Quantitative Effects of Fiscal Foresight

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Abstract

Changes in fiscal policy typically entail two kinds of lags: the legislative lag—between when legislation is proposed and when it is signed into law—and the implementation lag—from when a new fiscal law is enacted and when it takes effect. These lags imply that substantial time evolves between when news arrives about fiscal changes and when the changes actually take place—time when households and firms can adjust their behavior. We identify two types of fiscal news—government spending and changes in tax policy—and map the news processes into standard DSGE models. We identify news concerning taxes through the municipal bond market. If asset markets are efficient, the yield spread between tax-exempt municipal bonds and treasuries should be a function of the news concerning changes in tax policy. We identify news concerning government spending through the Survey of Professional Forecasters. We conclude that news concerning fiscal variables is a time-varying process. We also conclude that news can have qualitative and quantitative effects.

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1 Introduction

Through a variety of not easily quantified sources—news reports, television, the internet, word-of-mouth—economic agents acquire foresight about future variables that are important to their decisions. Forward-looking decision-makers react to this news even before the variables are realized.

Much of the recent work on foresight involves news about future changes in technology,[1] but fiscal policy provides a more tangible example. Changes in fiscal policy typically entail two kinds of lags: the legislative lag—between when legislation is proposed and when it is signed into law—and the implementation lag—from when a new fiscal law is enacted and when it takes effect. These lags imply that substantial time evolves between when news arrives about fiscal changes and when the changes actually take place—time when households and firms can adjust their behavior. Although researchers have recognized that economic agents might change their behavior in anticipation of not-yet-realized tax changes [Hall (1971), Judd (1985), Branson, Fraga, and Johnson (1986), Poterba (1988), Sims (1988), Leeper (1989)], the theoretical and empirical implications of such foresight are only beginning to be studied [Yang (2005), Kriwoluzky (2009), Leeper, Walker, and Yang (2008, 2009a), Mertens and Ravn (2008, 2009), Fisher and Peters (2009), Ramey (2009b), Schmitt-Grohé and Uribe (2008)].

Leeper, Walker, and Yang (2009a) and Leeper and Walker (2009) emphasize that the quantitative effects of foresight depend critically on the information process governing the news. In principle, when the information flows are modeled "correctly" and then embedded into a dynamic stochastic general equilibrium (DSGE) model, it is possible to obtain accurate qualitative predictions of the effects of fiscal news (conditional on the DSGE model). Fiscal foresight and "news shocks," however, are generally difficult to pin down. The news process imbedded into a DSGE model must be imposed by the modeler, and is therefore, prone to misspecification. Leeper and Walker (2009) show that slight modifications to information processes governing foresight can lead to substantial changes in equilibrium outcomes.

Fiscal foresight creates special problems for structural VARs because it can produce equilibrium time series with a non-fundamental moving average component that misaligns the agents' and the econometrician's information sets [Leeper, Walker, and Yang (2008)]. Difficulties associated with non-fundamental moving average representations in macro models were described by Hansen and Sargent (1980, 1991) and recently reiterated by Fernández-Villaverde, Rubio-Ramírez, Sargent, and Watson (2007). Economically meaningful shocks typically cannot be extracted from statistical innovations in conventional ways without making strong and unverifiable assumptions about information flows. Conventional econometric tools can yield false inferences by confounding shocks and incorrectly estimating dynamics. These difficulties suggest that one must be especially careful when examining foresight.

The primary contribution of the paper is to methodically construct a news process for fiscal foresight from data. We identify news about tax policy changes through the use of municipal bonds (see section 3.1). If asset markets are efficient, the yield spread between tax-exempt municipal bonds and treasury bonds should reflect the anticipated change in tax

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[1]For example, Beaudry and Portier (2006), Christiano, Ilut, Motto, and Rostagno (2008) Jaimovich and Rebelo (2009), Comin, Gertler, and Santacreu (2008), Fujiwara, Hirose, and Shintani (2008), Schmitt-Grohé and Uribe (2008), and Leeper and Walker (2009).

rates. We also identify news about changes in government spending following the approach described in Ramey (2009b,a). Ramey argues forcefully that at times significant changes in government spending are well anticipated. We use the Survey of Professional Forecasters to back out the amount of fiscal foresight contained in government spending. After characterizing these information flows as autoregressive moving-average processes, we feed the two sources of fiscal policy news into two canonical DSGE models. The paper makes the following additional contributions:

- We find that news concerning changes in fiscal policy is a time-varying process. There are periods in which agents have many quarters of foresight (e.g., wars, significant changes to the tax code). Over the time horizon that we examine, these "high foresight" periods are few and far between. Much of data consists of medium to low or no foresight. One consequence of this result is that models that do not take the time varying process of information flows into account will average away the effects of news. These studies might conclude that fiscal foresight is not relevant for explaining business cycle dynamics, but these models will not be able to assess the effects of fiscal foresight.

- We examine fiscal foresight in Braun's (1994) real business cycle model and Traum and Yang's (2010) new Keynesian model. These models are selected because they represent conventional models used for policy analysis and because they have been fit to U.S. data. We augment these models with foresight and find that foresight can have both quantitative and qualitative effects on short- and medium-run dynamics. Alternative news processes substantially alter equilibrium dynamics, underscoring the importance of accurately characterizing the stochastic processes governing fiscal news.

- We show how foresight interacts with common frictions imbedded in models to better fit data. Internal propagation mechanisms, such as habit formation, are shown to propagate the effects of foresight. For example, without habit formation, the effects of news about government spending or changes in tax policy are relatively short lived vis-á-vis the model that includes habit formation.

2 Two DSGE Models

In this section we briefly describe the real business cycle (RBC) model and new Keynesian (NK) model used in the analysis. The two models represent very different modeling strategies. Whereas the RBC model contains no frictions, the NK model includes investment adjustment costs, variable capital utilization rates, and sticky prices and wages. Stark differences in structure can imply very different impacts of fiscal news. In addition, the NK model contains more fiscal detail, government debt dynamics, and a specification of monetary policy behavior, which affect the transmission mechanism of fiscal news.

2.1 Real Business Cycle Model   Following Braun (1994), we employ a conventional real business cycle model with an elastic labor supply, additively-separable log preferences, and proportional taxes levied against both capital and labor earnings, which are used to finance government spending and transfers to households. Preferences over consumption and leisure are given by $E_0 \sum_{t=0}^{\infty} \beta^t [\ln c_t + \gamma_2 \ln(1 - \ell_t)]$, where $c_t = cp_t + \gamma_1 G_t$ and ℓ_t

denotes individual labor. Households derive utility from both private consumption, cp_t, and public consumption, G_t, where the relative weight is governed by γ_1. The household budget constraint is

$$cp_t + k_t \leq k_{t-1} + (1 - \tau_t^L)w_t\ell_t + (1 - \tau_t^L)(1 - \tau_t^K)(r_t - \delta)k_{t-1} + TR_t, \tag{1}$$

where k_t denotes the household's capital stock, r_t is the rental rate on capital, δ is the depreciation rate on capital, w_t is the wage rate, TR_t are transfers from the government to the household, and τ_t^L and τ_t^K are labor and capital taxes levied on the household. The unconventional specification for capital taxes reflects the presence of double taxation of capital income.

The firm maximizes profits subject to $Y_t = K_{t-1}^\theta (L_t z_t)^{1-\theta}$, where K_{t-1} and L_t denote the per capita capital stock and labor supply and z_t is a productivity shock that follows

$$\ln(z_t) = \ln(z_{t-1}) + \ln(\lambda_t),$$

where λ_t follows an AR(1) process.

The government budget constraint is

$$\tau_t^L w_t L_t + (\tau_t^L + \tau_t^K - \tau_t^L\tau_t^K)(r_t - \delta)K_{t-1} = G_t + TR_t. \tag{2}$$

We assume fiscal variables are governed by the following ARMA(1,q) processes:

$$\hat{\tau}_t^K = \rho_K \hat{\tau}_{t-1}^K + \sum_{i=0}^{q} \theta_i^K \varepsilon_{K,t-j} \tag{3}$$

$$\hat{\tau}_t^L = \rho_L \hat{\tau}_{t-1}^L + \sum_{i=0}^{q} \theta_i^L \varepsilon_{L,t-j} \tag{4}$$

$$\hat{G}_t = \rho_G \hat{G}_{t-1} + \sum_{i=0}^{q} \theta_i^G \varepsilon_{G,t-j}, \tag{5}$$

where a circumflex denotes log-deviations from the deterministic steady-state. The moving-average coefficients, the θ's, will be used to model the news process. We describe this in more detail in section 4.

2.2 New Keynesian Model

We adopt a conventional new Keynesian model based on Traum and Yang (2010) that incorporates several features that have become standard in the literature.

The model includes two types of households: savers, denoted by S, who have access to a complete set of contingent claims, and non-savers, denoted by N, who each period consume their entire disposable income. A fraction $\mu \in [0,1]$ of the population is savers and the remaining $1 - \mu$ fraction is non-savers. The continuum of agents have common preferences,

as represented by those of agent $j \in [0, 1]$

$$E_0 \sum_{t=0}^{\infty} \beta^t u_t^b \left[\frac{c_t^A(j)^{1-\gamma} - 1}{1 - \gamma} - \frac{L_t^A(j)^{1+\kappa}}{1 + \kappa} \right] \tag{6}$$

for $A \in \{S, N\}$, where $0 < \beta < 1$ is the household's discount rate, $\gamma \geq 0$ is the constant of relative risk-aversion, $\kappa \geq 0$ is the inverse of the Frisch labor supply elasticity, and u_t^b is a preference shock. $c_t^A(j)$ and $L_t^A(j)$ are, respectively, consumption of the final good and the quantity of labor supplied at time t by agent j. Each individual agent's labor input, $\ell \in [0, 1]$, is supplied in a monopolistically competitive setting. The total amount of labor supplied by household j satisfies $L_t^A(j) = \int_0^1 \ell_t^A(j, \ell) d\ell$, where $\ell_t^A(j, \ell)$ is the amount of labor supplied by agent j of type A.

The budget constraint for saver $j \in (0, 1 - \mu)$ is

$$H_t(j) + (1 - \tau_t^K) \frac{R_t^K v_t(j) k_{t-1}(j)}{P_t} + \frac{R_{t-1} b_{t-1}(j)}{\pi_t} = c_t^S(j) + \frac{i_t(j)}{1 + \tau_t^C} + b_t(j), \tag{7}$$

where $b_t(j)$ and $k_t(j)$ denote the level of nominal riskless government bonds and the stock of capital carried into period $t + 1$, P_t is the after-tax consumer price level, R_t and $\pi_t = P_t/P_{t-1}$ are the gross nominal interest rate on bonds purchased at time t and the gross inflation rate, and τ_t^L, τ_t^K, and τ_t^C are taxes levied against labor income, the return on capital, and consumption. The presence of consumption taxes distinguishes the producer price index, $\bar{P}$, from the consumer price index, $P_t = (1 + \tau_t^C) \bar{P}_t$. The term $H_t(j)$ represents individual j's human wealth (net labor income) and is given by

$$H_t(j) \equiv (1 - \tau_t^L) \int_0^l \frac{W_t(\ell)}{P_t} \ell_t^S(j, \ell) d\ell + z_t(j) + d_t(j), \tag{8}$$

where $W_t(\ell)$ is the nominal wage for labor type ℓ, $z_t(j)$ are government transfers, and $d_t(j)$ denotes the share of nominal firm profits received in the form of dividends by agent j. The law of motion for capital is given by

$$k_t(j) = (1 - \delta[v_t(j)]) k_{t-1}(j) + \left[1 - s \left(\frac{u_t^i i_t(j)}{i_{t-1}(j)} \right) \right] i_t(j), \tag{9}$$

where u_t^i is an exogenous efficiency shock and $s(\cdot)$ is the investment adjustment cost function that satisfies the properties $s(1) = s'(1) = 0$ and $s''(1) \equiv s > 0$. The depreciation rate, δ, is positively related to the utilization rate, v_t, and is given by

$$\delta[v_t(j)] = \delta_0 + \delta_1(v_t(j) - 1) + \frac{\delta_2}{2}(v_t(j) - 1)^2, \tag{10}$$

where δ_0, δ_1, and δ_2 are calibrated parameters[2].

