Fiscal News and Macroeconomic Volatility
—
Online Appendix

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1 IRFs to Government Spending Shocks

Figure 1 displays the impulse responses to one percent surprise (solid line) and anticipated (dashed line) increases in government spending.[1] The bottom row shows that the government spending shocks are both relatively persistent and lead to a significant deterioration of the government budget, resulting in a large and persistent buildup of debt. This debt buildup via the feedback embedded in the fiscal rule somewhat dampens the persistence in government spending, which would be even larger otherwise. The fiscal feedback is also responsible for the behavior of the capital and the labor tax rate. The former falls due to the increase in debt and the decrease of investment that results from a crowding out effect. In contrast, labor taxes rise due to the debt feedback and the positive feedback from the increase in labor services.

First, consider the surprise government spending shock. As would be expected, it acts like a standard demand shock, driving up output and inflation, and crowding out investment and consumption. As households tap into the capital stock to produce the additional government consumption while keeping up private consumption, they ramp up capacity utilization so that capital services increase. At the same time, households start working more, with an additional incentive to increase labor supply stemming from the higher marginal product of labor due to the increase in capital services. When capital services return to their steady state, this substitution effect dissipates and the wealth effect on labor supply, which was estimated to be small, starts to dominate. As a result, the real wage drops below steady state. The responses to the surprise government shock are similar to the responses to a spending

[1] The two shocks have standard deviations of 0.033% and 1.602%, respectively, and have been scaled to have a size of one percent each.

