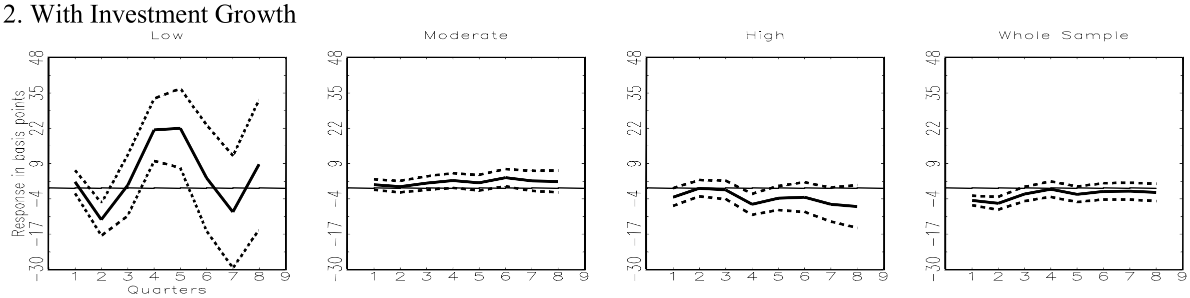


B. Inflation in Model 3

1. With Consumption Growth



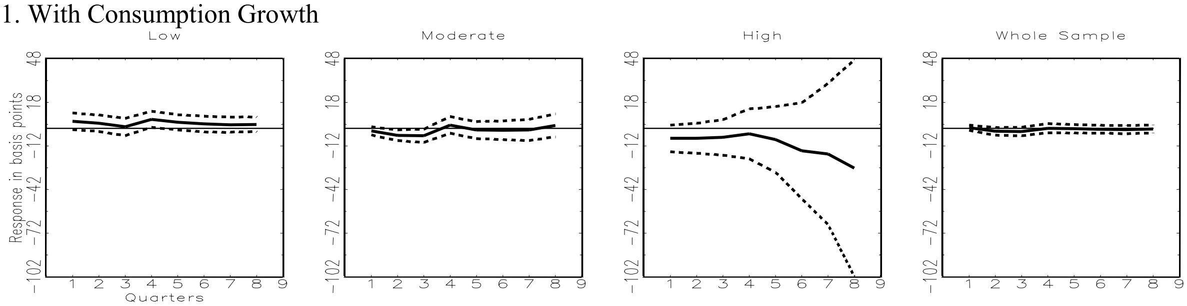
2. With Investment Growth



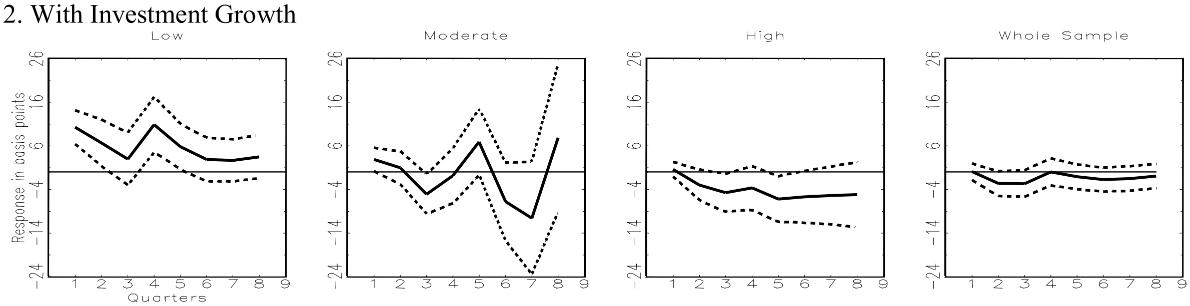
Notes: See notes to Figure 5.

Figure 7. Real Interest Rate Responses in Model 3′

1. With Consumption Growth



2. With Investment Growth

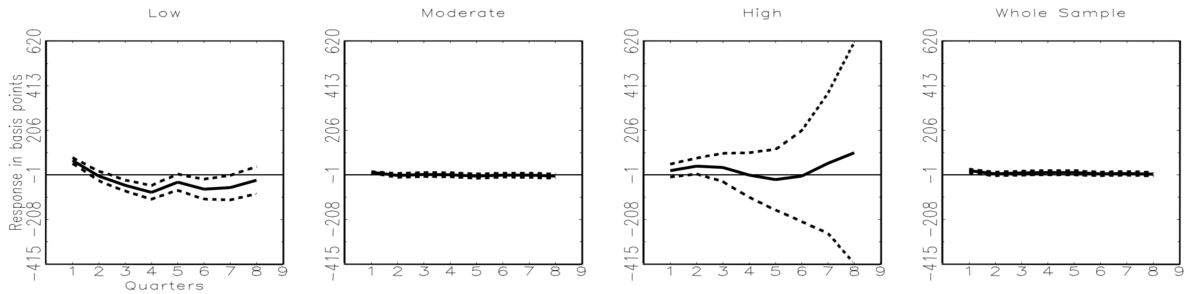


Notes: For Model 3′ with consumption growth, estimated thresholds, (τ_L, τ_H), are (1.398, 3.813), and the number of sample observations are (60, 70, 34). For Model 3′ with investment growth, estimated thresholds, (τ_L, τ_H), are (1.363, 2.641), and the number of sample observations are (59, 40, 65). Dashed lines are one-standard error bands.