The budget constraint for non-saver $j \in (1 - \mu, 1]$, who does not have access to asset

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[2]δ_1 is calibrated so that $v = 1$ in steady-state. The parameter $\psi \in [0, 1)$ is defined so that $\delta''(1)/\delta'(1) = \delta_2/\delta_1 \equiv \psi/(1 - \psi)$.

markets, is

$$c_t^N(j) = (1 - \tau_t^L) \int_0^1 \frac{W_t(\ell)}{P-t} \ell_t^N(j,\ell)d\ell + z_t(j). \tag{11}$$

Aggregate demand for labor services is not biased toward a certain labor type, A. Therefore, in equilibrium the total supply of labor services by savers and non-savers is identical. Specifically, $L_t^S(j) = L_t^N(j) = \int_0^1 \ell_t(\ell)d\ell \equiv L_t$. A labor clearinghouse purchases the differentiated labor inputs and groups them in order to generate a composite labor service, L_t, according to the following CES production function

$$L_t = \left[\int_0^1 l_t(l)^{\frac{1}{1+\eta_t^w}} dl \right]^{1+\eta_t^w}, \tag{12}$$

where η_t^w denotes a time-varying exogenous markup to wages. Maximizing profits for a given level of labor yields the following demand function for a particular labor input

$$l_t(l) = L_t^d \left(\frac{W_t(l)}{W_t} \right)^{-\frac{1+\eta_t^w}{\eta_t^w}}, \tag{13}$$

where L_t^d represents the demand for composite labor services and $\psi^w \equiv (1 + \eta_t^w)/\eta_t^w$ is the elasticity of substitution between inputs.

The production sector consists of monopolistically competitive intermediate goods producing firms who produce a continuum of differentiated inputs and a representative final goods producing firm. Each firm $i \in [0,1]$ in the intermediate goods sector produces a differentiated good, $y_t(i)$, with identical technologies given by

$$y_t(i) = u_t^a (v_t k_{t-1}(i))^\alpha (\ell_t(i))^{1-\alpha} (K_{t-1}^G)^{\alpha^G}, \tag{14}$$

where $k_t(i)$ and $\ell_t(i)$ denote the capital stock and level of employment used by firm i, $\alpha \in [0,1]$ is the cost share of capital, and α^G is the elasticity of output with respect to the stock of government capital K_{t-1}^G.

A representative final goods producing firm purchases inputs from the intermediate goods producing firms in order to produce a composite good, Y_t, according to the CES technology

$$Y_t = \left[\int_0^1 y_t(i)^{\frac{1}{1+\eta_t^p}} di \right]^{1+\eta_t^p}, \tag{15}$$

where η_t^p denotes an exogenous time-varying markup to the intermediate goods' prices. Maximizing profits for a given level of output yields firm i's demand function for intermediate inputs

$$y_t(i) = Y_t \left(\frac{\bar{p}_t(i)}{\bar{P}} \right)^{-\frac{1+\eta_t^p}{\eta_t^p}}, \tag{16}$$

where $\bar{p}_t$ is the price of intermediate good i, $\bar{P}_t$ is the price of the final good, and $\psi^p \equiv (1 + \eta_t^p)/\eta_t^p$ is the elasticity of substitution between intermediate goods.

Both wages and prices adjust according to a Calvo pricing mechanism. Each period, a union has the opportunity to adjust the nominal wage rate with probability $(1 - \omega_w)$. In the event that the union does not receive a pricing signal, wages are indexed to inflation according to the rule

$$W_t(l) = W_{t-1}(l)\pi_{t-1}^{\chi^w}, \tag{17}$$

where χ^w parameterizes the degree of wage indexation. If, on the other hand, a union is fortunate enough to be able to freely adjust the nominal wage rate, it chooses the optimal wage rate, $\widetilde{W}_t(\ell)$, to maximize the lifetime utility of households given by

$$E_t \sum_{i=0}^{\infty}(\beta\omega_w)^i \left\{ u_{t+i}^b \left[(1-\mu)\frac{(c_{t+i}^S)^{1-\gamma}-1}{1-\gamma} + \mu\frac{(c_{t+i}^N)^{1-\gamma}-1}{1-\gamma} - \frac{L_{t+i}^{1+\kappa}}{1+\kappa} \right] \right\}, \tag{18}$$

subject to the aggregate budget constraints for both savers and non-savers and the individual and aggregate labor demand functions. In a symmetric equilibrium, where $\widetilde{W}_t(\ell) = \widetilde{W}_t$, the aggregate nominal wage is

$$W_t = \left[(1-\omega_w)\widetilde{W}^{-\frac{1}{\eta_t^w}} + \omega_w(\pi_{t-1}^w)^{-\frac{\chi_w}{\eta_t^w}} W_{t-1}^{-\frac{1}{\eta_t^w}} \right]^{-\eta_t^w}, \tag{19}$$

where $\pi_t^w = W_t/W_{t-1}$ is the gross wage inflation rate.

Similarly, each intermediate goods producing firm may reset its price only with probability $(1 - \omega_p)$ in any given period. Firms that are unable to make optimal adjustments simply index their price level to past inflation by setting

$$\bar{p}_t(i) = \bar{p}_{t-1}(i)\bar{\pi}_{t-1}^{\chi_p}, \tag{20}$$

where χ^w parameterizes the degree of price indexation. Firms that are able to make optimal adjustments to their price level choose their price level, $\bar{p}_t(i)$, to maximize the sum of discounted future profits. In a symmetric equilibrium, where $\bar{p}_t(i) = \bar{p}_t$, the producer price index, $\bar{P}_t$, evolves according to

$$\bar{P}_t = \left[(1-\omega_p)\bar{p}_t^{-\frac{1}{\eta_t^p}} + \omega_p\bar{\pi}_{t-1}^{-\frac{\chi_p}{\eta_t^p}} \bar{P}_{t-1}^{-\frac{1}{\eta_t^p}} \right]^{-\eta_t^p}. \tag{21}$$

The fiscal authority finances government consumption, G_t, government investment, G_t^I, and government transfers, Z_t, through proportional taxes levied against consumption, labor income, and capital returns and by issuing one-period nominal debt. The government's flow budget constraint is

$$B_t + \tau_t^K \frac{R_t^K}{P_t}v_t K_{t-1} + \tau_t^L \frac{W_t}{P_t}L_t + \frac{\tau_t^C}{1+\tau_t^C}C_t = \frac{R_{t-1}B_{t-1}}{\pi_t} + G_t + G_t^l + Z_t. \tag{22}$$

Productive government capital evolves according to

$$K_t^G = (1 - \delta^G)K_{t-1}^G + G_t^I. \tag{23}$$

Fiscal variables are governed by the following processes

$$\hat{\tau}_t^K = \rho_K \hat{\tau}_{t-1}^K + (1 - \rho_K)\left(\varphi_K \hat{Y}_t + \gamma_K \hat{s}_{t-1}^b\right) + \phi_{KL}\sigma_L \varepsilon_t^L + \sum_{i=0}^q \theta_i^K \varepsilon_{K,t-i} \tag{24}$$

$$\hat{\tau}_t^L = \rho_L \hat{\tau}_{t-1}^L + (1 - \rho_L)\left(\varphi_L \hat{Y}_t + \gamma_L \hat{s}_{t-1}^b\right) + \phi_{KL}\sigma_K \varepsilon_t^K + \sum_{i=0}^q \theta_i^L \varepsilon_{L,t-i} \tag{25}$$

$$\hat{G}_t = \rho_G \hat{G}_{t-1} - (1 - \rho_G)\gamma_G \hat{s}_{t-1}^b + \sigma_G \varepsilon_t^G + \sum_{i=0}^q \theta_i^G \varepsilon_{G,t-i} \tag{26}$$

$$\hat{G}_t^I = \rho_{GI} \hat{G}_{t-1}^I - (1 - \rho_{GI})\gamma_{GI} \hat{s}_{t-1}^b + \sigma_{GI}\varepsilon_t^{GI} \tag{27}$$

$$\hat{Z}_t = \rho_Z \hat{Z}_{t-1} - (1 - \rho_Z)\gamma_Z \hat{s}_{t-1}^b + \sigma_Z \varepsilon_t^Z \tag{28}$$

$$\hat{\tau}_t^C = \rho_C \hat{\tau}_{t-1}^C + \sigma_C \varepsilon_t^C, \tag{29}$$

where $s_{t-1}^b \equiv B_{t-1}/Y_{t-1}$ and $\varepsilon_t^s \sim i.i.d.\ N(0,1)$ for $s \in \{K, L, GC, GI, C, Z\}$.

The monetary authority sets interest rate policy according to the following Taylor-type rule

$$\hat{R}_t = \rho_r \hat{R}_{t-1} + (1 - \rho_r)\left[\phi_\pi \hat{\pi}_t + \phi_y \hat{Y}_t\right] + \sigma^m \epsilon_t^m, \quad \epsilon_t^m \sim N(0,1), \tag{30}$$

so that the nominal interest rate adjusts in response to fluctuations in both output and inflation.

For a generic variable x_t, its aggregate counterpart is given by X_t. Aggregate consumption, which is composed of consumption by both savers and non-savers is given by

$$C_t = \int_0^1 c_t(j)dj = (1 - \mu)c_t^S + \mu c_t^N.$$

Lump-sum transfers are identical across households so that

$$Z_t = \int_0^1 z_t(j)dj = z_t.$$

Since non-savers do not have access to asset markets, the aggregate levels of bonds, investment, capital, and dividends are given by

$$B_t = \int_0^1 b_t(j)dj = (1 - \mu)b_t, \quad K_t = \int_0^1 k_t(j)dj = (1 - \mu)k_t,$$

$$I_t = \int_0^1 i_t(j)dj = (1 - \mu)i_t, \quad D_t = \int_0^1 d_t(j)dj = (1 - \mu)d_t.$$

The remaining exogenous disturbances follow AR(1) processes given by

$$\hat{u}_t^x = \rho_x \hat{u}_{t-1}^x + \sigma_x \varepsilon_t^x, \quad \varepsilon_t^x \sim N(0,1), \quad 0 < \rho_x < 1$$

for $x \in \{b, i, w, p, a\}$. To close the model, the aggregate resource constraint is

$$Y_t = C_t + I_t + G_t + G_t^I. \tag{31}$$

3 IDENTIFICATION OF FISCAL FORESIGHT

One of the main contributions of the paper is the identification of fiscal foresight through various empirical sources. We back out foresight with respect to changes in tax policy via the municipal bond market. We use data from the Survey of Professional Forecasters and Ramey (2009b) to identify foresight about government spending. Section 4 describes the mapping of the foresight into the DSGE model.

