Online Appendix

A Data

We follow Fernández-Villaverde et al. (2015) and use the following macroeconomic time series for the estimation and calculation of data moments:

1. Output is real GDP (GDPC1).
2. Consumption is real personal consumption expenditures (PCECC96).
3. Investment is real gross private domestic investment (GPDIC96).
4. Civilian Noninstitutional Population (CNP16OV, quarterly averages).
5. Inflation is GDP deflator (GDPDEF).
6. Hourly real wage is compensation per hour in the business sector (HCOMPBS) divided by the GDP deflator (GDPDEF).
7. Hours per capita are measured by hours of all persons in the business sector (HOABS).

Data for the period from 1970:Q1 to 2016:Q4 is from the St. Louis Fed's FRED database (mnemonics are in parentheses).

Government spending is government consumption and gross investment, both from NIPA. To construct the aggregate effective tax rates, we follow Leeper et al. (2010) (see also Appendix B in Fernández-Villaverde et al., 2015) and use national account information (NIPA). Specifically, the *average* capital tax rate is calculated as:

$$\tau_k = \frac{\tau_p \mathrm{CI} + \mathrm{CT} + \mathrm{PRT}}{\mathrm{CI} + \mathrm{PRT}}$$

where CI denotes taxes on capital income, CT denotes taxes on corporate income (NIPA Table 3.1, line 5), and PRT denotes property taxes (NIPA Table 3.3, line 8). We define CI = PRI/2 + RI + CP + NI; where the first term is half of the proprietor's (PRI, NIPA Table 1.12, line 9), and the latter three terms are, respectively, rental income (RI, NIPA Table 1.12, line 12), corporate profits (CP, NIPA Table 1.12, line 13), and interest income (NI, NIPA Table 1.12, line 18). Following Jones (2002), the average personal income tax τ_p is computed as: $\frac{\mathrm{PIT}}{\mathrm{WSA}+\mathrm{PRI}+\mathrm{CI}}$. The numerator is federal, state, and local taxes on personal income (PIT, NIPA Table 3.2, line 3 plus NIPA Table 3.3, line 4). The denominator is given by wage and salary accruals (WSA, NIPA Table 1.12, line 3).

The Treasury yield data are from Gurkaynak et al. (2007) (data are available for download on the website `http://www.federalreserve.gov/Pubs/feds/2006/200628/feds200628.xls`). Real term structure data are obtained by splicing together real yields from Chernov and Mueller (2012) and Gurkaynak et al. (2010). In particular, the data from Chernov and Mueller (2012) span 1971Q3 to 2002Q4. We merge these data with those from Gurkaynak et al. (2010). Throughout, we remove data for 2003 due to a high illiquidity premium. For the same liquidity reason, we also consider a shorter sample that excludes the financial crisis. The relative (il)liquidity of TIPS from their inception until 2003 (when the Treasury reaffirmed its commitment to the TIPS program) and in the aftermath of the Lehman Brothers bankruptcy in late 2008 (which resulted in its considerable TIPS inventory being released into the market) have been discussed by Sack and Elsasser (2004) and Campbell et al. (2009), among others.

The PCs in Table **??**–**??** are constructed from the observed yields with maturities of 3 months, one through five years, and ten-years. The PCs are standardized to have unit standard deviation.

The empirical analysis in Table **??** uses quarterly returns to match the quarterly frequency of fiscal variables. Excess bond returns are measured by the return to a portfolio of Treasury bonds with maturities between 1-2, 2-3, 4-5, 5 and 10 years, and more than 10 years. Only non callable, non flower notes and bonds are included in the portfolios. The portfolio returns are an equal-weighted average of the unadjusted holding period return for each bond in the portfolios. Quarter-end to quarter-end excess returns are constructed by compounding simple returns to the portfolios, then subtracting the compounded return to the shortest-maturity portfolio, which contains bonds with maturities less than 6 months. Excess returns to the aggregate stock market are constructed in the same way, using the CRSP value-weighted index. Finally, the five value-weighted quintile portfolios sorted on their book-to-market ratio (see Fama and French, 1992) are from Kenneth French's website.

B Solution and Estimation

The model is tractable enough to employ the estimation methodology recently proposed by Andreasen, Fernández-Villaverde, and Rubio-Ramírez (2017). We proceed as follows:

Model Solution First, we solve the model. To this end, we induce stationarity by eliminating trending variables with appropriate transformations. The desired policy functions that characterize the equilibrium are then obtained by employing a third-order perturbation approximation. We require at least a third-order approximation to generate variation in risk premia. A standard approach to efficiently compute a higher-order approximation to DSGE models with a yield curve exploits the fact that bond prices beyond the policy rate do not affect equilibrium allocations and prices. We take advantage of this property by solving the model in a two-step procedure: in a first step, we solve the model without bond prices exceeding one period; in a second step, all remaining bond prices with maturities up to ten years are computed recursively based on

$$Q_t^{(k)} = E_t \left[M_{t,t+1}^{\$} Q_{t+1}^{(k-1)} \right] ,$$

where $M_{t,t+1}^{\$} = M_{t,t+1} \frac{1}{\Pi_{t+1}}$ denotes the nominal stochastic discount factor, and $M_{t,t+1}$ denotes the real stochastic discount factor. We let $k = 2, \ldots, 40$ quarters. The nominal yield curve with continuous compounding is then given by $y_t^{(k)} = -\frac{1}{k} \log Q_t^{(k)}$. We also compute the real term structure based on

$$Q_{t,real}^{(k)} = E_t \left[M_{t,t+1} Q_{t+1,real}^{(k-1)} \right] .$$

This two-step procedure reduces the size of the simultaneous equation systems to be solved and, therefore, substantially reduces the computational burden of the approximation.

Analytical Model Moments Second, we derive analytical closed-form expressions for first and second unconditional moments of the nonlinear pruned state-space of the model. To ensure stable sample paths (and existence of finite unconditional moments) we adopt the pruned state-space system for non-linear DSGE models suggested by Andreasen et al. (2017). Intuitively, pruning means we are going to omit terms of higher-order effects than the considered approximation order (third-order, in our case) when the system is iterated forward in time.[1] Provided the linearized solution is stable, Andreasen et al. (2017) derive closed-form expressions for first and second unconditional moments of the pruned state-space of the DSGE. This allows us to efficiently compute the unconditional moments for our DSGE model solved up to third-order.[2]

Estimation Methodology Finally, we estimate a subset of model parameters via generalized method of moments (GMM). In our estimation, we use the first and second unconditional moments of the following quarterly macroeconomic and financial time series: (i) log output growth, Δy_t (henceforth, Δ denotes the temporal difference operator);

[1] For details on the pruning method, see Sims et al. (2008) for second-order and Andreasen et al. (2017) for higher-order approximations to the solutions of DSGE models.

[2] Although we solve the model by a third-order perturbation, we verified that our model moments are similar when we use a higher-order approximation and no pruning. In particular we checked that our results do not change when we use a fifth order solution to our DSGE model. To obtain a fifth order solution we use the tensor approach proposed by Levintal (2017).

(ii) log investment growth, Δinv_t; (iii) log consumption growth, Δc_t; (iv) inflation, π_t; (v) the one quarter nominal interest rate, r_t; (vi) the ten year nominal interest rate, $y_t^{(40)}$; and (vii) the slope of the term structure, $y_t^{(40)} - r_t$. All series are stored in $\mathbf{data}_t$ which is of dimension 7×1.[3] Our sample goes from 1970Q1 to 2016Q4, hence, the matrix **data** which is of dimension 7×188. We then define the following vector

$$\mathbf{q}_t = \begin{bmatrix} \mathbf{data}_t \\ diag\left(\mathbf{data}_t \mathbf{data}_t'\right) \\ vech\left(\mathbf{data}_t \mathbf{data}_t'\right) \end{bmatrix}.$$

Moreover, let $\boldsymbol{\theta}$ be a vector that contains the structural parameters. Our GMM estimator is then given by

$$\boldsymbol{\theta}_{GMM} = \text{argmin}_{\boldsymbol{\theta}\in\boldsymbol{\Theta}} \left(\frac{1}{T}\sum_{t=1}^{T} \boldsymbol{q}_t - m\left(\boldsymbol{\theta}\right)\right)' \boldsymbol{W} \left(\frac{1}{T}\sum_{t=1}^{T} \boldsymbol{q}_t - m\left(\boldsymbol{\theta}\right)\right) \tag{B.1}$$

Here, W is a positive definite weighting matrix and $m(\boldsymbol{\theta})$ is a vector that contains the model-implied unconditional moments computed in closed-form as described above. We use the conventional two-step implementation of GMM by letting $\boldsymbol{W}_T = \text{diag}\left(\hat{\boldsymbol{S}}^{-1}\right)$ in a preliminary first step to obtain $\hat{\boldsymbol{\theta}}^{\text{step 1}}$ where $\hat{\boldsymbol{S}}$ denotes the long-run variance of $\frac{1}{T}\sum_{t=1}^{T} \boldsymbol{q}_t$ when re-centered around its sample mean. Our final estimates $\hat{\boldsymbol{\theta}}^{\text{step 2}}$ are obtained using the optimal weighting matrix $\boldsymbol{W}_T = \hat{\boldsymbol{S}}^{-1}_{\hat{\boldsymbol{\theta}}^{\text{step 1}}}$, where $\hat{\boldsymbol{S}}_{\hat{\boldsymbol{\theta}}^{\text{step 1}}}$ denotes the long-run variance of our moments re-centered around $m\left(\hat{\boldsymbol{\theta}}^{\text{step 1}}\right)$. The long-run variances in both steps are estimated by the Newey-West estimator using 10 lags, but our results are robust to using more lags.