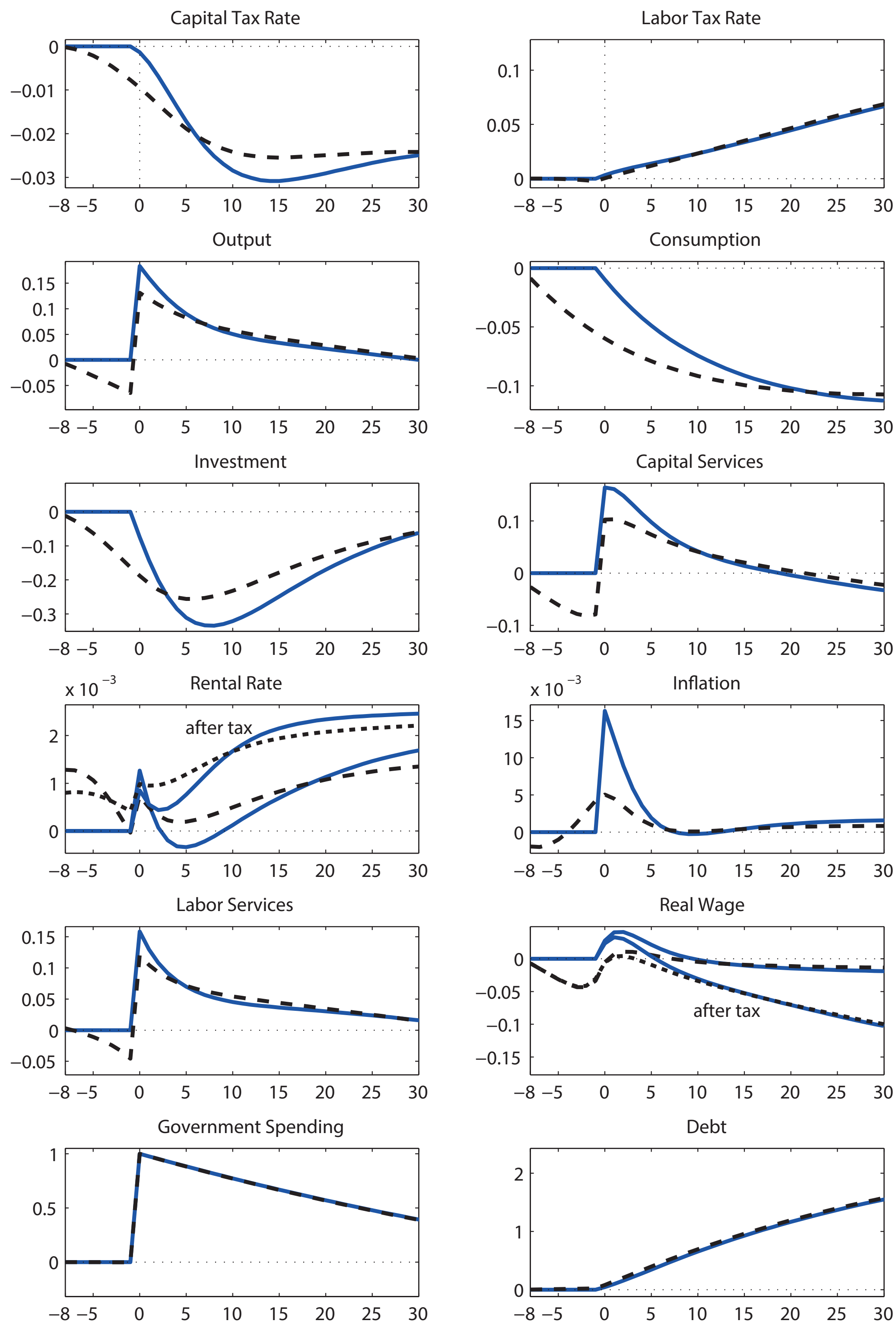

Figure 1: Impulse responses to unanticipated and anticipated government spending shocks. *Notes*: solid line: impulse responses to an unanticipated 1 percent increase in government spending g_t; dashed line (short-dashed for after-tax measures): impulse responses to an eight period anticipated 1 percent increase in government spending g_t that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

"news"-shock in Ramey (2011).[2] As in her study, spending, output, hours and labor income taxes rise, while consumption and investment fall. Moreover, the implied peak multiplier in her study is between 1.1 and 1.2, while it is about 0.9 in our baseline model.

Second, for the anticipated government spending shock, agents again have more time to adjust. Due to strong consumption habits, consumption starts falling immediately. Moreover, to save investment adjustment costs, households gradually reduce investment in order for it to be low when the government spending shock realizes and disinvestment is needed most. At the same time, capacity utilization u_t and thus capital depreciation $\delta(u_t)$ falls during the anticipation phase. The resulting resource savings from the lower capital depreciation rate temporarily overcompensate the disinvestment in capital so that the physical capital stock actually rises while capital services fall (the impulse responses for capacity utilization and capital stock are omitted for brevity). The lower capital services also depress the real wage via their effect on the marginal product of labor. This substitution effect overcompensates the wealth effect on the labor supply. The larger capital stock that is built up during the anticipation phase is used up when the shock actually realizes. In this case, households still disinvest, but ramp up capital utilization, so that capital services now rise. This increases the depreciation of the capital stock, which starts to fall. The increase in capital services upon realization of the shock is similar to the response of the surprise shock and thus also triggers a similar response of the real wage and, correspondingly, of labor services.

[2] Although the Ramey (2011)-shocks are expected changes in defense spending, spending actually starts rising one quarter after the announcement. Thus, the spending "news"-variable more closely corresponds to a surprise shock in our framework.