3.1 IDENTIFICATION OF TAX FORESIGHT   If markets are efficient, asset prices reflect all information currently available to market participants, especially news concerning the future paths of relevant variables. This hypothesis led Beaudry and Portier (2006) to include stock prices in a VAR in order to capture agents' expectations about future changes in productivity, while Fisher and Peters (2009) use stock prices to identify news about government spending. Due to the preferential tax treatment of municipal bonds, financial variables can also be used to extract the degree of tax foresight.

In the United States, municipal bonds are exempt from federal taxes.[3] The differential treatment of municipal and treasury bonds has useful implications for identifying news about tax changes. If $\mathcal{Y}_t^M$ is the yield on a municipal bond at t and $\mathcal{Y}_t$ the yield on a taxable bond, and assuming the bonds have the same term to maturity, callability, market risk, credit risk, and so forth, then an "implicit tax rate" is given by $\tau_t^I = 1 - \mathcal{Y}_t^M/\mathcal{Y}_t$. This is the tax rate at which the investor is indifferent between the tax-exempt and taxable bond. If participants in the municipal bond market are forward looking, the implicit tax rate should predict subsequent movements in individual tax rates.[4]

Newly issued tax-exempt bonds with maturity T, par value of \$1, and per-period coupon payments, C_M, will sell at par if

$$1 = \frac{C^M}{\sum_{t=1}^{T}(1 + R_t^\tau)^t} + \frac{1}{(1 + R_T^\tau)^T}, \tag{32}$$

where R_t^τ is the *after-tax* nominal interest rate for after-tax payments made in period t. No arbitrage conditions imply that a taxable bond with a similar maturity structure, paying

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[3]Depending upon the type of bond, municipal bonds can also be exempt from the Alternative Minimum Tax, state, and local taxes. See Richter and Walker (2010) for a thorough description of the municipal bond market.

[4]Several papers, using event study methodology, document the ability of the municipal bond market to forecast changes in fiscal policy [see, Poterba (1989), Fortune (1996), Park (1997), Richter and Walker (2010)].

coupon C, and selling at par will satisfy

$$1 = \frac{\sum_{t=1}^{T} C(1 - \tau_t^e)}{\sum_{t=1}^{T} (1 + R_t^\tau)^t} + \frac{1}{(1 + R_T^\tau)^T},\tag{33}$$

where τ_t^e is the future tax rate expected to hold in period t.

If bonds sell at par, then the yield-to-maturity is equal to the coupon payments. Therefore, the implicit tax rate at time T is given by $\tau_T^I = 1 - C_M/C$. Subtracting (33) from (32) and solving for C_M/C gives

$$1 - \tau_T^I = \sum_{t=1}^{T} \omega_t (1 - \tau_t^e),\tag{34}$$

where $\omega_t = \delta_t / \sum_{t=1}^{T} \delta_t$ and $\delta_t = (1 + R_t^\tau)^{-t}$. Because the ω weights sum to unity, the implicit tax rate at T is the weighted average of discounted expected future tax rates from $t = 1$ to T. We can use this expression to back out the average expected future tax rate between periods s and t

$$\tau_{s,t}^e = \frac{\tau_t^I \sum_{i=1}^{t} \delta_i - \tau_s^I \sum_{i=1}^{s} \delta_i}{\sum_{j=s+1}^{t} \delta_i}.\tag{35}$$

As described in Kochin and Parks (1988), the forward tax rate for the interval between periods s and t is a weighted average of the forward tax rates for that interval, with weights equal to the normalized discount factors for payments in that interval. In an environment with no change in tax policy and perfect information, we would expect these rates to be similar across maturity lengths.

Given that we have bond yields at various maturity lengths (see the data description in Appendix D), it is possible to use the municipal bond yield curve as a measure of the expected *path* of tax rates. Implicit tax rates over two different maturity lengths yield a time series of implied forward tax rates. Figures 1 and 2 plot the path of expected future tax rates for bonds with maturity lengths of 1 and 5 years from 1954 to 2005. The shaded regions correspond to the total legislative lags, documented in Yang (2008).[5] Substantial movements in the implicit forward tax rates that occur within the shaded regions indicate that there is significant news about future tax policy that arrives before the legislation is passed. In principle, this news provides agents with some degree of tax foresight.

The Tax Reform Act of 1986 provides the clearest example of the information content of implicit forward tax rates.[6] Over a 1-year time horizon, the response is relatively small, since the policy was phased in over several years. However, average expected future tax rates over a five-year time horizon correspond perfectly to the legislative lag, as the peak expectation coincides with the announcement of the policy and the trough expectation coincides with the implementation of the legislation. By the time the tax reform actually took effect, agents

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[5]Note that the differences in shading have no meaning except to differentiate between tax events.

[6]This outcome is not surprising, given Auerbach and Slemrod's (1997) evidence of how economic behavior adjusted during the long legislative and implementation processes associated with this act.

had factored the entire effect of the policy into their expectations of taxes over the next five years by the time the legislation was passed. Although not all tax events are well aligned with agents' expectations, over shorter time horizons implicit forward tax rates are generally far more responsive to proposed tax legislation than over longer time horizons.

One potential reason why the implicit tax rates do not correspond one-for-one with changes in tax policy is because risk must be taken into account when constructing the yield spreads between treasuries and municipal bonds. Differences in credit risk, call features, duration, underlying collateral, *etc.* all imply that investors would require a premium for holding municipal bonds. Fortune (1996) introduces a time-invariant "quality premium", θ, in the relationship between yields on municipal bonds and treasuries. The risk-adjusted implicit tax rate is then

$$\tau_t^{RI} = 1 - \frac{\mathcal{Y}_t^M + \theta}{\mathcal{Y}_t}. \tag{36}$$

In order to determine how well the risk-adjusted implicit tax rate forecasts changes in tax rates, we follow Fortune (1996) in constructing an ex-post tax rate. Let τ_{t+i} denote the representative agent's tax rate in period $t+i$. Given that coupons are typically paid semi-annually, we construct a series of future tax rates at semi-annual frequency, $\tau_{t+6}, \tau_{t+12}, \tau_{t+18}, ..., \tau_{t+6n}$, with t being the spot date and n the number of semiannual periods to maturity. The ex-post tax rates are constructed from the known statutory tax rates over the period to maturity,

$$T_t = \sum_{i=1}^{N} \omega_i \tau_{t+6i},$$

where the weights are defined as above.

To determine how well municipal bonds forecast changes in tax rates, Fortune decomposes the ex-post tax rate into a convex combination of the risk-adjusted implicit tax rate, τ_t^{RI}, and the spot tax rate, τ_t, along with a forecast error

$$T_t = \alpha_1^\tau \tau_t^{RI} + (1 - \alpha_1^\tau)\tau_t + \varepsilon_t. \tag{37}$$

The optimal weight given to each component depends upon the degree to which that component helps in predicting changes in ex-post tax rates. Let $\zeta_{\tau^{RI}}$ denote the forecast error from predicting changes in the ex-post tax rate conditioning on the risk-adjusted implicit tax rate, $\zeta_{\tau^{RI}} = T_t - \tau_t^{RI}$. Let ζ_τ denote the forecast error from predicting changes in the ex-post tax rate conditioning on the spot tax rate alone, $\zeta_\tau = T_t - \tau_t$. The composite forecast error is given by the convex combination of the two, $\varepsilon_t = \alpha_1^\tau \zeta_{\tau^{RI}} + (1 - \alpha_1^\tau)\zeta_\tau$. The optimal weight, α_1, is chosen so as to minimize the variance of the forecast error. This weight is given by

$$\alpha_1^\tau = \frac{\sigma_{\zeta_\tau}^2}{\sigma_{\zeta_\tau}^2 + \sigma_{\zeta_{\tau^{RI}}}^2}. \tag{38}$$

where $\sigma_{\zeta_\tau}^2$ and $\sigma_{\zeta_{\tau^{RI}}}^2$ are the variances of the forecast errors ζ_τ and $\zeta_{\tau^{RI}}$, respectively. Thus, more weight is given to the variable that has the smaller forecast error variance. For example,

if agents have perfect foresight (that is, if agents knew exactly what their tax rates were going to be through period N) and markets are efficient, the variance of the forecast error conditional on the implicit tax rate $\sigma^2_{\zeta_{\tau RI}}$ would be zero and α^τ_1 would be set to unity.

Substituting (36) into (37) and re-arranging gives

$$T_t - \tau_t = \alpha^\tau_1(\tau^I_t - \tau_t) + \alpha^\tau_2(1/\mathcal{Y}_t) + \varepsilon_t, \tag{39}$$

where α^τ_1 measures the information content of municipal bonds and $\alpha^\tau_2 = -\alpha^\tau_1\theta$ measures the risk premium.

Table 1 displays the results of the estimation of (39) using marginal income tax rates for married individuals filing joint returns collect from Internal Revenue Service publications and the Tax Policy Center. The series of actual and ex post tax rates were constructed using the maximum tax rates and marginal tax rates for investors earning \$100,000, \$75,000, and \$50,000 annually in constant 1980 dollars. The yields to maturity are taken from tax-exempt prime-grade general-obligation municipal bonds obtained from Salomon Brothers' Analytical Record of Yields and Yield Spreads for maturity lengths of 1, 5 and 10 years.[7] As the table reports, the information parameter α^τ_1 is of the correct sign and statistically significant for all maturity lengths and income groups, suggesting that the information parameter contains relevant news about future tax rates. Not surprisingly, the information content of implicit tax rates is greatest for agents who face the highest marginal tax rates. The risk premium parameter α^τ_2 is also positive across most maturity lengths.

In order to capture the time varying nature of the information content contained in municipal bonds and allow for time-varying risk premia, Fortune (1996) estimates a version of (39) in which the coefficients vary with time according to a random walk specification

$$\alpha^\tau_{j,t} = \alpha^\tau_{j,t-1} + \eta_t, \qquad j = 1, 2, \qquad \eta \sim N(0, \Delta^2). \tag{40}$$

The standard deviation of the information parameter and risk premium will give an indication of the amount of time variation in these parameters. Equations (40) and (39) form a state-space representation for which the Kalman filter can be used to estimate the model.

Table 2 reports the estimation allowing for time-varying parameter values. Notice that the standard deviation is largest for the information parameter (δ_1). This suggests that the information content of municipal bonds, and hence foresight with respect to tax policy, is very much a time-varying process. Figure 4, which plots the predicted path of the information parameter, based on the marginal tax rate for an individual earning \$75,000 in constant 1980 dollars, also demonstrates this point. For the decade of the 1970s, the information contained in municipal bonds is nearly negligible relative to the 1980s. The spikes in the information parameter correspond to the Economic Recovery Tax Act of 1981 and the Tax Reform Act of 1986.

3.2 Identification of Government Spending Foresight
To identify foresight with respect to government spending we follow Ramey (2009b) in using the Survey of Professional

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[7]Following Fortune (1996), we also include a dummy variable for the 1986 Tax Reform Act (TRA). This dummy variable is included to account for the significant change in the market structure of the municipal bond market caused by the TRA (see Richter and Walker (2010)).