To summarize, the estimation procedure implemented by GMM is as follows:

- 1. Step: Let $\boldsymbol{W}_T = \text{diag}\left(\hat{\boldsymbol{S}}^{-1}\right)$ and obtain $\hat{\boldsymbol{\theta}}^{\text{step 1}}$ from B.1.
- 2. Step: Use $\hat{\boldsymbol{\theta}}^{\text{step 1}}$ to compute $\boldsymbol{W}_T = \hat{\boldsymbol{S}}^{-1}_{\hat{\boldsymbol{\theta}}^{\text{step 1}}}$, and obtain $\hat{\boldsymbol{\theta}}^{\text{step 2}}$ from B.1.

C Solving the Benchmark Model

C.1 Households with Epstein-Zin Preference

The agent's optimization problem is:

$$\begin{aligned} \max \quad & V(C_t, N_t^s) = \left\{(1-\beta)U(C_t, N_t^s)^{1-\psi} + \beta E_t\left[V_{t+1}^{1-\gamma}\right]^{\frac{1-\psi}{1-\gamma}}\right\}^{\frac{1}{1-\psi}} \\ \text{s.t.} \quad & E_t\left[\sum_{s=0}^{\infty} M^{\$}_{t,t+s} P_{t+s} C_{t+s}\right] \le E_t\left[\sum_{s=0}^{\infty} M^{\$}_{t,t+s}(W_{t+s} P_{t+s} N^s_{t+s} - P_{t+s} T_{t+s} + P_{t+s}\Psi_{t+s})\right], \end{aligned}$$

where

$$C_t = \left[\int_0^1 C_t(j)^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}}$$

and

$$U(C_t, N_t^s) = \left[\frac{C_t^{1-\psi}}{1-\psi} - \varphi_t^{1-\psi}\frac{N_t^{s\,1+\omega}}{1+\omega}\right]^{\frac{1}{1-\psi}}.$$

[3] We have also repeated our procedure adding to the first and second moments used in the baseline estimation the first and fifth autocovariances to capture the persistence in the data. Our point estimates do not significantly change and the conclusion from model-implied moments remain qualitatively the same.

The first order conditions are:

$$\frac{\partial V_t}{\partial C_t} \quad : \quad \frac{\left[V_t^{1-\psi}\right]^{\frac{1}{1-\psi}-1}}{1-\psi}(1-\beta)C_t^{-\psi} - \lambda M_{t,t}^{\$}P_t = 0 \tag{C.1}$$

$$\frac{\partial V_t}{\partial N_t^s} \quad : \quad \frac{\left[V_t^{1-\psi}\right]^{\frac{1}{1-\psi}-1}}{1-\psi}(1-\beta)(-\varphi_t^{1-\psi}N_t^{s\omega}) + \lambda M_{t,t}^{\$}W_t P_t = 0 \tag{C.2}$$

$$\frac{\partial V_t}{\partial C_{t+1}} \quad : \quad \frac{\left[V_t^{1-\psi}\right]^{\frac{1}{1-\psi}-1}}{1-\psi}\beta\left(\frac{1-\psi}{1-\gamma}\right)E_t\left[V_{t+1}^{1-\gamma}\right]^{\frac{1-\psi}{1-\gamma}-1}(1-\gamma)V_{t+1}^{-\gamma}\frac{\partial V_{t+1}}{\partial C_{t+1}} - \lambda M_{t,t+1}^{\$}P_{t+1} = 0. \tag{C.3}$$

Furthermore,

$$\frac{\partial V_{t+1}}{\partial C_{t+1}} = \frac{1}{1-\psi}\left[V_{t+1}^{1-\psi}\right]^{\frac{1}{1-\psi}-1}(1-\beta)C_{t+1}^{-\psi}. \tag{C.4}$$

Finally, combining (C.1) ,(C.3) and (C.4), I obtain the intertemporal consumption optimality condition:

$$\frac{\lambda(1-\psi)}{V_t^{\psi}(1-\beta)} = \frac{C_t^{-\psi}}{P_t} = \beta\left(\frac{C_{t+1}^{-\psi}}{P_{t+1}}\right)\left(\frac{V_{t+1}^{\psi-\gamma}}{M_{t,t+1}^{\$}}\right)E_t\left[V_{t+1}^{\frac{1}{1-\gamma}}\right]^{\frac{\gamma-\psi}{1-\gamma}}.$$

To get the nominal pricing kernel, I solve for $M_{t,t+1}^{\$}$,

$$M_{t,t+1}^{\$} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\psi}\left(\frac{P_{t+1}}{P_t}\right)^{-1}\left[\frac{V_{t+1}}{E_t[V_{t+1}^{1-\gamma}]^{\frac{1}{1-\gamma}}}\right]^{\psi-\gamma}.$$

C.2 Aggregation

There is a continuum of intermediate goods firms, $j \in [0,1]$ producing differentiated output $Y_t(j)$ at price $P_t(j)$. There is a representative final good producer that bundles the intermediate good into a final good via the aggregator:

$$Y_t^{aggr} = \left(\int_0^1 Y_t(j)^{\frac{\eta-1}{\eta}}dj\right)^{\frac{\eta}{\eta-1}},$$

where $\eta > 1$ is the elasticity of substitution among goods. Following profit maximization by the final good producer, the first order condition gives the demand curve for each intermediate good:

$$Y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\eta}Y_t^{aggr}, \tag{C.5}$$

and the aggregate price index is:

$$P_t^{1-\eta} = \int_0^1 P_t(j)^{1-\eta}dj.$$

Integrating Equation (C.5) over j to get the aggregation equation of output:

$$Y_t = \int_0^1 Y_t(j)dj = \underbrace{\int_0^1\left(\frac{P_t(j)}{P_t}\right)^{-\eta}dj}_{L_{p,t}}\,Y_t^{aggr},$$

where $L_{p,t}$ is the distortionary from price dispersion. To deal with the integral, we can use the property of Calvo (1983) such that only a α fraction of firms each period can optimally set their price to P_t^*.

$$\begin{aligned} L_{p,t} = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\eta} dj &= \int_0^{1-\alpha} \left(\frac{P_t^*}{P_t}\right)^{-\eta} dj + \int_{1-\alpha}^1 \left(\frac{P_{t-1}(j)}{P_t}\right)^{-\eta} dj \\ &= \int_0^{1-\alpha} \left(\frac{P_t^*}{P_t}\right)^{-\eta} dj + \int_{1-\alpha}^1 \left(\frac{P_{t-1}(j)}{P_{t-1}}\right)^{-\eta} \left(\frac{P_{t-1}}{P_t}\right)^{-\eta} dj \\ &= \int_0^{1-\alpha} \left(\frac{P_t^*}{P_t}\right)^{-\eta} dj + \left(\frac{P_{t-1}}{P_t}\right)^{-\eta} \int_{1-\alpha}^1 \left(\frac{P_{t-1}(j)}{P_{t-1}}\right)^{-\eta} dj \\ &= (1-\alpha)\left(\frac{P_t^*}{P_t}\right)^{-\eta} + \alpha\left(\frac{P_{t-1}}{P_t}\right)^{-\eta} \int_0^1 \left(\frac{P_{t-1}(j)}{P_{t-1}}\right)^{-\eta} dj \\ &= (1-\alpha)\left(\frac{P_t^*}{P_t}\right)^{-\eta} + \alpha\left(\frac{P_{t-1}}{P_t}\right)^{-\eta} L_{p,t-1}. \end{aligned}$$