2 IRFs to Fiscal Shocks (Federal)

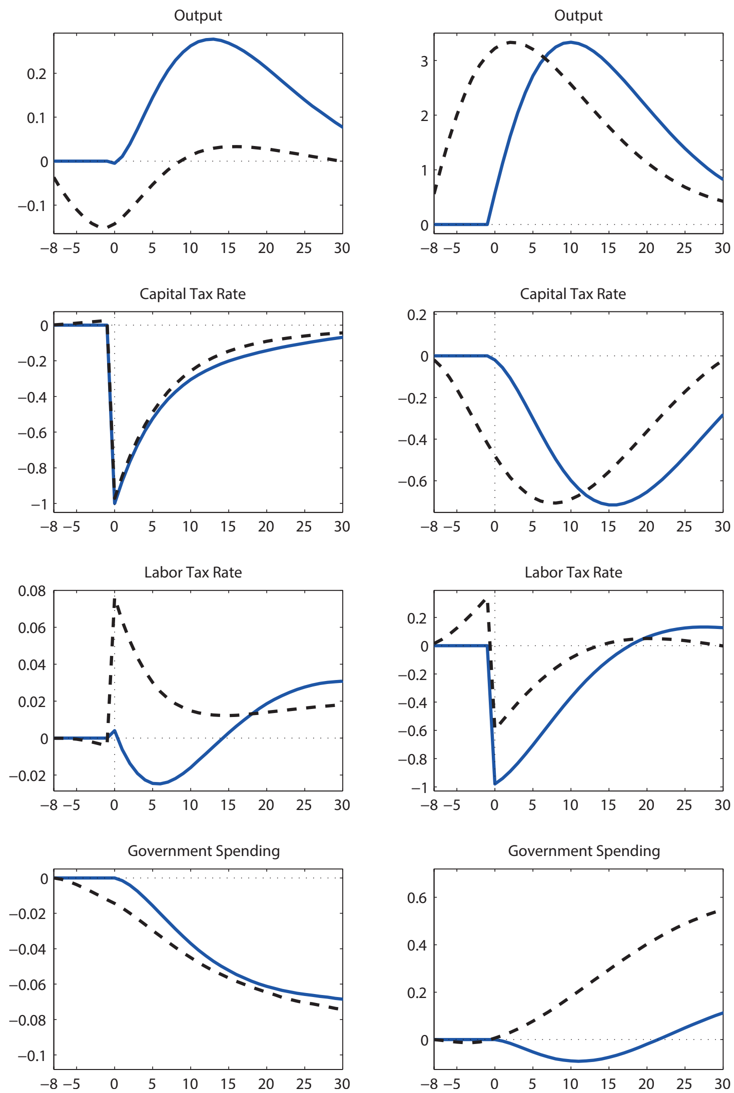

Figure 2: Impulse responses to unanticipated and anticipated capital tax shocks (left panel) and labor tax shocks (right panel), using federal government data only.
Notes: solid line: impulse responses to an unanticipated 1 percent increase in the respective tax rate; dashed line: impulse responses to an eight period anticipated 1 percent increase in the respective tax rate that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state.

3 Additional and Expanded Tables

Table 1: Parameters fixed prior to estimation

Parameter	Value	Target/Motivation (matched to quarterly data)
σ_c	2	Common in RBC models
γ	0.00064	Set labor effort in steady state to 20%
β	0.99	Common in RBC models
δ_0	0.025	Annual physical depreciation of 10%
δ_1	0.0484	Set capacity utilization $u = 1$ in steady state
δ_τ	0.05	Twice the rate of physical depreciation δ_0 (Auerbach, 1989)
α	0.3253	Match capital share in output
ψ	0.055	Set profits to zero
η_p	10	Set price markup to 11% in steady state
η_w	10	Set wage markup to 11% in steady state
μ^y	1.0045	Match average sample growth rate of per capita output
μ^a	0.9957	Match average sample growth rate of relative price of investment
τ^n	0.207	Match average sample labor tax rate
τ^k	0.387	Match average sample capital tax rate
G/Y	0.2038	Match average sample mean
B/Y	2	Match average sample gross federal debt to GDP ratio of 50%
T	-0.0145	Balance government budget in steady state
Π	1.0089	Match average sample mean

Table 2: Prior and Posterior Distributions

Parameter	Prior distribution			Posterior distribution				Federal
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent	Mean
			Preference and Technology Parameters					
χ_w	Beta	0.50	0.20	0.583	0.087	0.439	0.728	0.661
χ_p	Beta	0.50	0.20	0.005	0.003	0.001	0.011	0.004
θ_p	Beta	0.50	0.20	0.715	0.010	0.699	0.731	0.881
θ_w	Beta	0.50	0.20	0.622	0.020	0.588	0.653	0.486
σ_l	Gamma	2.00	0.75	0.786	0.110	0.610	0.969	2.598
σ_s	Beta	0.50	0.20	0.047	0.004	0.041	0.054	0.020
κ	Gamma	4.00	1.50	4.069	0.198	3.737	4.394	3.901
δ_2/δ_1	Inv.-Gamma	0.50	0.15	0.110	0.005	0.102	0.118	0.090
ϕ_c	Beta	0.70	0.10	0.939	0.006	0.928	0.948	0.864