Forecasters (SPF) conducted by the Federal Reserve Bank of Philadelphia. The data we examine are mean *forecasts* of real federal government consumption and gross investment from 1981Q1 to 2010Q1 over one, two, three, four, and five quarter horizons. Data on quarterly nominal federal government consumption and gross investment spending from 1981Q1 to 2010Q1 are obtained from the National Income and Product Accounts, published by the Bureau of Economic Analysis (BEA). A real series of federal government consumption expenditures and gross investment in chained 2005 dollars (RGFED) was generated using the component-specific real GDP quantity index (QI) [BEA Table 1.1.3, line 22] and annual component-specific nominal GDP (NGFED) [BEA Table 1.1.5, line 22]. Appendix D contains a complete description of the data.

Ramey (2009b) (and references therein) provides ample empirical evidence for foresight with respect to government spending. Among other tests, she finds that one- and four-quarter ahead Professional Forecasts Granger cause VAR shocks. Using data from 1939 to 2008, she also finds that a "defense news" variable corresponding to major war dates has significant explanatory power in forecasting changes in government and defense spending. Figure 3 plots real government spending along with Ramey's war dates. As is evident from this picture, defense news is predominately followed by stark changes in government consumption and investment expenditures.

Similar to the analysis for tax foresight, we assume that forecasts of government spending can be decomposed into two components

$$G_{t+j} = \alpha_t^G G_{t+j|t} + (1 - \alpha_t^G)\rho_G^j G_t + \varepsilon_t \qquad \text{for } j = 1, ..., 5 \tag{41}$$

$$\alpha_t^G = \alpha_{t-1}^G + \eta_t^G, \qquad \eta \sim N(0, \Delta^2). \tag{42}$$

The first component, $G_{t+j|t}$, is the SPF forecast of government spending at time $t + j$ conditional on time t information. The SPF provides forecasts for real government spending 1 through 5 quarters ahead. The second component assumes an AR(1) process for government spending similar to (5). We fit the AR(1) model to the real government spending series described in Appendix D. Analogous to the tax foresight case and (38), α^G will be determined by whichever forecast has the smaller forecast error variance. Specification (41) implicitly assumes that forecasts from the SPF contain more information about changes in government spending than can be extracted from in-sample AR(1) forecasting rules.

As with tax foresight, we allow the information parameter for government spending to be a time-varying process. Figure 5 plots the α_t^G parameter for $j = 1, 2, 3$ from 1980 through 2009. The estimation reveals that news about government spending is also a time-varying process. The increase in the information parameter throughout the decade of 2000 is consistent with the increase in the frequency of defense spending events documented by Ramey, figure 3.

4 Mapping of News into DSGE Models

There are two dimensions to fiscal foresight–horizon and intensity. Foresight horizon is a measure of how far in advance agents are aware of potential changes to fiscal policy. Foresight intensity measures how confident agents are about pending changes to fiscal variables.

As an example of foresight horizon, consider changes to the tax code. The foresight

horizon would include both the legislative lag, the time when legislation is first proposed, and the implementation lag–and could be much longer than the sum of the two lags. For example leading up to the 1980 presidential election, then candidate Reagan made a campaign promise to overhaul the tax code if elected. Even though a low probability event at the time, agents would have placed positive probability a decrease in tax rates which would have preceded the legislative lag by several years.

An example of foresight intensity pertaining to government spending is the recently enacted American Recovery and Reinvestment Act of 2009. Prior to the passage of the bill agents did not know the size or composition of the anticipated government spending. Table 3 taken from Leeper, Walker, and Yang (2009b) contains the Congressional Budget Office's estimates of costs and outlays associated with two pieces of legislation involving government investment. Based on historical spending rates, the CBO assumes that outlays for government investment take place over several years following the authorization. For the ARRA, Congress authorized \$27.5 billion for highway construction in 2009, yet the estimated outlays are only \$2.75 billion for fiscal year 2009. Another example is the National Highway Bridge Reconstruction and Inspection Act of 2008, which was not enacted but would have authorized appropriations of about \$1 billion in fiscal year 2009 for repairing, rehabilitating, and replacing bridges on public roadways. Outlays associated with this legislation were planned to extend more than four years into the future. Due to the differences between outlays and authorized spending, agents have a precise measure of the projected increase in government spending that can be attributed to the ARRA over the next several years.

To map the degree of fiscal foresight into the DSGE models, we calibrate the moving-average coefficients in the tax and government spending processes to match the foresight intensity and horizon of several episodes in recent U.S. history. As an illustrative example of this mapping, consider the following moving-average representation for tax rates

$$\tau_t = \varepsilon_{t-1} - \theta \varepsilon_t. \tag{43}$$

If $|\theta| < 1$, then (43) is a non-fundamental moving-average representation, and the space spanned by current and past tax rates $\{\tau_{t-j}\}_{j=0}^{\infty}$ is smaller than the space spanned by the structural innovations, $\{\varepsilon_{t-j}\}_{j=0}^{\infty}$.

One consequence of this result is that the variance of the one-step-ahead forecast error for agents conditioning on structural innovations is smaller than the forecast error variance for agents conditioning *only* on current and past tax rates. To show this analytically we must derive the Wold representation of (43), which is given by[8]

$$\tau_t = \tilde{\varepsilon}_t - \theta \tilde{\varepsilon}_{t-1} \tag{44}$$

$$\tilde{\varepsilon}_t = \left[\frac{L - \theta}{1 - \theta L} \right] \varepsilon_t. \tag{45}$$

Representation (44) shows that current and past τ_t span an equivalent space to current and past $\tilde{\varepsilon}_t$, which is a strictly smaller space than ε_t. The variance of the one-step-ahead forecast

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[8]See Leeper, Walker, and Yang (2009a) for a more detailed derivation.

error using representation (44) is given by

$$E\{\tau_{t+1} - E[\tau_{t+1}|\{\tau_{t-j}\}_{j=0}^{\infty}]\}^2 = \sigma_{\tilde{\varepsilon}}^2 = \sigma_{\varepsilon}^2 \qquad (46)$$

where the last equality follows because the term, $\frac{L-\theta}{1-\theta L}$, known as a Blaschke factor, has unit modulus (see Lippi and Reichlin (1994)) and hence $\text{var}(\varepsilon_t) = \text{var}(\tilde{\varepsilon}) = \sigma_{\varepsilon}^2$.

Suppose now that agents are able to condition on current and past structural innovations directly. These agents are able to use (43) to forecast next period's tax rate. The variance of the forecast error for this process is given by

$$E\{\tau_{t+1} - E[\tau_{t+1}|\{\varepsilon_{t-j}\}_{j=0}^{\infty}]\}^2 = \theta^2 \sigma_{\varepsilon}^2 \qquad (47)$$

Comparing this forecast error variance with (46) shows that the MA coefficient θ determines the degree to which agents conditioning on the structural shocks are better informed. As $\theta \to 0$, agents who observe the structural innovations have perfect one-step-ahead foresight in the sense that they observe $\varepsilon_t = \tau_{t+1}$ and the corresponding forecast error is zero. As $\theta \to 1$, the information sets and the variance of forecast errors converge. Therefore calibrating the moving-average parameter θ is tantamount to calibrating the intensity of foresight available to agents.

We are then able to back out the corresponding MA coefficients by equating the variance the forecast errors from the DSGE model with the reduced form estimates from section 3. Note that the *reduction* in the variance of the forecast error by conditioning on the risk-adjusted implicit tax rate is given by the ratio

$$\frac{E\{\tau_{t+1} - E[\tau_{t+1}|\{\tau_{t-j}\}_{j=0}^{\infty}]\}^2}{E\{\tau_{t+1} - E[\tau_{t+1}|\{\tau_{t-j}\}_{j=0}^{\infty}, \{\tau_{t-j}^{RI}\}_{j=0}^{\infty}]\}^2} = \frac{\sigma_{\zeta_\tau}^2}{\alpha^2 \sigma_{\zeta_{\tau^*}}^2 + (1-\alpha)^2 \sigma_{\zeta_\tau}^2} = (1-\alpha)^{-1} \qquad (48)$$

Our definition of foresight equates conditioning on the implicit tax rate in section 3 with conditioning on the structural shocks in the DSGE models. Therefore the mapping between the information parameter α and the MA coefficient θ is determined by

$$\frac{E\{\tau_{t+1} - E[\tau_{t+1}|\{\tau_{t-j}\}_{j=0}^{\infty}, \{\tau_{t-j}^{RI}\}_{j=0}^{\infty}]\}^2}{E\{\tau_{t+1} - E[\tau_{t+1}|\{\tau_{t-j}\}_{j=0}^{\infty}]\}^2} = 1 - \alpha = \theta^2 = \frac{E\{\tau_{t+1} - E[\tau_{t+1}|\{\varepsilon_{t-j}\}_{j=0}^{\infty}]\}^2}{E\{\tau_{t+1} - E[\tau_{t+1}|\{\tau_{t-j}\}_{j=0}^{\infty}]\}^2} \qquad (49)$$

As the implicit tax rate becomes a perfect predictor of future tax changes $\alpha \to 1$, which delivers $\theta \to 0$, implying perfect one-step-ahead foresight. Therefore, estimates of the information parameters α_1^τ and α_1^G will pin down foresight intensity–the reduction in the forecast error variance due to fiscal foresight.

We are able to match the foresight horizon through the functional form of the MA representation. For example, if agents have two quarters of foresight then the fiscal rules must have two MA coefficients, $\tau_t = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2}$. By observing the structural shocks, agents will have knowledge about tax rates two quarters in advance. Three quarters of foresight require three MA coefficients, and so on.

We normalize the MA coefficients to sum to unity. This normalization yields the interpretation of MA coefficients as relative weights that dictate the importance of news at

different horizons. For example, the MA coefficient for the process

$$\tau_t = \theta\varepsilon_{t-1} + (1-\theta)\varepsilon_{t-2} \tag{50}$$

determines the importance of news one quarter ahead versus two quarters ahead. As $\theta \to 1$, agents have perfect foresight one period ahead and as $\theta \to 0$, agents have perfect foresight two periods ahead.

In order to capture the time varying nature of news, we examine two different specifications of news for both the government spending and the tax processes. We refer to these specifications as "high degree of foresight," "medium degree of foresight", and "low degree of foresight." The moving-average components for the quarterly news processes are:

Tax Foresight

- High Degree: $0.12\varepsilon_t^i + 0.05\varepsilon_{t-1}^i + 0.09\varepsilon_{t-2}^i + 0.2\varepsilon_{t-3}^i + 0.4\varepsilon_{t-4}^i + 0.14\varepsilon_{t-5}^i$

- Medium Degree: $0.33\varepsilon_t^i + 0.32\varepsilon_{t-1}^i + 0.35\varepsilon_{t-2}^i$

- Low Degree: $0.47\varepsilon_t^i + 0.53\varepsilon_{t-1}^i$

for $i \in \{L, K\}$.

Government Spending

- High Degree: $0.11\varepsilon_t^G + 0.31\varepsilon_{t-1}^G + 0.27\varepsilon_{t-2}^G + 0.28\varepsilon_{t-3}^G + 0.02\varepsilon_{t-4}^G + 0.01\varepsilon_{t-5}^G$

- Low Degree: $0.59\varepsilon_t^G + 0.24\varepsilon_{t-1}^G + 0.09\varepsilon_{t-2}^G + 0.08\varepsilon_{t-3}^G$

These processes are calibrated to fit U.S. data. We calibrate the high degree of tax foresight specification using data from the 1980s. The 1980s was a high news decade because of two major changes to the tax code–the Economic Recovery Tax Act of 1981 (HR 4242) and the Tax Reform Act of 1986 (HR 4170). Both bills implemented major changes to the tax code and had an average legislative lag of well over a year [Yang (2008)]. To calibrate the high degree of tax foresight, we average the information parameter for municipal bond yields of 1 and 5 year horizons given by Figure 4 over the decade of the 1980s as a measure of foresight intensity. We then use the legislative lags associated with tax changes in the 1980s provided by Yang (2008) to specify the functional form of the MA processes. This specification yields 5 quarters of foresight, which is a conservative estimate because both pieces of legislation were phased in over several years.