The resulting price dispersion is:

$$L_{p,t} = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\eta} dj = (1-\alpha)\left(\frac{P_t^*}{P_t}\right)^{-\eta} + \alpha\left(\frac{P_{t-1}}{P_t}\right)^{-\eta} L_{p,t-1}.$$

The aggregate price index can be calculated in a similar fashion:

$$\begin{aligned} P_t^{1-\eta} = \int_0^1 P_t(j)^{1-\eta} dj &= \int_0^{1-\alpha} {P_t^*}^{1-\eta} dj + \int_{1-\alpha}^1 P_{t-1}(j)^{1-\eta} dj \\ &= (1-\alpha){P_t^*}^{1-\eta} + \alpha \int_0^1 P_{t-1}(j)^{1-\eta} dj \\ &= (1-\alpha){P_t^*}^{1-\eta} + \alpha P_{t-1}^{1-\eta}, \end{aligned}$$

which can be rewritten in the following price aggregator:

$$1 = (1-\alpha)\left(\frac{P_t^*}{P_t}\right)^{1-\eta} + \alpha\left(\frac{P_{t-1}}{P_t}\right)^{1-\eta}.$$

Finally, aggregated output is

$$Y_t = L_{p,t} Y_t^{aggr},$$

with market clearing condition:

$$Y_t^{aggr} = C_t + Inv_t + Gov_t.$$

C.3 Loglinearized Phillips Curve

To linearize F_t and J_t, we apply Taylor series expansion to the expectation terms in the following steps for Equation (??). First, define $\Upsilon_t = \log \mathbb{E}_t\left[e^{m_{t,t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+(\eta-1)\pi_{t+1}+f_{t+1}}\right]$. Then,

$$\begin{aligned} F_t &= 1 + \alpha\mathbb{E}_t\left[M_{t,t+1}^{nom}\left(\frac{Y_{t+1}}{Y_t}\right)\Pi_{t+1}^{\eta} F_{t+1}\right] \\ Fe^{f_t} &= 1 + \alpha\Upsilon e^{\log\mathbb{E}_t\left[e^{m_{t,t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+(\eta-1)\pi_{t+1}+f_{t+1}}\right]} \\ f + f_t &= log(1+\alpha\Upsilon e^{\Upsilon_t}) \\ &= \log(1+\alpha\Upsilon e^{\Upsilon}) + \underbrace{\frac{\alpha\Upsilon e^{\Upsilon}}{1+\alpha\Upsilon e^{\Upsilon}}}_{const_f}(\Upsilon_t - \Upsilon). \end{aligned}$$

Notice a variable without a time subscript implies the non-stochastic steady state of the variable. In steady state, $f = \log(1+\alpha\Upsilon e^{\Upsilon})$, so

$$\begin{aligned}
f_t &= const_f \Upsilon_t - const_f \Upsilon \\
&= const_f \log \mathbb{E}_t \left[e^{m_{t,t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+(\eta-1)\pi_{t+1}+f_{t+1}} \right] - const_f \Upsilon \\
&= const_f \left\{ \mathbb{E}_t \left[m_{t,t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+(\eta-1)\pi_{t+1}+f_{t+1} \right] \right. \\
&\quad \left. + \frac{1}{2} var_t \left(m_{t,t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+(\eta-1)\pi_{t+1}+f_{t+1} \right) \right\} - const_f \Upsilon,
\end{aligned}$$

in which the last equality relies on the lognormality assumption.

For J_t, define $\Phi_t = \log \mathbb{E}_t \left[e^{m_{t,t+1}-\Delta z_{t+1}+\kappa\Delta r^K_{t+1}+(1-\kappa)\Delta\tilde{w}_{t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+\eta\pi_{t+1}+j_{t+1}} \right]$, then the same procedure as above gives us the loglinearized Equation (**??**):

$$\begin{aligned}
& j_t \\
=\ & const_j \Phi_t - const_j \Phi \\
=\ & const_j \log \mathbb{E}_t \left[e^{m_{t,t+1}-\Delta z_{t+1}+\kappa\Delta r^K_{t+1}+(1-\kappa)\Delta\tilde{w}_{t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+\eta\pi_{t+1}+j_{t+1}} \right] - const_j \Phi \\
=\ & const_j \left\{ \mathbb{E}_t \left[m_{t,t+1}-\Delta z_{t+1}+\kappa\Delta r^K_{t+1}+(1-\kappa)\Delta\tilde{w}_{t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+\eta\pi_{t+1}+j_{t+1} \right] \right. \\
& \left. + \frac{1}{2} var_t \left(m_{t,t+1}-\Delta z_{t+1}+\kappa\Delta r^K_{t+1}+(1-\kappa)\Delta\tilde{w}_{t+1}+\Delta\tilde{y}_{t+1}+\Delta a_{t+1}+\eta\pi_{t+1}+j_{t+1} \right) \right\} \\
& - const_j \Phi,
\end{aligned}$$

where $const_j = \frac{\alpha\Phi e^{\Phi}}{1+\alpha\Phi e^{\Phi}}$.

C.4 The System of Equations for the Model with Growth

We have a system of thirty-three equations resulting from equilibrium conditions, first order conditions and policy rules:

Pricing kernel,

$$M^{\$}_{t,t+1} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\psi} \left(\frac{P_{t+1}}{P_t} \right)^{-1} \left[\frac{V_{t+1}}{E_t[V^{1-\gamma}_{t+1}]^{\frac{1}{1-\gamma}}} \right]^{\psi-\gamma}$$

Value function,

$$V_t = \left\{ (1-\beta) \left(\frac{{C_t}^{1-\psi}}{1-\psi} - \varphi_t^{1-\psi} \frac{{N^s_t}^{1+\omega}}{1+\omega} \right) + \beta E_t \left[V^{1-\gamma}_{t+1} \right]^{\frac{1-\psi}{1-\gamma}} \right\}^{\frac{1}{1-\psi}}$$

Fiscal rule,

$$\begin{aligned}
Tax_t &= \tau_t + \tau^k_t R^k_t K_{t-1} \\
\tau_t &= \rho_b D_{t-1}(t) + \rho_g Gov_t
\end{aligned}$$

Wage setting of the agent,

$$W_t = \varphi_t^{(1-\psi)} C_t^{\psi} N_t^{s\,\omega},$$

Production function,

$$Y_t = Z_t K^{\kappa}_{t-1} (A_t N^d_t)^{1-\kappa}$$

Capital accumulation,

$$K_t = ((1-\delta) + \Phi_t)K_{t-1}$$

Capital adjustment cost,

$$\Phi_t = b1 + \frac{b2}{(1-1/\zeta)}\left(\frac{Inv_t}{K_{t-1}}\right)^{1-1/\zeta}$$
$$\Phi'_t = b2\left(\frac{Inv_t}{K_{t-1}}\right)^{-1/\zeta}$$

Return on investment,

$$1 = \mathbb{E}_t[M_{t,t+1}R^I_{t+1}]$$
$$R^I_t q^{inv}_{t-1} = (1-\tau^k_t)R^K_t + q^{inv}_t\left(1-\delta+\Phi_t-\Phi'_t\frac{Inv_t}{K_{t-1}}\right)$$
$$1 = q^{inv}_t\Phi'_t$$

Aggregate labor supply and demand,

$$N^s_t = N^d_t,$$
$$Y_t = L_{p,t}Y^{aggr}_t$$

Market clearing condition,

$$Y^{aggr}_t = C_t + Inv_t + Gov_t$$

Government budget constraint,

$$D_{t-1}(t) = Tax_t - Gov_t + P^{real}_t D_t(t+1)$$

Capital labor ratio,

$$W_t = \frac{(1-\kappa)}{\kappa}R^K_t\frac{K_{t-1}}{N^d_t}$$

Optimal price setting,

$$\left[\frac{1}{1-\alpha}\left(1-\alpha\left(\frac{1}{\Pi_t}\right)^{(1-\eta)}\right)\right]^{\frac{1}{(1-\eta)}} F_t = \frac{\nu\kappa^{-\kappa}(1-\kappa)^{-(1-\kappa)}R^{K\,\kappa}_t W^{(1-\kappa)}_t J_t}{Z_t A^{1-\kappa}_t}$$
$$F_t = 1+\alpha\mathbb{E}_t\left[M^{nom}_{t,t+1}\left(\frac{Y^{aggr}_{t+1}}{Y^{aggr}_t}\right)\Pi^{\eta}_{t+1}F_{t+1}\right]$$
$$J_t = 1+\alpha\mathbb{E}_t\left[M^{nom}_{t,t+1}\left(\frac{Z_t}{Z_{t+1}}\right)\left(\frac{A_t}{A_{t+1}}\right)^{1-\kappa}\left(\frac{R^K_{t+1}}{R^K_t}\right)^{\kappa}\left(\frac{W_{t+1}}{W_t}\right)^{(1-\kappa)}\left(\frac{Y^{aggr}_{t+1}}{Y^{aggr}_t}\right)\Pi^{(1+\eta)}_{t+1}J_{t+1}\right]$$