Table 2: Prior and Posterior Distributions - Continued

Parameter	Prior distribution			Posterior distribution				Federal
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent	Mean
				Preference Shock				
ρ_{pref}	Beta	0.50	0.20	0.085	0.032	0.034	0.139	0.106
σ_{pref}	Inv.-Gamma	0.10	2.00	12.277	1.219	10.211	14.315	5.488
				Wage Markup Shock				
ρ_w	Beta	0.50	0.20	0.964	0.005	0.956	0.972	0.988
σ_w	Inv.-Gamma	0.10	2.00	15.128	1.180	13.161	17.123	0.031
σ_w^4	Inv.-Gamma	0.10	2.00	0.033	0.019	0.025	0.066	7.786
σ_w^8	Inv.-Gamma	0.10	2.00	12.309	1.415	10.018	14.650	0.031
				Stationary Technology Shock				
ρ_z	Beta	0.50	0.20	0.952	0.004	0.945	0.959	0.908
σ_z	Inv.-Gamma	0.10	2.00	0.458	0.030	0.408	0.505	0.553
σ_z^4	Inv.-Gamma	0.10	2.00	0.543	0.028	0.494	0.587	0.128
σ_z^8	Inv.-Gamma	0.10	2.00	0.505	0.030	0.458	0.554	0.502
				Non-Stationary Technology Shock				
ρ_x	Beta	0.50	0.20	0.623	0.023	0.583	0.658	0.455
σ_x	Inv.-Gamma	0.10	2.00	0.402	0.029	0.355	0.450	0.588
σ_x^4	Inv.-Gamma	0.10	2.00	0.394	0.028	0.346	0.439	0.591
σ_x^8	Inv.-Gamma	0.10	2.00	0.329	0.030	0.281	0.378	0.245
				Stationary Investment-Specific Productivity Shock				
ρ_{zI}	Beta	0.50	0.20	0.967	0.004	0.960	0.973	0.998
σ_{zI}	Inv.-Gamma	0.10	2.00	0.357	0.021	0.324	0.393	0.354
σ_{zI}^4	Inv.-Gamma	0.10	2.00	0.040	0.032	0.022	0.116	0.083
σ_{zI}^8	Inv.-Gamma	0.10	2.00	0.032	0.013	0.025	0.057	0.031
				Non-Stationary Investment-Specific Productivity Shock				
ρ_a	Beta	0.50	0.20	0.843	0.010	0.826	0.859	0.955
σ_a	Inv.-Gamma	0.10	2.00	0.199	0.012	0.180	0.219	0.086
σ_a^4	Inv.-Gamma	0.10	2.00	0.158	0.013	0.137	0.180	0.065
σ_a^8	Inv.-Gamma	0.10	2.00	0.166	0.011	0.148	0.185	0.092