The medium and low degrees of tax foresight are calibrated to match the data from the 1970s and 1990s, respectively. There were several changes to the tax code in the 1970s– Revenue Act of 1971, Tax Reduction Act of 1975, Revenue Adjustment Act of 1975, Tax Reform Act of 1976, Tax Reduction and Simplification Act of 1977 and the Revenue Act of 1978. Most of these were relatively minor compared to the Tax Reform Act of 1986 and as evidenced by Figure 4, the information content of municipal bonds was, on average, smaller than for the 1980s. Conversely, the information contained in the municipal bonds from 1990 through 2001 is nearly zero. For both medium and low degrees of foresight, we assume agents

have three quarters of foresight. This specification matches the legislative lags for the major tax changes over these two decades as recorded by Yang (2008).

For government spending foresight, we use two specifications of news–high and low. The high news period is calibrated to match the data from 2000 through 2009. As shown in Figure 5, the information content of the SPF's forecasts for changes in government spending at 1, 2 and 3 quarters ahead is highest during this decade. This corresponds nicely to the narrative approach of Ramey (2009a) given by figure 3. The 2000s contained many defense spending increases: [i] 2002Q1, the Bush administration calls for an increase in the Pentagon budget over the next 5 years; [ii] 2002Q3, Announced increases in the Department of Defense budget over the next 10 years to deal with counter-terrorism efforts and the response to 9/11; [iii] Several increases in spending to finance the wars in Afghanistan and Iraq.

The low degree of foresight is an average of the information parameter, α_1^G for 1980 through 2000. The functional form of the government spending process assumes three-quarter-ahead foresight, which is less than the maximum provided by the SPF of five. We specify only three quarters of foresight because the four– and five-step-ahead forecasts where given nearly zero weight in the estimation (41).

5 Implications of Fiscal Foresight

Direct evidence of the degree of fiscal foresight—whether it is from the narrative studies of Romer and Romer (2009) and Ramey (2009a,b), the regressions of Fortune (1996), or the tax chronology of Yang (2008)—makes it clear that the degree of foresight varies substantially across time. While some fiscal events are almost wholly surprises, others are years in the making [Steigerwald and Stuart (1997), Romer and Romer (2007)]. At odds with this evidence, formal empirical work on fiscal foresight tends to impose time-invariant degrees of foresight, fixing *a priori* the horizon over which fiscal events are known [Blanchard and Perotti (2002), Mountford and Uhlig (2009), Mertens and Ravn (2008, 2009)]. This section explores, in the context of the two DSGE models, how different assumptions about the degree of fiscal foresight and the nature of the fiscal news processes alter the models' predictions of the impacts of anticipated fiscal changes. With the exception of the fiscal news processes, parameters in both models are set at the values estimated or calibrated by Braun (1994), reported in appendix C.1, and Traum and Yang (2010), reported in appendix C.2.

Results in this section employ the estimated fiscal rules in the two models: equations (3)–(5) for the RBC model and equations (24)–(28) for the NK model. In what follows, we use values for the moving-average coefficients in the rules—the θ's—and trace out the implications of values of the coefficients that coincide with different degrees of fiscal foresight.

Figures 6–8 report responses of consumption, output, employment, and investment in the RBC model to changes in labor taxes, capital taxes, and government spending. Solid black lines correspond to responses reported in Braun's (1994) original paper to unanticipated changes in fiscal instruments. The other three lines are associated with a high degree of foresight (heavy dotted-dashed line), a medium degree (light dotted-dashed line), and a low degree (dashed line). Relative to a surprise tax increase, foresight about higher labor taxes induces agents to increase their work effort, production, and savings before the higher tax rate is realized, allowing them to smooth their consumption paths [figure 6]. With a sufficiently high degree of foresight, these variables even *increase* during the anticipation

period.[9] A high degree of foresight with respect to labor taxes in the model of Braun leads to qualitative differences in output, employment and investment. This is especially true for investment due to the the double taxation of capital income. The investment response on impact in the model with no foresight is -0.6% lower on impact. Even the low degree of foresight case implies an impact effect of a decrease in investment of only -0.18% on impact, and with a high degree of foresight, investment increases to 0.1%.

Capital taxes operate on the agents' intertemporal savings margin, which amplifies the impacts of anticipated increases [figure 7]. Output, employment, and investment exhibit their largest movements over the foresight horizon. As the degree of foresight increases, and this trough is pushed out in time, these variables can exhibit "hump-like" responses even in the absence of any frictions, such as habit formation and adjustment costs, that are typically introduced into DSGE model to produce humps. This outcome echoes a point made by Leeper and Walker (2009) that news processes can in themselves constitute a propagation mechanism.

Figure 8 displays the usual result that higher government spending crowds out private consumption. Government spending carries with it an expectation of higher taxes that reduce wealth, encouraging more work effort and raising output in the short run. While news alters the quantitative details, it does not affect the qualitative finding for consumption. News does matter for inferences about whether government spending crowds out investment in the short run. Foresight induces agents to save in anticipation of the eventual tax increase and a high degree of foresight can have government spending *crowd in* investment during the anticipation period, which produces a short-run U-shaped response in output. Again, "hump-like" patterns emerge from the news process.

We now turn to the NK model. One important distinction between the RBC model and the NK model is that the NK model has many frictions (e.g., investment adjustment costs, monopolistically competitive intermediate goods and labor sectors, variable capital utilization, etc.) built into the model in order to provide a tighter fit to data. These frictions serve to smooth out the response of agents to news about future changes to tax rates and government spending. Figure 9 shows the response to a capital tax shock to the NK model. Notice that relative to the RBC model, where most of the difference between foresight and no foresight occurs in the first 6 quarters, the different responses of output, investment, and aggregate consumption to different specifications of news is nearly negligible for the first year. However, the impulse response functions of the RBC model converge more quickly than do those of the NK model. In other words, the frictions of the NK model serve to smooth the initial response of news shocks but also propagate their effects.

To better understand how the frictions of the NK model interact with fiscal foresight, figures XX through XX plot impulse response functions with specific frictions turned off. Figure 10 plots the response of investment to a capital tax shock with investment adjustment costs and variable capital utilization turned on (solid lines) and off (dashed lines). The difference between the impulse responses for high foresight and no foresight is much larger when the frictions are turned off. The intuition is straightforward: as adjustments to capital become less costly, firms are able to respond much more to foresight about changes in tax

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[9]This counterintuitive short-run response to a tax hike is likely to cause problems for identification schemes that rely on certain classes of sign restrictions.

rates.

Figure 11 shows the response to a one-percentage increase in labor taxes of employment given 18% of households are unable to save compared to an economy where every household is able to save. Both responses assume agents have a high degree of foresight. The effects of foresight rely heavily on agents' ability to intertemporally substitute. Knowledge of a significant increase in labor taxes in the future has a muted effect for households that operate hand-to-mouth. Figure 11 shows that as a significant fraction of non-savers are added to the economy, the overall response of employment is muted due to the inability to intertemporally substitute.

In addition to the absence of frictions, the NK model differs from the RBC model in its specification of fiscal financing. In the RBC model, all fiscal financing operates through contemporaneous lump-sum taxes. The NK model, in contrast, initially uses debt financing of fiscal deficits. Debt financing, in turn, portends adjustments in a mix of future distorting taxes, government spending, government investment, and transfer payments. These adjustments induce additional dynamics that add to the propagation of fiscal disturbances in the NK model relative to the the RBC setup. They also have important consequences for the impacts of varying degrees of fiscal news. Figure 12 shows that the effect of government spending foresight can have large effects in the NK model. The black line shows the response with no foresight to an increase in government consumption. The usual result follows: investment and consumption fall due to the government absorbing a larger share of goods, while output increases. However with a high degree of foresight, output could fall in period t as agents anticipate a much higher increase in government consumption in period $t + 3$. This suggests that no-foresight impact multipliers would be positive, while the high-foresight multipliers would be negative.

6 CONCLUSION

We find that news concerning changes in fiscal policy is a time-varying process. There are periods in which agents have many quarters of foresight (e.g., wars, significant changes to the tax code). Over the time horizon that we examine, these "high foresight" periods are few and far between. Much of data consists of medium to low or no foresight. One consequence of this result is that models that do not take the time varying process of information flows into account will average away the effects of news. These studies might conclude that fiscal foresight is not relevant for explaining business cycle dynamics, but these models will not be able to assess the effects of fiscal foresight. We examined fiscal foresight in Braun's (1994) real business cycle model and Traum and Yang's (2010) new Keynesian model. We have shown how foresight interacts with common frictions imbedded in models to better fit data. Internal propagation mechanisms, such as investment adjustment costs, are shown to propagate the effects of foresight. We find that fiscal foresight has both quantitative and qualitative short-run effects in typical DSGE models. Alternative news processes substantially alter equilibrium dynamics, underscoring the importance of accurately characterizing the stochastic processes governing fiscal news.

A Tables

Table 1: Linear Regression Model: Fixed Coefficients

$$T_t - \tau_t = \alpha_0 + \alpha_1(\tau_t^I - \tau_t) + \alpha_2(1/\mathcal{Y}_t^M) + \alpha_3\text{TRA86} + \varepsilon_t$$

	1-Year 1965:1-1994:12				5-Year 1965:1-1990:12				10-Year 1965:1-1985:12			
	Max	$100K	$75K	$50K	Max	$100K	$75K	$50k	Max	$100K	$75K	$50K
α_0	0.008	-0.000	-0.006	-0.007	-0.066	-0.072	-0.070	-0.073	-0.039	-0.046	-0.068	-0.077
t_{α_0}	0.501	-0.036	-1.197	-1.153	-1.472	-2.003	-2.748	-1.865	-0.736	-1.072	-2.370	-1.677
α_1	0.203	0.164	0.070	0.079	0.301	0.219	0.091	0.102	0.318	0.240	0.101	0.108
t_{α_1}	4.039	3.792	3.110	3.010	5.117	4.899	3.461	3.049	4.316	4.622	3.137	2.621
α_2	0.073	0.051	0.022	0.022	0.246	0.190	0.080	0.090	0.134	0.081	0.038	0.072
t_{α_2}	1.555	1.549	1.180	1.060	1.264	1.341	1.030	0.906	0.423	0.354	0.293	0.427
α_3	-0.003	0.002	0.003	0.001	0.078	0.077	0.055	0.058	0.085	0.080	0.058	0.062
t_{α_3}	-0.152	0.169	0.446	0.071	2.922	3.894	4.930	4.075	2.936	3.753	4.706	3.864
DW	1.974	1.777	2.058	1.964	2.089	2.054	2.387	2.193	2.092	2.037	2.395	2.186
Q_{12}	7.382	15.164	9.781	3.715	13.021	11.750	21.285	9.867	13.249	10.065	25.688	9.873
	(0.831)	(0.233)	(0.635)	(0.988)	(0.368)	(0.466)	(0.046)	(0.628)	(0.351)	(0.610)	(0.012)	(0.627)

Cochrane-Orcutt estimation was used in order to correct for serial correlation. The Box-Ljung statistic (Q_{12}) tests for serial correlation over a 12-quarter period. The corresponding p-value is in parentheses. The correction was successful in all but two cases.