Price dispersion.

$$L_{p,t} = \int_0^1\left(\frac{P_t(j)}{P_t}\right)^{-\eta}dj = (1-\alpha)\left(\frac{P^*_t}{P_t}\right)^{-\eta} + \alpha\left(\frac{P_{t-1}}{P_t}\right)^{-\eta}L_{p,t-1}$$

Price aggregator.

$$1 = (1-\alpha)\left(\frac{P^*_t}{P_t}\right)^{1-\eta} + \alpha\left(\frac{P_{t-1}}{P_t}\right)^{1-\eta}$$

Nominal pricing kernel,

$$M^{nom}_{t-1,t} \quad = \quad \frac{M_{t-1,t}}{\Pi_t} \tag{C.6}$$

Euler equation,

$$\frac{1}{R^{(1)}_t} \quad = \quad \mathbb{E}_t[M^{nom}_{t,t+1}] \tag{C.7}$$

Real bond price,

$$P^{real}_t \quad = \quad \mathbb{E}_t[M_{t,t+1}] \tag{C.8}$$

Taylor rule,

$$\frac{R^{(1)}_t}{R} \quad = \quad \left(\frac{R^{(1)}_{t-1}}{R}\right)^{\rho_r} \left(\frac{\Pi_t}{\Pi^*}\right)^{(1-\rho_r)\rho_\pi} \left(\frac{Y^{aggr}_t/A_t}{Y^{aggr}_{t-1}/A_{t-1}}\right)^{(1-\rho_r)\rho_x} e^{u_t}, \tag{C.9}$$

where g_t, u_t and z_t are exogenous shocks to government spending, monetary policy and productivity, respectively:

$$\begin{aligned}
g_{t+1} &= (1-\phi_g)\theta_g + \phi_g g_t + \phi_{g,d}\left(\frac{D_t(t+1)}{Y^{aggr}_t} - \frac{D}{Y^{aggr}}\right) + \phi_{g,y}\log\left(\frac{Y^{aggr}_t}{Y^{aggr}}\right) + e^{\sigma_{g,t+1}}\epsilon_{g,t+1} \\
\sigma_{g,t+1} &= (1-\phi_{\sigma_g})\theta_{\sigma_g} + \phi_{\sigma_g}\sigma_{g,t} + \sigma_{\sigma_g}\epsilon^g_{\sigma,t+1} \\
\tau^k_{t+1} &= (1-\phi_{\tau^k})\theta_{\tau^k} + \phi_{\tau^k}\tau^k_t + \phi_{\tau^k,d}\left(\frac{D_t(t+1)}{Y^{aggr}_t} - \frac{D}{Y^{aggr}}\right) + \phi_{\tau^k,y}\log\left(\frac{Y^{aggr}_t}{Y^{aggr}}\right) + e^{\sigma_{\tau^k,t+1}}\epsilon_{\tau^k,t+1} \\
\sigma_{\tau^k,t+1} &= (1-\phi_{\sigma_{\tau^k}})\theta_{\sigma_{\tau^k}} + \phi_{\sigma_{\tau^k}}\sigma_{\tau^k,t} + \sigma_{\sigma_{\tau^k}}\epsilon_{\sigma,t+1} \\
z_{t+1} &= \phi_z z_t + e^{\sigma_{z,t+1}}\epsilon_{z,t+1} \\
\sigma_{z,t+1} &= (1-\phi^z_\sigma)\theta^z_\sigma + \phi^z_\sigma\sigma_{z,t} + \sigma^z_\sigma\epsilon^z_{\sigma,t+1} \\
\Delta a_{t+1} &= (1-\phi_a)g_a + \phi_a\Delta a_t + \sigma_a\epsilon_{a,t+1} \\
u_{t+1} &= \sigma_u\epsilon_{u,t+1},
\end{aligned}$$

Finally, balanced growth is achieved by specifying φ_t to be cointegrated with A_t, as in Colacito, Croce, Ho, and Howard (2017), in the following recursive process:

$$\log\left(\frac{\varphi_t}{A_t}\right) \quad = \quad \phi_\varphi\log\varphi + (1-\phi_\varphi)g_a - (1-\phi_\varphi)\left[\Delta a_t - \log\left(\frac{\varphi_{t-1}}{A_{t-1}}\right)\right].$$

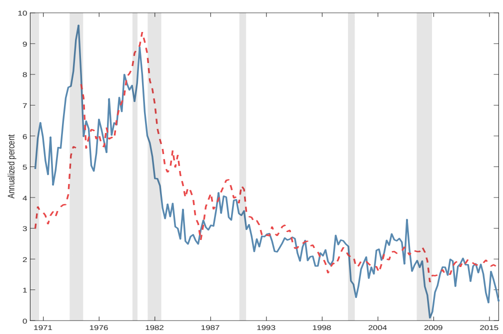
ϕ_φ is calibrated to be 0.1.

D VAR Analysis

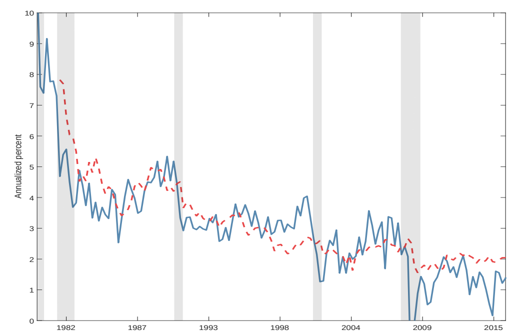
All VARs are estimated in levels with two lags of each variable, an intercept term, and a time trend. None of the results changes if we use a VAR with four lags, an intercept term, but no time trend. Also, in the empirical analysis we proxy for the nominal price level with GDP deflator; proxying for the nominal price level with the BLS consumer price index delivers almost identical results. Similarly, replacing the 5-year yield with the 10-year yield delivers identical results. Finally, to improve precision, we impose a Minnesota prior (see Hamilton 1994, p. 360) on the estimation and compute confidence bands by drawing from the posterior.

As a preliminary check, we investigate the forecast of inflation implied by our VAR. Inflation is a key variable in our model, and in the data: covariances between shocks to current and expected inflation, and bond prices determine the sign and magnitude of bond risk premia. Moreover, for our analysis of the variance ratio in Section **??** to be valid, it is important to verify that inflation forecasts implied by our dynamic VAR model are accurate, in the sense that they capture investor inflation expectations. Figure D.1 shows that this is indeed the case: The dashed line are forecasts of GDP (Panel A) and CPI (Panel B) inflation taken from the Philadelphia Fed Survey of Professional Forecasters (SPF). The solid line reports estimated inflation forecasts from the VAR model. The figure documents that survey- and model-based forecasts of GDP and CPI inflation closely track each other.

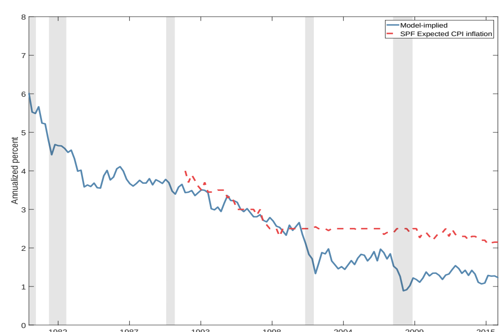
Figure D.1: 1- and 10-year ahead inflation forecasts from surveys and VAR model



(a) GDP deflator.



(b) CPI.



(c) CPI.

The figure displays expected inflation over 1-, Panels (a) and (b), and 10-years, Panel (c), from the empirical VAR (blue solid line) and from the SPF forecasts (red dashed line). The model underlying the solid line is the eight variables VAR with two lags described in this Appendix. The model uses GDP inflation in Panel (a), and CPI inflation in Panels (b) and (c). These two series are contrasted with forecasts, as of date t in the horizontal axis, of average GDP inflation, Panel (a), and average CPI inflation, Panels (b) and (c). CPI forecasts are unavailable prior to 1981:Q3. The SPF forecasts are not used in model estimation.