Table 2: Prior and Posterior Distributions - Continued

Parameter	Prior distribution			Posterior distribution				Federal
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent	Mean
				Government Spending Shock				
ρ_g	Beta	0.50	0.20	0.976	0.002	0.973	0.980	0.960
ρ_{xg}	Beta	0.50	0.20	0.931	0.011	0.913	0.949	0.826
σ_g	Inv.-Gamma	0.10	2.00	0.033	0.017	0.025	0.060	0.030
σ_g^4	Inv.-Gamma	0.10	2.00	0.033	0.021	0.024	0.067	0.033
σ_g^8	Inv.-Gamma	0.10	2.00	1.602	0.023	1.563	1.640	2.404
ϕ_{gD}	Normal	0.00	1.00	-0.003	0.000	-0.004	-0.003	-0.009
				Labor Tax Shock				
$\rho_{\tau n}$	Beta	0.70	0.20	0.936	0.012	0.914	0.953	0.998
$\sigma_{\tau n}$	Inv.-Gamma	0.10	2.00	0.227	0.061	0.132	0.335	0.174
$\sigma_{\tau n}^4$	Inv.-Gamma	0.10	2.00	0.213	0.104	0.025	0.333	0.215
$\sigma_{\tau n}^8$	Inv.-Gamma	0.10	2.00	0.049	0.064	0.024	0.243	0.270
ϕ_{nD}	Normal	0.00	1.00	0.003	0.001	0.002	0.004	0.001
ϕ_{nl}	Normal	0.00	1.00	0.021	0.004	0.015	0.028	0.028
				Capital Tax Shock				
$\rho_{\tau k}$	Beta	0.70	0.20	0.765	0.024	0.724	0.802	0.875
$\sigma_{\tau k}$	Inv.-Gamma	0.10	2.00	0.929	0.079	0.796	1.055	1.060
$\sigma_{\tau k}^4$	Inv.-Gamma	0.10	2.00	0.898	0.091	0.739	1.043	1.173
$\sigma_{\tau k}^8$	Inv.-Gamma	0.10	2.00	1.078	0.080	0.938	1.206	1.298
ϕ_{kD}	Normal	0.00	1.00	-0.002	0.001	-0.003	-0.001	-0.001
ϕ_{kI}	Normal	0.00	1.00	0.019	0.003	0.015	0.023	-0.009
				Tax Shock Correlations				
$\{\varepsilon_{\tau k}, \varepsilon_{\tau n}\}$	Beta*	0.00	0.30	0.517	0.122	0.316	0.715	-0.103
$\{\varepsilon_{\tau k}^4, \varepsilon_{\tau n}^4\}$	Beta*	0.00	0.30	-0.165	0.149	-0.392	0.083	-0.727
$\{\varepsilon_{\tau k}^8, \varepsilon_{\tau n}^8\}$	Beta*	0.00	0.30	0.055	0.212	-0.292	0.408	-0.456
				Monetary Policy				
ρ_R	Beta	0.50	0.20	0.828	0.007	0.815	0.840	0.864
σ_R	Inv.-Gamma	0.10	2.00	0.386	0.019	0.358	0.420	0.317
ϕ_{R_Π}	Gamma	1.50	3.00	2.265	0.041	2.202	2.335	2.392
ϕ_{R_Y}	Gamma	0.50	3.00	0.000	0.000	0.000	0.000	0.000

Table 2: Prior and Posterior Distributions - Continued

Parameter	Prior distribution			Posterior distribution				Federal
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent	Mean
				Measurement Error				
σ_y^{me}	Uniform	0.01	0.01	0.000	0.000	0.000	0.000	0.000
σ_w^{me}	Uniform	0.07	0.04	0.142	0.000	0.142	0.142	0.142
$\sigma_{\tau n}^{me}$	Uniform	0.46	0.26	0.234	0.024	0.193	0.272	0.318
$\sigma_{\tau k}^{me}$	Uniform	0.40	0.23	0.792	0.000	0.792	0.792	0.792

Notes: The standard deviations of the shocks and measurement errors have been transformed into percentages by multiplying with 100. Beta* indicates that the correlations follow a beta-distribution stretched to the interval [-1,1].

Table 3: Variance Decomposition (in %):