Table 2: Linear Regression Model: Variable Coefficients

$$T_t - \tau_t = \alpha_{0,t} + \alpha_{1,t}(\tau_t^I - \tau_t) + \alpha_{2,t}(1/\mathcal{Y}_t) + \alpha_{3,t}\text{TRA86} + \varepsilon_t$$
$$\alpha_{i,t} = \alpha_{i,t-1} + \eta_{i,t} \quad \eta_t \sim N(0,\Delta^2) \quad \varepsilon_t \sim N(0,\sigma^2)$$

	1-Year 1965:1-1994:12				5-Year 1965:1-1990:12				10-Year 1965:1-1985:12			
	Max	$100K	$75K	$50K	Max	$100K	$75K	$50k	Max	$100K	$75K	$50K
δ_0	0.0001	0.0001	0.1468	0.0019	0.0000	0.0000	0.2199	0.0097	0.0024	0.0001	0.2592	0.0014
δ_1	1.0052	0.6311	0.8500	0.3797	0.6695	0.6058	1.0004	1.2521	2.7655	0.2542	2.0762	2.6473
δ_2	0.1429	0.1232	0.0007	0.0001	0.0008	0.0005	0.0028	0.0008	18.6405	0.0006	0.0058	6.0488
δ_3	0.0013	0.0022	0.0020	0.0023	0.0135	0.0123	0.0061	0.0068	0.0175	0.0160	0.0099	0.0087
σ	0.0253	0.0180	0.0117	0.0084	0.0528	0.0328	0.0416	0.0245	0.0756	0.0246	0.0255	0.0258

Maximum Likelihood estimation was used in order to obtain the standard errors of the transition equation steps (square roots of the diagonal elements in Δ), δ_0, δ_1, δ_2, δ_3. All off diagonal entries are assumed to be zero. The parameter σ is the standard deviation of the measurement equation.

Table 3: Authorizations and Outlays for ARRA and NHBRIA

ARRA, Highway Construction in Title XII (billions)									
	2009	2010	2011	2012	2013	2014	2015	2016	2009-16
Budget Authority	27.5	0	0	0	0	0	0	0	27.5
Estimated Outlay	2.75	6.875	5.5	4.125	3.025	2.75	1.925	.55	27.5
National Highway Bridge Reconstruction and Inspection Act (millions)									
	2009	2010	2011	2012	2013				2009-13
Budget Authority	1,029	5	5	5	5				1,049
Estimated Outlay	280	425	169	56	46				976

Top panel: estimated costs in billions of dollars for highway construction in Title XII of the American Recovery and Reinvestment Act of 2009 Bottom panel: estimated costs in millions of dollars for the National Highway Bridge Reconstruction and Inspection Act of 2008. Source: Leeper, Walker, and Yang (2009b).
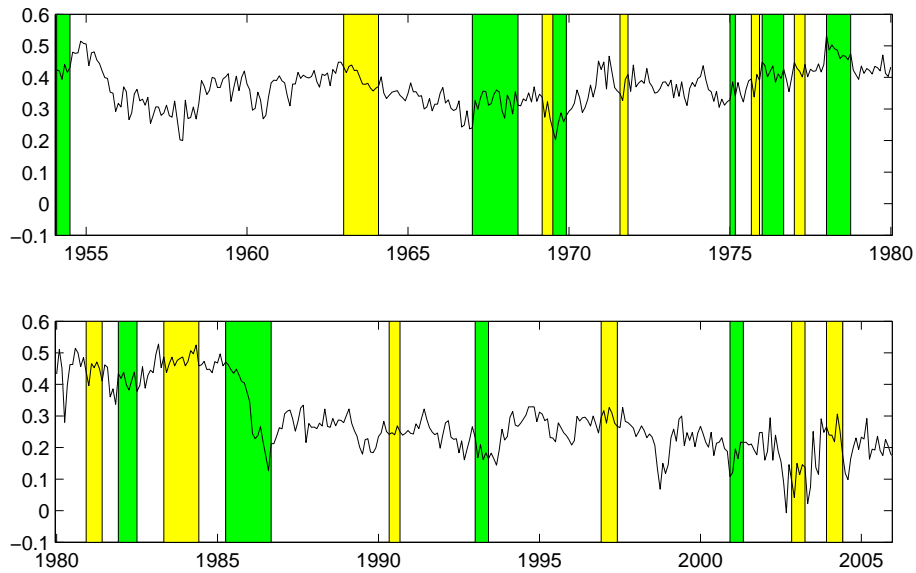
B Figures

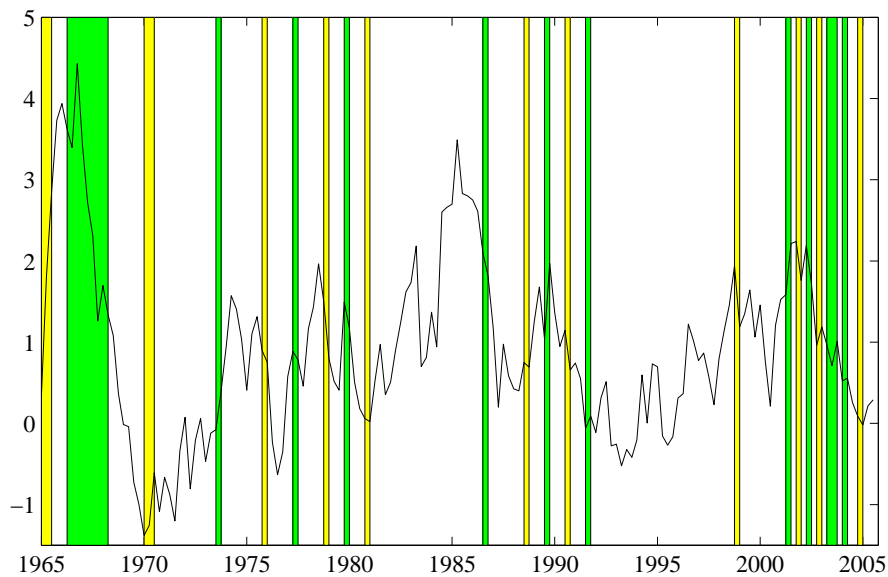Figure 1: Average Forward Tax Rates: 1-Year Time Horizon
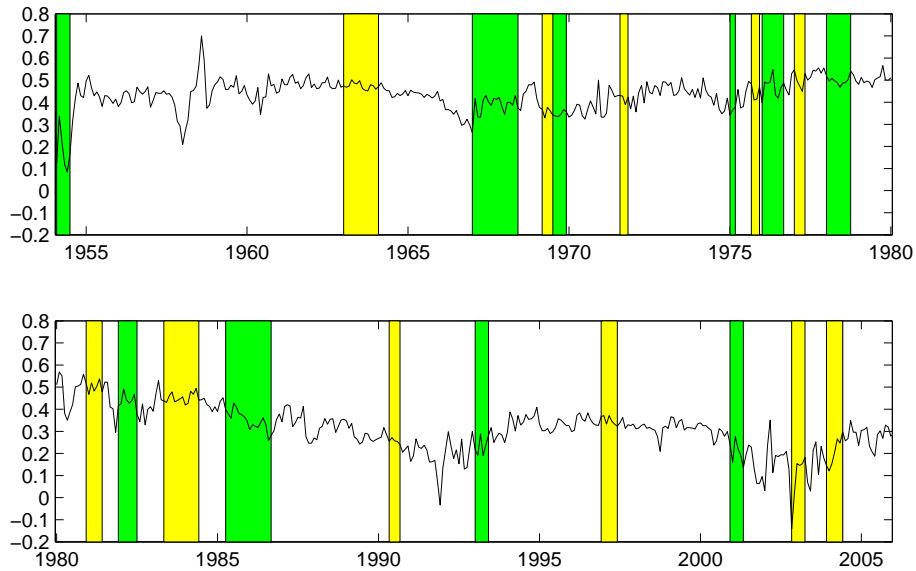
Shaded regions correspond to tax events documented in Yang (2009). Note that shading differences are only intended to help differentiate between events.

Figure 2: Average Forward Tax Rates: 5-Year Time Horizon

Shaded regions correspond to tax events documented in Yang (2009). Note that shading differences are only intended to help differentiate between events.

Figure 3: Annual log deviations in real government consumption expenditures

Shaded regions correspond to defense spending events documented in Ramey (2009a). Note that shading differences are only intended to help differentiate between events.

Figure 4: Time-Varying Information Parameter α_1^τ

The solid black and dotted-dashed lines correspond to bonds with maturity lengths of 1 and 5 years. Estimation is based on the marginal tax rate for an individual earning $75,000 in constant 1980 dollars.
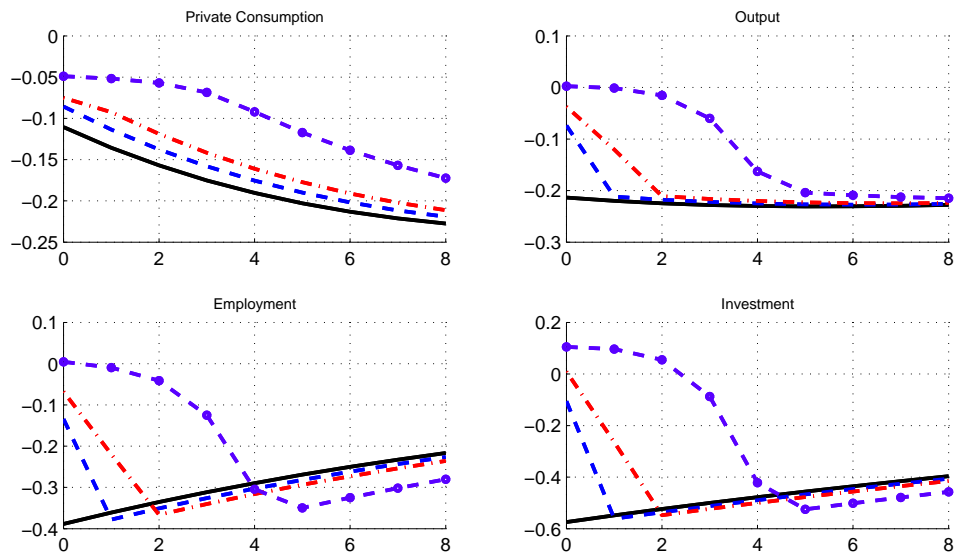
Figure 5: Time-Varying Information Parameter α_1^G
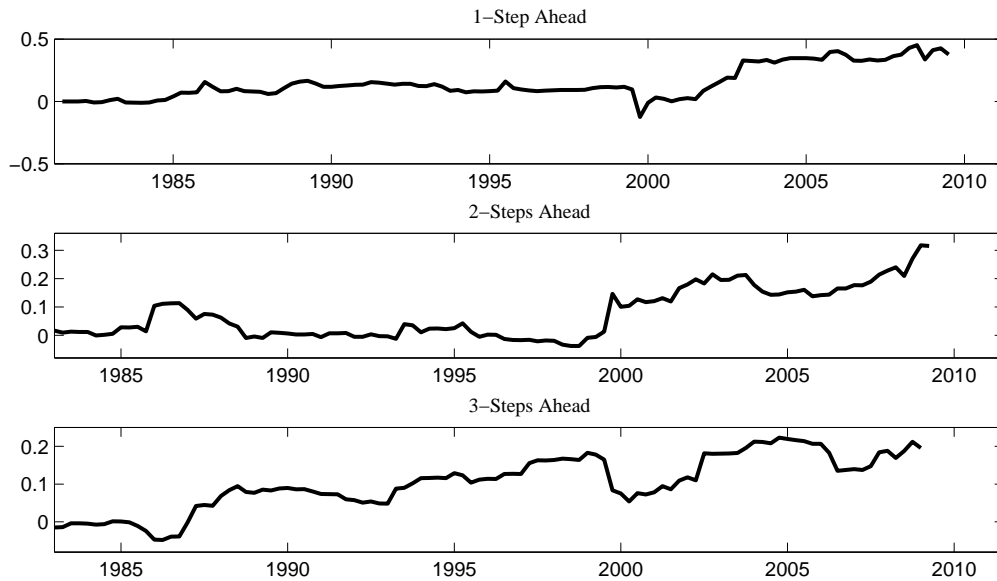
Information parameter, α_1^G, for 1, 2 and 3 step ahead forecasts of real government spending from 1980Q1 through 2010Q1.