To estimate the dynamic causal effects of *level* shocks to fiscal policy (government spending and capital income tax rates) we combine the structural VAR (SVAR) estimators with Instrumental Variable (IV) techniques. Following the terminology in Stock and Watson (2017), we refer to this methodology as the SVAR-IV. This method was introduced by Stock (2008), and has been used by Stock and Watson (2012), Mertens and Ravn (2013), Gertler and Karadi (2015), Ramey and Zubairy (2018), and a growing list of other researchers. See also Ramey (2016) for a review. The intuition behind this approach is to find external instruments that are: (1) contemporaneously correlated with the structural policy shocks of interest (a.k.a. relevance condition); (2) contemporaneously uncorrelated with the other structural shocks (exogeneity condition). We refer to Mertens and Ravn (2013), Montiel Olea et al. (2016), and Stock and Watson (2017) for a detailed econometric description of the SVAR-IV approach.

Our instrument for government spending is the one-quarter ahead forecast revision of the growth rate of real federal spending, as implied by the SPF. Importantly for our purpose, Ramey (2011) shows that while a defense news variable based on military spending is not very informative in a sample that excludes the WWII or the Korean War like our own, a news variable based on professional forecasters is a powerful instrument for government spending shocks in such a sample. We also follow Perotti (2011), and we use forecast revisions rather than forecast errors. See Section 5.4 in Perotti (2011) for an in-depth discussion. More specifically, let f_t be the log of federal government spending, and denote with $f^e_{t|t-1}$ the SPF expectation of federal spending. We further define $\Delta f^e_{t|t} = f^e_{t|t} - f^e_{t-1|t}$. The revision of expectation of $\Delta f_t = f_t - f_{t-1}$ is given by $\Delta f^e_{t|t} - \Delta f^e_{t|t-1}$. Our instrument is the residual of a regression of spending revision onto the output gap and federal surplus (see Auerbach, 2003). Such a construction of the instrument is essential to address the "anticipation" or "non-fundamentalness" problem (see, e.g. Lippi and Reichlin, 1994).

Our instrument for capital tax rates is given by the narrative account of legislated federal corporate income tax liability changes in the United States developed by Mertens and Ravn (2013). To comply with the exogeneity condition, which requires that the instruments are orthogonal to all nontax structural shocks, Mertens and Ravn (2013) follow the Romer and Romer (2009) approach, and retain only those changes in tax liabilities that are unrelated to the current state of the economy. The final narrative measure contains 16 observations for corporate income tax liability changes. Importantly, the average corporate income tax rate used in the VAR by Mertens and Ravn (2013) has a high correlation (over the common sample) of about 92% with our capital tax rate series described in Section A.

Lastly, to recover the *uncertainty* shocks, we use a Cholesky decomposition with the following ordering: four fiscal policy variables (g_t, $\sigma_{g,t}$, τ^k, and $\sigma_{\tau^k,t}$), output, inflation, the one-quarter yield, and the 5-year yields. Changing the ordering of the fiscal instruments, i.e. using (τ^k, and $\sigma_{\tau^k,t}$, followed by g_t, $\sigma_{g,t}$) does not affect the results. Both orderings are motivated by our view that the fiscal uncertainty shocks are exogenous. This identification approach has been used in the literature on uncertainty, see e.g. Baker et al. (2016), Basu and Bundick (2017), and Fernández-Villaverde et al. (2015).

E Additional Results

Table E.1 reports a series of robustness checks for the main results of Table **??**. Each regression in Table E.1 includes G, G vol, and MWD/GDP, and controls for variables that proxy for the state of the economy. More specifically, we include: non-farm payroll, output gap, and GDP growth. We also control for the CP (Cochrane and Piazzesi, 2005) factor since Koijen et al. (2017) show that it forecasts future economic activity at business cycle horizons. Finally, to address the concern that each of these series can capture different aspects of economic growth, we also include as a control variable a measure of "Real activity" which is obtained from more than 130 macroeconomic and financial variables (Ludvigson and Ng, 2009).[4] For each specification where we control for the state of the macroeconomy, we also run a companion regression which - besides the macroeconomic state - controls for the information from the term structure that is contained in first three principal components of the yield curve. The sole exception is the CP factor since this variable is already constructed from the yield curve. The Table conveys an unequivocal message. At two years maturity, G and G vol are significant predictors of bond excess returns across all specifications. At long maturity, G is, again, significant across all specifications, and G vol is always significant except

[4]Ludvigson and Ng (2009) call the first principal component "real activity" because it is highly correlated with standard measures of real activity. For example, its correlation with log differenced industrial production exceeds 0.8.

when the slope (or a variable highly correlated with the slope, like CP) is included among the control variables. This is fully consistent with our analysis in the main text: "[...] the correlation between the slope and the government spending uncertainty series makes it hard for OLS to discern between the two predictors." Interestingly, even the inclusion of output gap (a very robust macro predictor of bond returns, see Cooper and Priestley (2009)) does not overturn the statistical significance of G vol (see specification (7) of Panels A and B). In fact, using output gap together with government spending variables delivers an impressive R^2 of 30% for long maturities (relative to a 17% when only information from the term structure is included in the forecasting regression – see specification (6) in Panel B of Table **??**).

Table E.2 reports the pricing errors. Each row of the table reports the error for a specific portfolio (the first six rows refer to bond portfolios, the seventh is the market, the next 25 rows are the Fama-French book-to-market and size portfolios). Each column reports a different model. The first column contains the risk-neutral SDF and therefore reports the average pricing errors to be explained. The model in the second column has the market return as the only factor (MKT). The last three columns refer to our fiscal models, the first includes only government spending level, the second includes exclusively government spending uncertainty, and the last one includes both government spending level and uncertainty. There are two important takeaways from this Table. First, with regard to the model which includes only government spending level (specification 3), the portfolio error improves in 20 instances (out of 32) when compared to the CAPM. Second, the model with both level and uncertainty (specification 5) is the best model in 17 instances among all five candidate models. Hence, the improvement of the fiscal model over the CAPM, and the improvement of the fiscal model with level and uncertainty relative to a model with just level or uncertainty, are not due to few outliers but rather due to an improvement across asset classes (bonds and stocks) and, within stocks, across size and book-to-market quintiles.

Moreover, Table E.3 adds industry portfolios to the cross-section of test assets used in Table **??**. This helps breaking the factor structure in book-to-market and size sorted portfolios. Adding industry portfolios reduces the fit of our fiscal models only by 5% (the R^2 in Panels B, C and D of Table **??** are 67%, 72%, 74% compare to 62%, 67%, 69% in Table E.3) without affecting the statistical significance of our fiscal factors. Importantly, the sampling variability of our cross-sectional R^2 remains low across all specifications.

Further, Table E.4 quantifies the contribution of each shock to the variability of macroeconomic and financial variables by shutting down one shock at the time and examine the volatility of the endogenous variables. Panel A shows that transitory productivity level shocks are an important driver of consumption and output volatilities whereas uncertainty shocks to transitory productivity contribute to inflation volatility. Moreover, government spending and capital tax (level and uncertainty) shocks also generate sizeable effects on investment, hours and inflation. In particular, government spending level and uncertainty shocks are significant drivers of the variability in hours. Tax rate level and uncertainty shocks in turn have strong influence on the variability of investment. Panel B of Table E.4 shows that uncertainty in government spending is a key driver of the variation in the slope of the term structure. All shocks are important drivers of nominal yields movements, except for permanent productivity and monetary shocks. To summarize, we find that stochastic volatility in government spending generates sizeable variation in the slope of the term structure without distorting the ability of the model to match key macroeconomic moments.

Finally, Table E.5 reports the unconditional means of nominal and real yields when the model is simulated with all but one shocks active at the time. Both transitory productivity and government spending uncertainty contribute positively to the slope of the nominal and real term structures in the model.

Figure E.1 reports the autocorrelation functions in the data and in the model. Figure E.2 reports the impulse response functions for structural shocks other than fiscal shocks in the model. The four Panels show responses of output, price level, nominal one quarter and nominal five year rates to one standard deviation shocks to transitory productivity level and uncertainty, permanent productivity and monetary policy.

Finally, Figure E.3 plots yield shock decompositions for the baseline model and two alternative models; one with low persistence in fiscal variables and another one without stochastic volatility in fiscal variables.

Table E.1: **Forecasting Excess Returns to Treasury Bonds: 1970Q1 to 2016Q4.** This table reports coefficient estimates, corresponding reverse regression p-values, and R^2s for regressions of annual excess returns of Treasury bonds (for 2- and 5-year maturities) on fiscal variables, an indicator variable for the zero lower bound, and other predictors measured in quarter t. The column F-test reports the p-value for the hypothesis that the fiscal variables have jointly no incremental explanatory power beyond the other control variables. Reverse regression p-values (in parentheses) are calculated using the delta method of Wei and Wright (2013). Control variables include the maturity-weighted debt-to-GDP ratio, MWD/GDP (see Greenwood and Vayanos, 2014); the first three PCs of the Treasury yield curve; the first PC of many macroeconomic time series (LN) constructed by Ludvigson and Ng (2009); the CP (Cochrane and Piazzesi, 2005) factor; three measures of the state of the economy, namely Non-Farm Payroll, Output Gap, and Output Growth. Bold values indicate significance at least at the 10% level.