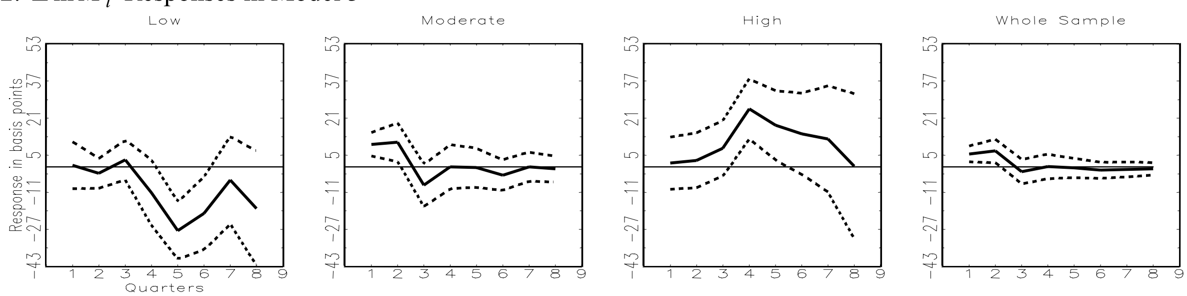
Figure 8. Responses of Financing Methods

A. With Consumption Growth

1. $\Delta \ln D_t$ Responses in Model 2

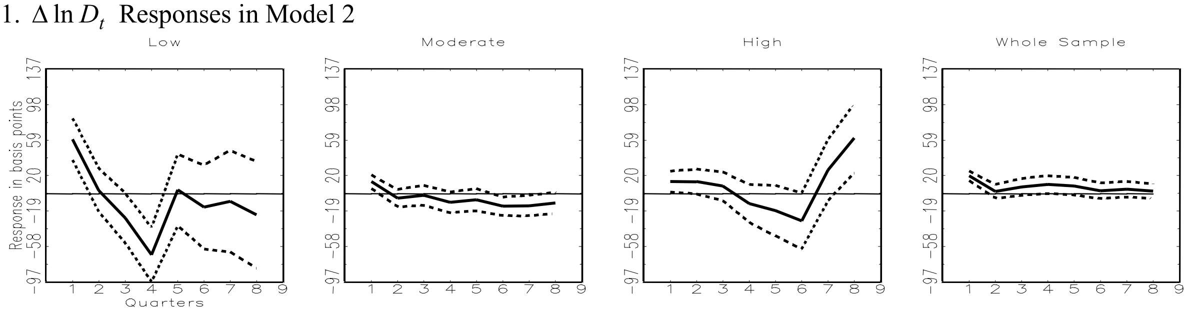


2. $\Delta \ln M_t$ Responses in Model 3

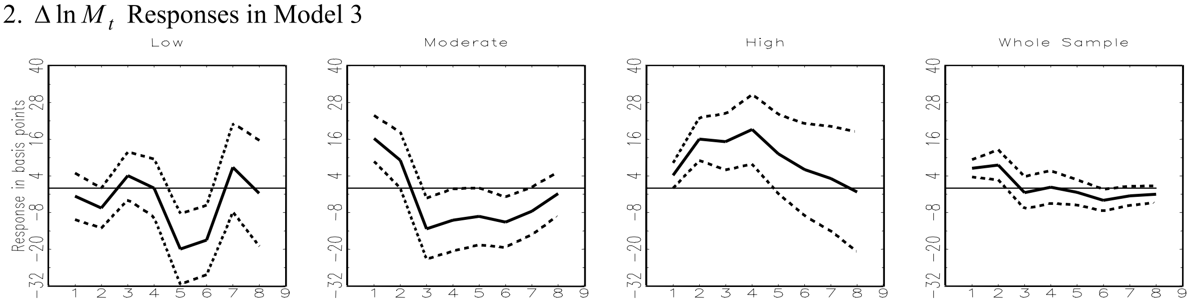


B. With Investment Growth

1. $\Delta \ln D_t$ Responses in Model 2



2. $\Delta \ln M_t$ Responses in Model 3



Notes: See notes to Figure 4 for rows 1 and 3 and notes to Figure 5 for rows 2 and 4.