B.1 IMPULSE RESPONSE FUNCTIONS
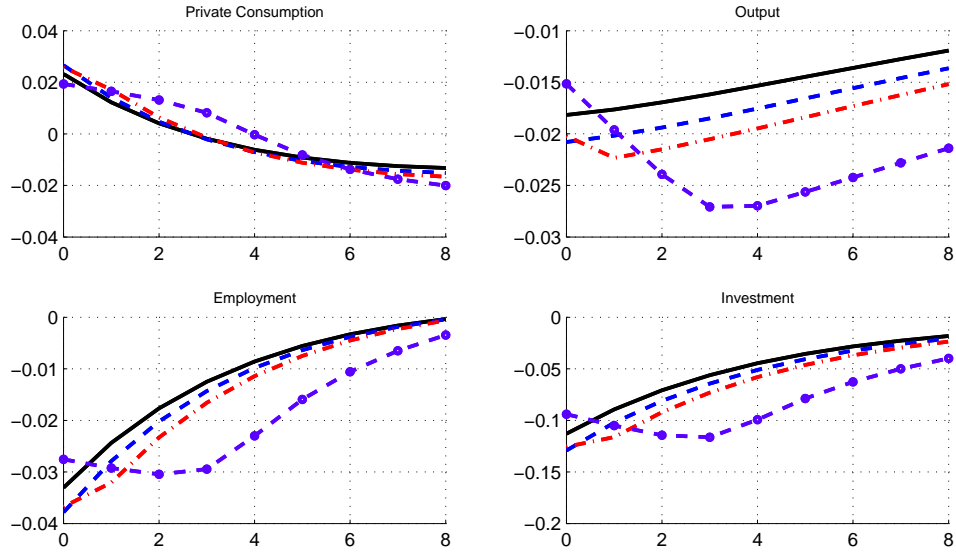
B.1.1 RBC MODEL

Figure 6: Labor Tax Shock

Response of a 1 percent increase in labor taxes. The solid black line corresponds to the RBC model of Braun (1994) where agents have no foresight. The other responses correspond to agents having a low degree of foresight (dashed blue line), a moderate degree of foresight (dotted-dashed red line) and a high degree of foresight (heavy dotted dashed blue line).
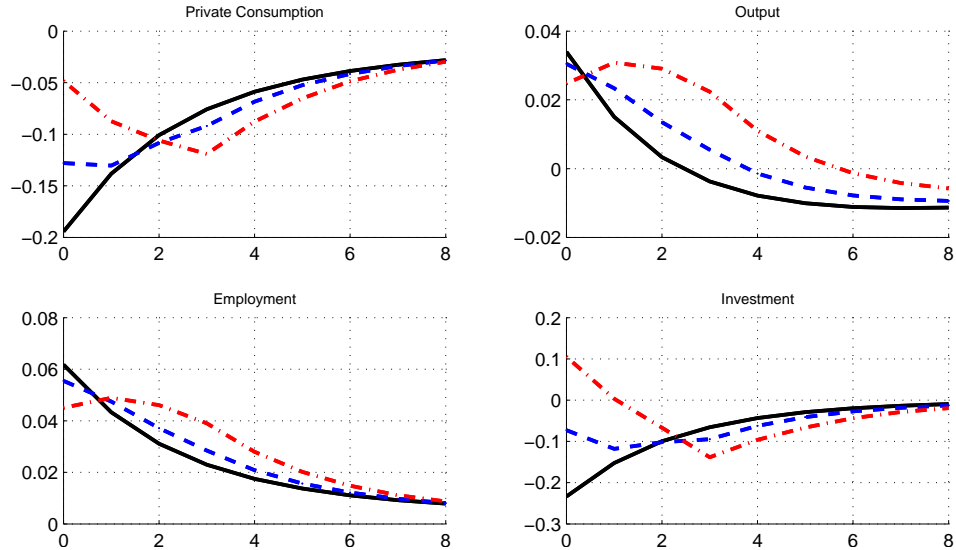
Figure 7: Capital Tax Shock

Response of a 1 percent increase in capital taxes. The solid black line corresponds to the RBC model of Braun (1994) where agents have no foresight. The other responses correspond to agents having a low degree of foresight (dashed blue line), a moderate degree of foresight (dotted-dashed red line) and a high degree of foresight (heavy dotted dashed blue line).
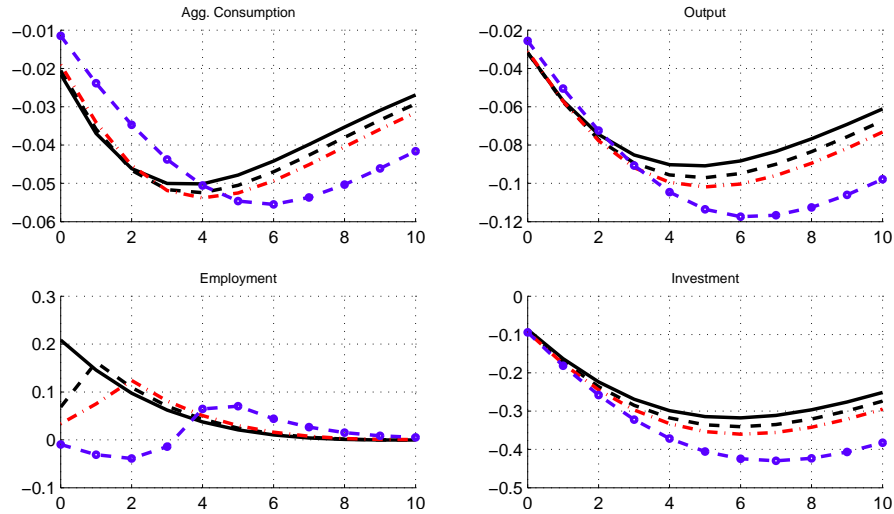
Figure 8: Government Spending Shock

Response of a 1 percent increase in government spending. The solid black line corresponds to the RBC model of Braun (1994) where agents have no foresight. The other responses correspond to agents having a low degree of foresight (dashed blue line) and a high degree of foresight (dotted dashed red line).

B.1.2 New Keynesian Model

Figure 9: Capital Tax Shock

Response of a 1 percent increase in capital taxes. The solid black line corresponds to the New Keynesian model where agents have no foresight. The other responses correspond to agents having a low degree of foresight (dashed blue line), 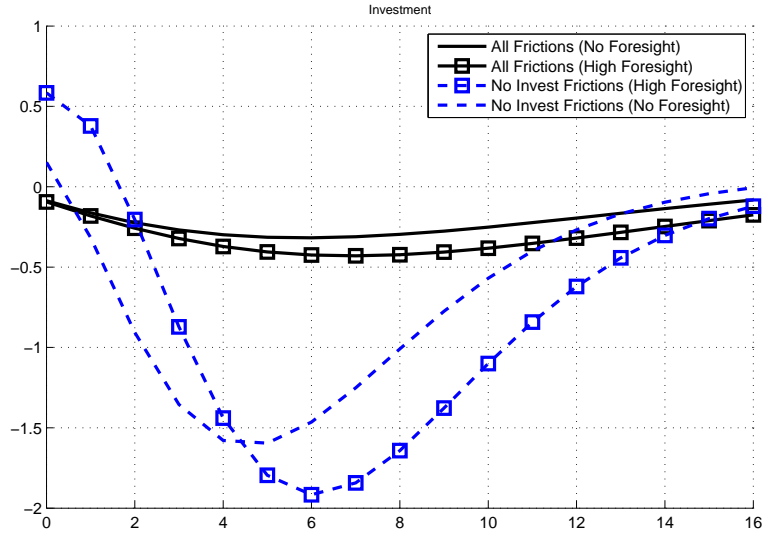a moderate degree of foresight (light dotted dashed red line), and a high degree of foresight (heavy dotted dashed purple line).

Figure 10: Response of Investment to Capital Tax Shock

Response of investment to a 1 percent increase in capital taxes. The solid black lines corresponds to the NK model with capital utilization and investment adjustment costs with no foresight and high degree of foresight (square). The dashed line turns off the investment frictions for no foresight and high foresight.

Figure 11: Response of Employment to Labor Tax Shock
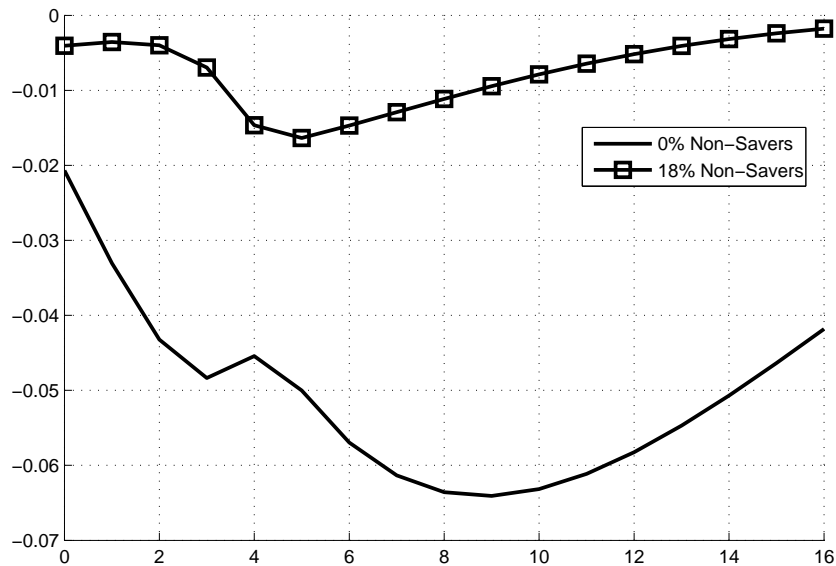
Response of employment to a 1 percent increase in labor taxes assuming a high degree of foresight. The solid black line corresponds to the NK model with no non-savers. The other response assumes 18% of households are unable to save.