	Predictors												
	G	G vol	MWD/GDP	PC1	PC2	PC3	LN	CP	Payroll	Output Gap	Output Growth	R^2	F-test
					Panel A: Excess Returns on 2-year Treasury Bond								
(1)	**0.48**	**0.29**	**0.51**				0.90					0.23	
	(0.03)	(0.05)	(0.01)				(0.15)						(0.01)
(2)	**0.64**	**0.25**	**0.54**	0.59	0.11	-0.40	**0.99**					0.31	
	(0.01)	(0.05)	(0.00)	(0.16)	(0.73)	(0.11)	(0.04)						(0.00)
(3)	**0.52**	**0.29**	**0.44**					0.09				0.20	
	(0.02)	(0.04)	(0.02)					(0.47)					(0.01)
(4)	**0.44**	**0.30**	**0.53**						-0.60			0.22	
	(0.08)	(0.05)	(0.01)						(0.41)				(0.02)
(5)	**0.60**	**0.26**	**0.57**	0.64	0.08	-0.38			-0.69			0.30	
	(0.02)	(0.04)	(0.00)	(0.14)	(0.86)	(0.14)			(0.27)				(0.00)
(6)	**0.66**	**0.35**	**0.54**							0.20		0.20	
	(0.03)	(0.02)	(0.02)							(0.84)			(0.02)
(7)	**1.01**	**0.38**	**0.63**	**0.78**	0.13	-0.30				1.00		0.29	
	(0.00)	(0.01)	(0.00)	(0.06)	(0.66)	(0.24)				(0.31)			(0.00)
(8)	**0.54**	**0.32**	**0.53**								-0.39	0.20	
	(0.01)	(0.04)	(0.01)								(0.66)		(0.01)
(9)	**0.76**	**0.31**	**0.60**	0.63	0.02	-0.37					-0.31	0.28	
	(0.00)	(0.02)	(0.00)	(0.14)	(0.95)	(0.15)					(0.77)		(0.00)
					Panel B: Excess Returns on 5-year Treasury Bond								
(1)	**1.82**	**0.75**	**1.61**				1.10					0.18	
	(0.01)	(0.05)	(0.01)				(0.54)						(0.01)
(2)	**1.59**	0.38	**1.24**	1.10	1.33	-1.05	2.02					0.25	
	(0.05)	(0.21)	(0.02)	(0.37)	(0.15)	(0.22)	(0.21)						(0.03)
(3)	**1.22**	0.46	**1.02**					**0.73**				0.22	
	(0.06)	(0.18)	(0.07)					(0.07)					(0.05)
(4)	**1.79**	**0.75**	**1.64**						-0.68			0.17	
	(0.03)	(0.05)	(0.01)						(0.83)				(0.01)
(5)	**1.54**	0.40	**1.31**	1.20	1.27	-1.00			-1.35			0.25	
	(0.06)	(0.19)	(0.01)	(0.35)	(0.18)	(0.24)			(0.53)				(0.03)
(6)	**2.49**	**1.00**	**1.80**							2.20		0.18	
	(0.01)	(0.01)	(0.01)							(0.48)			(0.00)
(7)	**3.07**	**0.92**	**1.56**	**2.02**	**1.93**	-0.61				**6.12**		0.30	
	(0.00)	(0.02)	(0.01)	(0.10)	(0.03)	(0.52)				(0.06)			(0.00)
(8)	**2.07**	**0.80**	**1.62**								0.42	0.17	
	(0.00)	(0.04)	(0.01)								(0.57)		(0.00)
(9)	**2.05**	0.52	**1.37**	1.24	1.08	-0.97					0.23	0.24	
	(0.01)	(0.13)	(0.01)	(0.32)	(0.26)	(0.26)					(0.57)		(0.01)

Table E.2: **Model for Stocks and Bonds: Pricing Errors.** This table reports pricing errors for the 25 book-to-market and size sorted stock portfolios, the market portfolio, and six bond portfolios of maturities 1-2, 2-3, 3-4, 4-5, 5-10, and more than 10 years. They are expressed in percent per year (quarterly numbers multiplied by 400). Each column corresponds to a different stochastic discount factor (SDF) model. MAPE stands for the mean absolute pricing error. Specification (1) column contains the risk-neutral SDF and therefore reports the average pricing errors to be explained. The SDF model of specification (2) has the market return as the only factor (MKT). Specification (3) presents the model including government spending level and the market. Specification (4) presents the results for the model with government spending uncertainty and the market. Finally, the last specification refers to the model including government spending level and uncertainty and the market. The sample is from 1970Q1 to 2016Q4..

	(1) RN SDF	(2) MKT	(3) MKT + G level	(4) MKT + G vola	(5) MKT + G level + G vola
1-2 yr	0.72	-1.68	-1.00	-1.42	-1.41
2-3 yr	1.18	-1.46	-1.24	-1.49	-1.25
3-4 yr	1.58	-1.22	-1.23	-1.22	-1.21
4-5 yr	1.70	-1.23	-1.41	-1.25	-1.19
5-10 yr	2.15	-1.17	-1.53	-1.05	-0.56
$>$ 10 yr	3.32	-0.85	-1.38	-0.28	0.83
Market	6.49	-0.29	1.09	1.51	1.70
SG	2.74	-8.54	-6.80	-5.78	-5.05
S12	10.05	0.28	-0.39	0.43	1.31
S13	10.08	1.06	-1.02	-0.77	-0.73
S14	12.87	4.45	2.01	2.67	3.63
SV	14.25	5.25	2.39	1.90	1.85
2G	6.03	-5.01	-5.00	-4.56	-4.15
22	9.66	0.24	-1.91	-1.71	-1.21
23	10.75	1.94	1.29	0.66	0.15
24	11.83	3.19	1.02	0.24	-0.20
2V	12.36	3.40	0.21	-0.26	-0.26
3G	6.44	-4.13	-3.15	-3.17	-3.42
32	10.01	0.73	1.17	0.87	0.52
33	9.54	1.20	0.89	-0.21	-1.21
34	11.18	2.71	1.71	0.67	-0.17
3V	13.23	4.58	1.21	0.86	1.01
4G	7.71	-2.56	0.77	1.14	1.01
42	8.11	-0.87	-0.01	0.21	0.28
43	9.07	0.37	1.33	1.47	1.47
44	10.42	1.85	1.30	0.92	0.84
4V	10.94	1.92	2.18	1.66	1.14
BG	5.99	-2.93	1.06	1.01	0.39
B2	7.59	-0.76	0.36	0.97	1.38
B3	7.49	-0.04	2.94	2.86	2.38
B4	6.60	-1.41	-0.71	-0.84	-1.06
BV	8.82	1.01	3.84	3.97	3.69
MAPE		2.13	1.67	1.50	1.46

Table E.3: **Pricing Model for Stocks and Bonds: Robustness.** We estimate cross-sectional regressions with and without a constant. In particular, the table reports results from running the cross-sectional regression $\overline{R_i^e} = (\gamma) + \beta_i \lambda + \alpha_i$, where $\overline{R_i^e}$ is the mean excess return of portfolio i and β_i is the vector of factor betas of portfolio i estimated in the first-pass regression. We use the following test assets: 25 equity portfolios sorted on size and book-to-market, five industry portfolios, the market portfolio (consisting of a value-weighted stock index and a long-term government bond index), and six maturity-sorted Fama bond portfolios obtained from the CRSP. The table reports the estimates of the factor risk premia $\widehat{\lambda}$ on the factors and the constant term, Fama and MacBeth (1973) p-values (in parentheses), and the GMM-VARHAC p-values which account for sampling error in the betas (in braces). The penultimate column reports asymptotic p-values of chi-squared tests of the null hypothesis that all pricing errors are jointly zero (Pr. err. = 0). To compute the test statistic we use the OLS covariance matrix of $\widehat{\alpha}$. The last column reports the R^2 of the cross-sectional regression, and, for the model with the constant, its standard error. In addition, we also report the root mean square alpha (RMSE) and the mean absolute pricing error (MAPE) across all test assets. These are expressed as percentages per year. Return data is quarterly from 1970Q1 to 2016Q4. Bold values are significant at least at the 10% level.