Figure 12: Response to Government Spending Shock
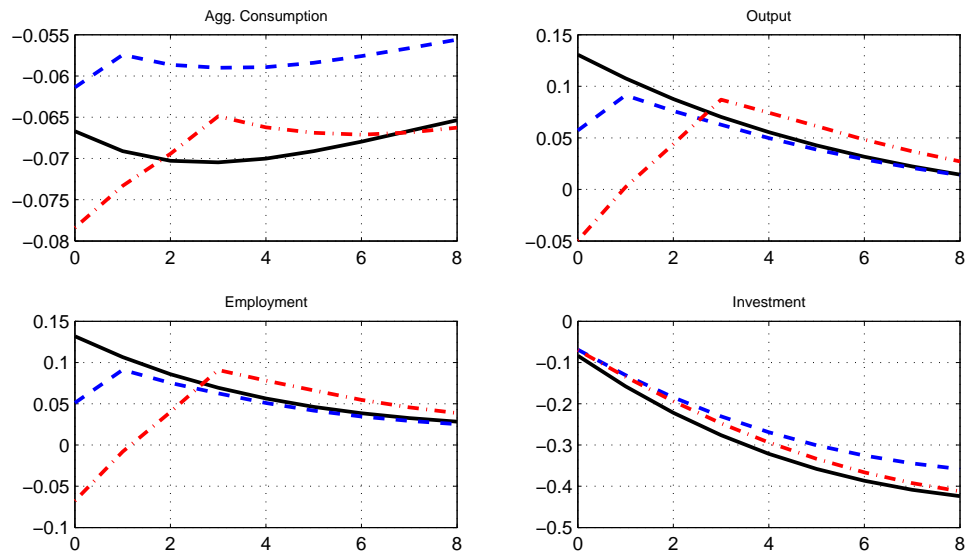
Response to a 1 percent increase in government spending. The solid black line corresponds to the NK model with no foresight. The dashed and dotted-dashed lines correspond to low and high degrees of foresight, respectively.

C Parameter Values

This appendix reports the parameter values estimated or calibrated by Braun (1994) for the real business cycle model and by Traum and Yang (2010) for the new Keynesian model.

C.1 RBC Model

Table 4: RBC Model Parameters

Baseline Calibration		
Annual discount factor	β	0.9709
Capital depreciation rate	δ	0.0834
Government consumption preference parameter	γ_1	0.4
Government spending-to-output ratio	G/Y	0.2
Implied Parameters		
Nominal interest rate	r	0.1390
Capital-to-output ratio	K/Y	3.2366
Consumption-to-output ratio	C/Y	0.6101
Private consumption-to-output ratio	CP/Y	0.5301
Labor-to-output ratio	N/Y	0.3825
Nominal wage rate	W	1.4378
Transfers-to-output ratio	TR/Y	0.0205
Investment-to-output ratio	I/Y	0.2699
Estimated Parameters		
Capital share	θ	0.45
Leisure preference parameter	γ_2	4.21
State-state labor tax rate	τ^L	0.25
State-state capital tax rate	τ^K	0.281
Persistence of labor tax shock	ρ_L	0.95
Persistence of capital tax shock	ρ_K	0.786
Persistence of government spending shock	ρ_G^1	0.647
Persistence of growth shock	ρ_λ	0.9

C.2 New Keynesian Model

Table 5: New Keynesian Model Parameters

Baseline Calibration

Quarterly discount factor	β	0.99
Capital share	α	0.36
Private capital depreciation rate	δ_0	0.025
Government capital depreciation rate	δ^G	0.02
Elasticity of substitution between labor inputs	ψ^w	8
Elasticity of substitution between intermediate goods	ψ^p	8
Steady-state inflation rate	π	1
Government consumption-to-output ratio	s^{GC}	0.0698
Government investment-to-output ratio	s^{GI}	0.00395
Quarterly debt-to-output ratio	s^b	1.5436
Steady-state labor tax rate	τ^L	0.209
Steady-state capital tax rate	τ^K	0.196
Steady-state consumption tax rate	τ^C	0.0149
Elasticity of output with respect to public capital	α^G	0.05

Implied Parameters

Gross Nominal interest rate	R	1.0101
Capital-to-output ratio	K/Y	7.2152
Consumption-to-output ratio	C/Y	0.7459
Labor-to-output ratio	L/Y	0.3547
Nominal wage rate	w	1.557
Transfers-to-output ratio	s^{TR}	0.0978
Savers consumption-to-output ratio	C^S/Y	0.7923
Non-savers consumption-to-output ratio	C^N/Y	0.5342
Steady-state output	Y	1.9369

Estimated Parameters

Risk aversion	γ	2.7
Inverse Frisch elasticity of labor	κ	2.1
Fraction of savers	μ	0.18
Wage stickiness	ω_w	0.69
Price stickiness	ω_p	0.82
Capital utilization	ψ	0.38
Investment adjustment costs	s	7.4
Wage partial indexation	χ^w	0.39
Price partial indexation	χ^p	0.31
Government consumption response to debt	γ_{GC}	0.17
Government investment response to debt	γ_{GI}	0.0033
Capital tax response to debt	γ_K	0.17
Labor tax response to debt	γ_L	0.16
Transfers response to debt	γ_Z	0.074
Capital response to output	φ_K	0.78
Labor response to output	φ_L	0.43
Interest rate response to inflation	ϕ_π	1.9

Interest rate response to output	ϕ_y	0.095
Lagged interest rate response	ρ_r	0.86
Persistence of technology shock	ρ_a	0.89
Persistence of preference shock	ρ_b	0.94
Persistence of investment shock	ρ_i	0.55
Persistence of wage markup shock	ρ_w	0.3
Persistence of price markup shock	ρ_p	0.34
Persistence of government consumption shock	ρ_{GC}	0.96
Persistence of government investment shock	ρ_{GI}	0.76
Persistence of capital tax shock	ρ_K	0.89
Persistence of labor tax shock	ρ_L	0.94
Persistence of consumption tax shock	ρ_C	0.90
Persistence of transfers shock	ρ_Z	0.79
Std. Dev of technology shock	σ_a	0.64
Std. Dev of preference shock	σ_b	2.4
Std. Dev of monetary policy shock	σ_m	0.14
Std. Dev of investment shock	σ_i	4.3
Std. Dev of wage markup shock	σ_w	0.27
Std. Dev of price markup shock	σ_p	0.19
Std. Dev of government consumption shock	σ_{GC}	2.8
Std. Dev of government investment shock	σ_{GI}	4
Std. Dev of capital tax shock	σ_K	4.2
Std. Dev of labor tax shock	σ_L	2.3
Std. Dev of consumption shock	σ_C	3.3
Std. Dev of transfers shock	σ_Z	2.6
Co-movement between capital and labor taxes	ϕ_{KL}	0.23

D Data Description

D.1 Municipal Bonds   We utilize municipal and Treasury bond data with maturity lengths of one, five, and ten years. Yields to maturity from 1954M1 to 1994M12 on tax-exempt prime-grade general-obligation municipal bonds are obtained from Salomon Brothers' Analytical Record of Yields and Yield Spreads. Salomon Brothers' municipal data are collected on bonds of various maturity lengths on the first of each month and based on estimates of the yields of new issues sold at face value. Yields on similarly-rated (AAA) municipal bonds from 1995M1-2006M12 are obtained from Bloomberg's Municipal Fair Market Bond Index. Market yields on constant-maturity-adjusted, non-inflation-indexed U.S. Treasury securities from 1954M1-2006M12 are obtained from the Federal Reserve's Statistical Release on Selected Interest Rates. These yields reflect the average of the weekly values within each month, which are interpolated from the daily yield curve.

D.2 Government Spending   Data on quarterly nominal federal government consumption and gross investment spending from 1981Q1 to 2010Q1 are obtained from the National Income and Product Accounts, published by the Bureau of Economic Analysis (BEA). A real series of federal government consumption expenditures and gross investment in chained 2005 dollars (RGFED) was generated using the component-specific real GDP quantity index (QI) [NIPA Table 1.1.3, line 22] and annual component-specific nominal GDP (NGFED) [NIPA Table 1.1.5, line 22]. The following formula was applied in order to convert from current dollars to chained 2005 dollars:

$$\text{RGFED}_{\text{BY}}^{Q} = \left(\frac{\text{QI}_{\text{CY}}^{Q}}{\text{QI}_{\text{BY}}^{A}} \right) \text{NGFED}_{\text{BY}}^{Q},$$

Table 6: Base Years for NIPA Variables in the SPF

Range of Surveys	Base Year
1996Q1 to 1999Q3	1992
1999Q4 to 2003Q4	1996
2004Q1 to 2009Q2	2000
2009Q3 to 2010Q1	2005

where A and Q designate between annual and quarterly values and CY and BY denote current quarter and base year (annual) values.

D.3 SURVEY OF PROFESSIONAL FORECASTERS   Mean *forecasts* of real federal government consumption and gross investment from 1981Q1 to 2010Q1 over one, two, three, four, and five year horizons are taken from the Survey of Professional Forecasters (SPF), conducted by the Federal Reserve Bank of Philadelphia. Unfortunately, the published data is not provided under a constant base year and is affected by several changes in the base year set by the BEA. This creates two minor complications. First, the BEA does not publish price indexes corresponding to historical base years. Second, the components of and the methodology for collecting federal government spending data has changed over time. In the first quarter of 1996, the BEA's price and quantity indexes switched to chain-weighted measures. Moreover, in the same quarter, government purchases were replaced by government consumption and gross investment spending, which lead to a substantial upward revision in the government component of GDP.[10] These changes forced us to employ two different methods in order to transform this series of forecasts into constant 2005 dollars.

Between 1981Q1 and 1995Q4, we collect nominal government purchases (Table 1) and the component-specific implicit price deflator (Table 7.1) from quarterly issues of the Survey of Current Business, which were downloaded from the Federal Reserve Archival System for Economic Research. A time series of these variables was created using the most recently revised estimates. Real forecasts were then converted to current dollars by multiplying the quarterly real forecast by the quarterly implicit price deflator and dividing by 100. In order to account for the change in the definition of government spending, we collect current data on nominal federal government consumption and gross investment and calculate the difference from the past definition. We then scale up the calculated nominal forecasts in order to obtain government spending forecasts based on its new definition. Finally to convert these values into constant 2005 dollars, we multiply by 100 and divide the corresponding quarterly implicit price deflator.

Between 1996Q1 and 2010Q1, the data is first converted to current dollars by constructing the component-specific implicit price deflator (IPD) in each of the relevant base years. In order to re-base the index, we applied the following transformation

$$\text{NIPD}_{\text{CY}}^{\text{Q}} = \frac{\text{OIPD}_{\text{CY}}^{\text{A}}}{\text{OIPD}_{\text{NBY}}^{\text{A}}},$$

where NIPD and OIPD correspond to the implicit price deflator series under the new and old base years and NBY stands for the new (desired) base year. We then construct a new IPD series with base years corresponding to the data specified in Table 6. Using the generated series, we obtain nominal forecasts by multiplying each quarterly data point by the current implicit price deflator with the appropriate base year. The constructed nominal series is then converted to constant 2005 dollars using the same procedure that was applied to pre-1996 data.

D.4 MARGINAL TAX RATES   Marginal income tax rates for married individuals filing joint returns are obtained from Internal Revenue Service publications and the Tax Policy Center. Following Fortune (1996),

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[10]For more details surrounding the precise changes in the definition of government spending see the Survey of Business issues from September 1995 and January 1996.

marginal tax brackets, reported in current dollars, are converted to constant 1980 dollars using the implicit price deflator [NIPA Table 1.1.9]. A series of actual and ex post tax rates are then constructed using the maximum tax rates and the marginal tax rates for investors earning $100,000, $75,000, and $50,000 annually in constant 1980 dollars. Annual tax rates are then applied to each month of each corresponding year.

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