Table E.3: **Pricing Model for Stocks and Bonds: Robustness (continued)**

Panel A: $\overline{R_i^e} = (\gamma) + \beta_{i,MKT}\lambda_{MKT} + \alpha_i$

Constant	λ_{MKT}	RMSE	MAPE	H_0 : Pr. error = 0 , p-value	R^2
	0.060	2.786	1.973	0.024	0.37
	(0.003)				
	{0.005}				
0.005	**0.046**	2.684	2.019	0.016	0.41
(0.097)	(0.067)				(0.27)
{0.099}	{0.079}				

Panel B: $\overline{R_i^e} = (\gamma) + \beta_{i,g}\lambda_g + \beta_{i,MKT}\lambda_{MKT} + \alpha_i$

Constant	λ_g	λ_{MKT}	RMSE	MAPE	H_0 : Pr. error = 0 , p-value	R^2
	-0.967	**0.055**	2.193	1.636	0.024	0.60
	(0.003)	(0.004)				
	{0.041}	{0.018}				
0.002	**-0.920**	0.049	2.170	1.692	0.015	0.62
(0.506)	(0.008)	(0.052)				(0.27)
{0.689}	{0.079}	{0.151}				

Panel C: $\overline{R_i^e} = (\gamma) + \beta_{i,\sigma_g}\lambda_{\sigma_g} + \beta_{i,MKT}\lambda_{MKT} + \alpha_i$

Constant	λ_{σ_g}	λ_{MKT}	RMSE	MAPE	H_0 : Pr. error = 0 , p-value	R^2
	1.164	**0.050**	2.058	1.399	0.000	0.66
	(0.002)	(0.009)				
	{0.064}	{0.024}				
0.003	**1.119**	0.041	2.002	1.495	0.000	0.67
(0.319)	(0.004)	(0.089)				(0.24)
{0.549}	{0.081}	{0.202}				

Panel D: $\overline{R_i^e} = (\gamma) + \beta_{i,g}\lambda_g + \beta_{i,\sigma_g}\lambda_{\sigma_g} + \beta_{i,MKT}\lambda_{MKT} + \alpha_i$

Constant	λ_g	λ_{σ_g}	λ_{MKT}	RMSE	MAPE	H_0 : Pr. error = 0 , p-value	R^2
	-1.010	**1.255**	**0.048**	2.043	1.351	0.000	0.66
	(0.002)	(0.002)	(0.077)				
	{0.091}	{0.075}	{0.100}				
0.005	**-0.962**	**1.288**	0.033	1.945	1.378	0.000	0.69
(0.097)	(0.006)	(0.002)	(0.189)				(0.22)
{0.406}	{0.099}	{0.079}	{0.399}				

Table E.4: **Quantitative Importance of Structural Shocks**: This table reports the quantitative importance of the structural shocks in the model. *A* and *Z* denote permanent and transitory productivity, respectively. *G* denotes government spending. Panel A (Panel B) reports the standard deviations of macro variables (asset prices) with all but one structural shocks active at the time.

Panel A: Macro Variables

	Output	**Consumption**	**Investment**	**Wages**	**Hours**	**Inflation**
All Shocks	1.73	1.48	5.87	1.31	1.52	0.63
All except A	1.64	1.43	5.76	1.23	1.49	0.63
All except Monetary	1.68	1.44	5.78	1.21	1.39	0.61
All except Z Level	1.12	0.93	5.31	0.70	1.49	0.59
All except Z Uncertainty	1.66	1.41	5.71	1.23	1.50	0.36
All except G Level	1.45	1.36	5.54	1.29	0.81	0.60
All except G Uncertainty	1.53	1.38	5.63	1.28	1.01	0.57
All except Tax Level	1.70	1.47	4.10	1.30	1.43	0.63
All except Tax Uncertainty	1.71	1.46	3.76	1.30	1.43	0.63

Panel B: Asset Prices

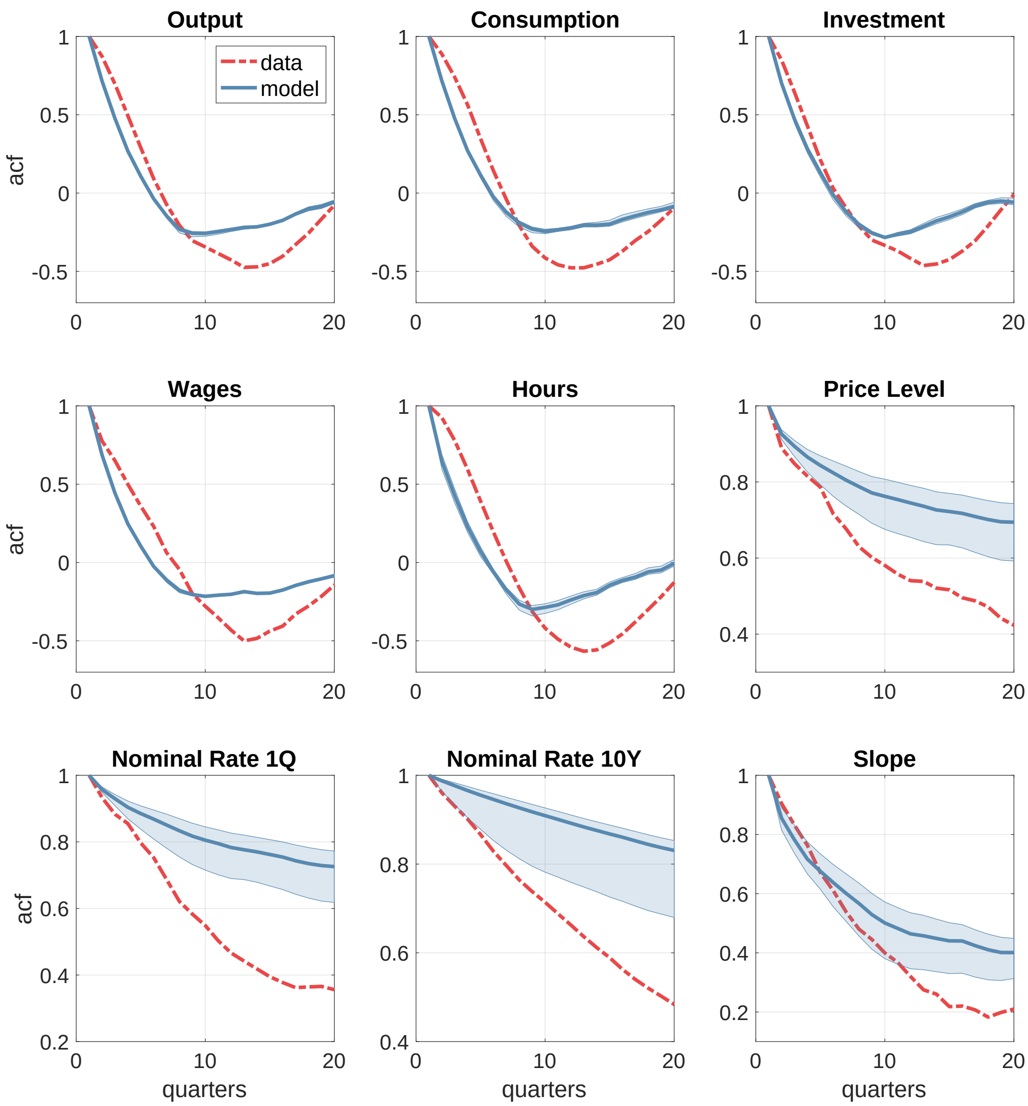
	Nominal Yields					
	1Q	**3Y**	**5Y**	**7Y**	**10Y**	**Slope**
All Shocks	3.70	3.17	2.91	2.68	2.36	1.77
All except A	3.69	3.13	2.88	2.65	2.35	1.75
All except Monetary	3.63	3.14	2.88	2.66	2.35	1.62
All except Z Level	3.47	2.92	2.67	2.45	2.16	1.71
All except Z Uncertainty	2.00	1.31	1.10	0.95	0.80	1.49
All except G Level	3.52	3.07	2.83	2.62	2.31	1.55
All except G Uncertainty	3.35	3.05	2.84	2.63	2.33	1.35
All except Tax Level	3.69	3.15	2.89	2.66	2.35	1.66
All except Tax Uncertainty	3.69	3.13	2.87	2.64	2.33	1.69

Table E.5: **Nominal and Real Term Structure: The Effect of Structural Shocks.** This table reports the mean of the nominal and real term structure under different simulations. In particular, it shows the nominal and real yields across different maturities resulting from simulations with all but one structural shock active at the time. A and Z denote permanent and transitory productivity, respectively. G denotes government spending. All reported yields are expressed in annualized percentages.

	Nominal Term Structure					
	1Q	**3Y**	**5Y**	**7Y**	**10Y**	**Slope**
All Shocks	5.62	5.85	6.09	6.38	6.85	1.23
All except A	5.61	5.83	6.08	6.37	6.85	1.24
All except Monetary	5.67	5.85	6.10	6.39	6.86	1.19
All except Z Level	5.64	5.86	6.11	6.40	6.87	1.23
All except Z Uncertainty	6.41	6.59	6.79	7.03	7.43	1.01
All except G Level	5.75	5.93	6.17	6.45	6.92	1.17
All except G Uncertainty	5.78	5.93	6.16	6.44	6.91	1.13
All except Tax Level	5.69	5.88	6.13	6.41	6.88	1.19
All except Tax Uncertainty	5.65	5.87	6.12	6.41	6.88	1.23

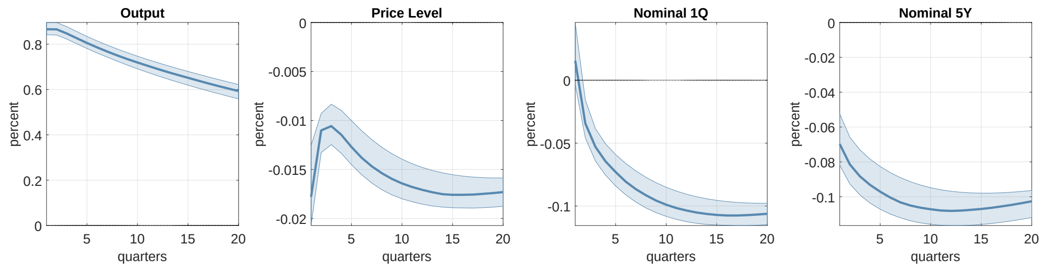
	Real Term Structure					
	2Y	**3Y**	**5Y**	**7Y**	**10Y**	**Slope**
All Shocks	3.88	3.91	3.98	4.08	4.23	0.37
All except A	3.87	3.90	3.98	4.07	4.23	0.38
All except Monetary	3.89	3.91	3.99	4.08	4.24	0.36
All except Z Level	3.88	3.91	3.99	4.08	4.24	0.37
All except Z Uncertainty	4.15	4.18	4.24	4.31	4.44	0.31
All except G Level	3.92	3.94	4.01	4.10	4.26	0.35
All except G Uncertainty	3.93	3.95	4.01	4.10	4.26	0.33
All except Tax Level	3.90	3.93	4.00	4.09	4.24	0.36
All except Tax Uncertainty	3.89	3.92	3.99	4.09	4.24	0.37

Figure E.1: Autocorrelation Functions

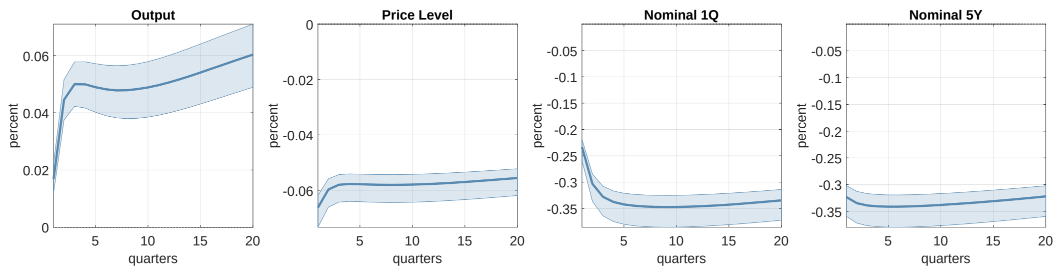


In this figure, we plot autocorrelation functions of the observable variables in the model and the data. The dashed line corresponds to the data. The solid line is the model-implied median and the shaded areas correspond to 95% confidence bands when considering parameter uncertainty. The sample period for the data is from 1970Q1 to 2016Q4.

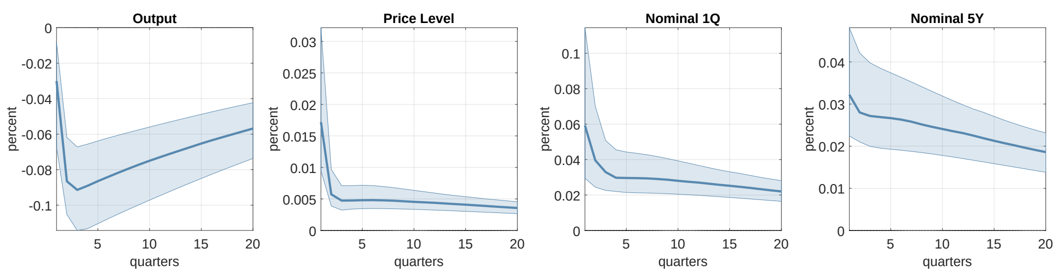
Figure E.2: Impulse Responses for Structural Shocks



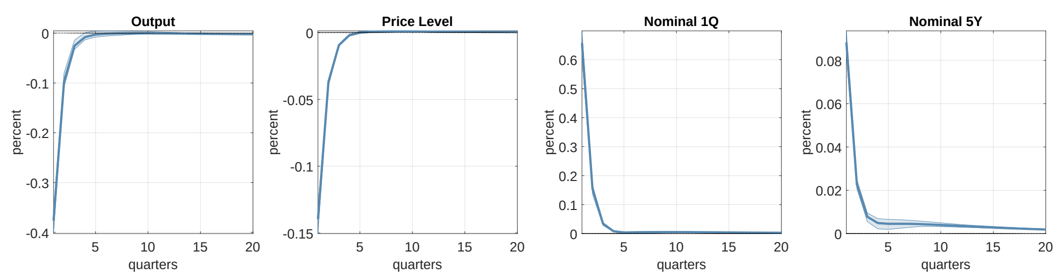
(a) Transitory Productivity Level Shock.



(b) Transitory Productivity Uncertainty Shock.



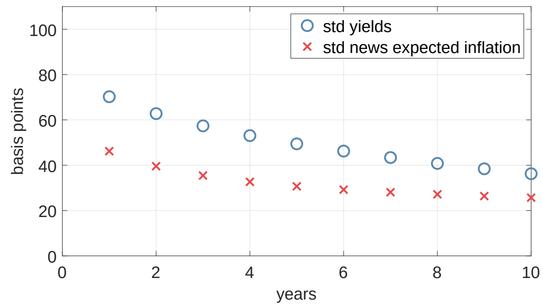
(c) Permanent Productivity Level Shock.



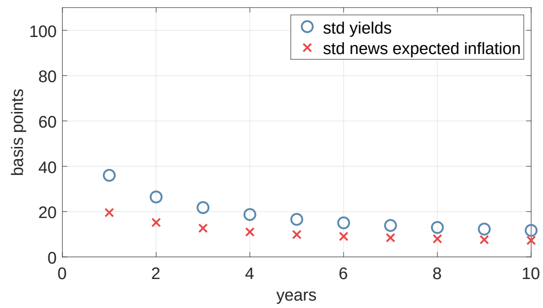
(d) Monetary Shock.

In this figure, we plot the impulse responses of output, inflation, the nominal short- and long-term bond yields to a positive one standard deviation shock to transitory productivity level and uncertainty, to permanent productivity and to monetary policy. The blue shaded areas correspond to 95% confidence bands when considering parameter uncertainty.

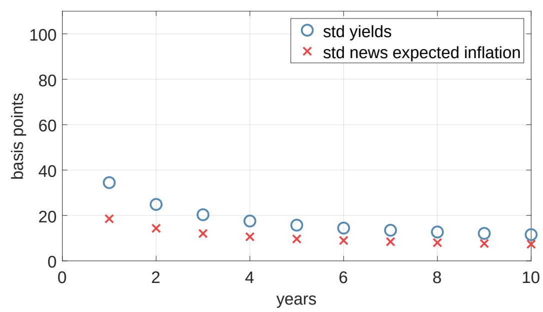
Figure E.3: Yield Shock Decomposition



(a) Baseline Model - Theoretical



(b) Low Persistence in Fiscal Variables



(c) No SV in Fiscal Variables

In this figure, we plot in Panel a the theoretical model-implied unconditional standard deviations of quarterly shocks. Unconditional model-implied standard deviations of yield shocks (circles) and news about expected inflation (Xs) are determined from our baseline model. Panels b and c show corresponding results for model variants with low persistence in fiscal variables and no stochastic volatility in fiscal variables, respectively.

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