	Pref./Wage Markup			Technology							Policy						
	ξ^{pref}	ε_w^0	$\varepsilon_w^{4,8}$	ε_z^0	$\varepsilon_z^{4,8}$	ε_x^0	$\varepsilon_x^{4,8}$	ε_{zI}^0	ε_a^0	$\varepsilon_a^{4,8}$	ξ^R	ε_g^0	$\varepsilon_g^{4,8}$	$\varepsilon_{\tau n}^0$	$\varepsilon_{\tau n}^{4,8}$	$\varepsilon_{\tau k}^0$	$\varepsilon_{\tau k}^{4,8}$
4 periods																	
GDP	11.6	9.1	1.7	13.7	15.3	28.2	12.7	0.7	0.7	1.0	3.4	0.0	0.2	0.4	0.0	0.3	0.6
Cons.	69.1	0.9	0.5	1.1	2.2	10.1	13.2	0.0	0.9	1.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Invest.	2.1	12.2	1.7	18.8	19.2	24.4	7.6	1.3	0.8	3.9	5.8	0.0	0.0	0.6	0.0	0.6	0.9
Hours	1.2	27.4	0.8	8.8	11.2	1.0	9.5	0.2	6.6	12.6	8.7	0.0	0.0	1.6	0.0	9.4	1.0
Infl.	1.0	3.6	0.8	8.1	2.7	2.2	6.0	0.1	4.6	22.3	35.1	0.0	0.0	0.3	0.0	5.0	7.9
Cap. Tax	0.1	0.3	0.0	0.5	0.5	0.2	0.2	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	68.6	0.0
Lab. Tax	0.0	0.4	0.0	0.2	0.1	0.1	0.1	0.0	0.1	0.2	0.1	0.0	0.0	77.0	0.0	0.2	0.0
Gov. Spend.	0.0	0.0	0.0	0.0	0.0	73.0	0.0	0.0	3.9	0.0	0.2	22.7	0.0	0.0	0.0	0.0	0.0
16 periods																	
GDP	6.6	5.8	2.2	8.4	13.1	21.1	19.4	0.5	2.3	3.2	2.1	0.0	13.6	0.3	0.0	0.2	0.9
Cons.	53.0	1.3	0.8	1.5	3.3	15.3	21.2	0.0	1.2	1.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Invest.	1.7	9.6	2.9	14.5	20.4	19.8	13.7	1.0	2.5	6.3	4.5	0.0	0.2	0.5	0.0	0.5	1.8
Hours	0.8	37.0	17.8	3.7	7.7	6.3	6.5	0.3	2.1	7.1	2.2	0.0	1.6	1.5	0.0	2.1	3.2
Infl.	0.8	3.1	1.0	6.9	4.8	2.5	6.2	0.6	4.5	22.1	30.4	0.0	0.1	0.2	0.0	4.3	12.3
Cap. Tax	0.4	3.0	1.3	4.3	8.0	4.0	2.7	0.2	0.2	0.4	0.3	0.0	0.1	0.1	0.0	19.9	47.3
Lab. Tax	0.1	9.2	2.8	0.1	0.7	0.3	0.3	0.0	0.6	2.2	0.3	0.0	0.3	71.4	0.8	0.1	0.1
Gov. Spend.	0.0	0.0	0.0	0.0	0.0	1.3	1.5	0.0	0.2	0.1	0.0	0.1	96.7	0.0	0.0	0.0	0.0
Uncond. Variance																	
GDP	6.2	5.8	2.4	8.6	14.3	19.9	18.8	0.5	2.3	4.1	2.0	0.0	13.0	0.2	0.0	0.5	1.1
Cons.	49.9	1.4	0.9	1.7	3.6	16.0	22.4	0.0	1.3	1.9	0.0	0.0	0.4	0.0	0.0	0.0	0.0
Invest.	1.7	9.3	3.5	14.2	22.5	18.4	13.2	0.9	2.2	6.6	3.8	0.0	0.2	0.4	0.0	0.9	2.0
Hours	0.8	22.6	16.3	2.5	5.5	7.1	13.1	0.3	5.5	13.7	1.3	0.0	7.2	1.3	0.0	1.2	1.5
Infl.	1.4	4.3	2.1	8.9	12.4	2.4	5.2	0.7	5.7	23.4	20.7	0.0	0.1	0.4	0.0	3.5	8.4
Cap. Tax	0.6	3.6	2.7	5.1	12.5	6.1	8.6	0.4	2.8	6.1	0.3	0.0	2.1	0.3	0.0	12.8	30.8
Lab. Tax	0.3	11.9	8.3	6.2	14.4	10.2	15.1	0.4	0.4	0.9	1.3	0.0	25.8	2.7	0.0	0.9	0.1
Gov. Spend.	0.0	0.1	0.1	0.0	0.1	1.8	3.0	0.0	0.3	0.6	0.0	0.1	93.9	0.0	0.0	0.0	0.0

Notes: Variance decompositions are performed at the posterior median. ε_i^0 represents contemporaneous shock components; $\varepsilon_i^{4,8}$ represents the sum of the 4 and 8 quarter anticipated shock components. For ease of exposition, we have combined the two anticipated shock components into one and left out the anticipated stationary investment-specific shocks that contribute less than 0.01 percent to the variance of the variables. Due to space constraints, we also do not show the shocks' variance contributions to wages and the interest rate.

Table 4: Variance Decomposition, Federal Government Only (in %):

	Pref./Wage Markup			Technology							Policy						
	ξ^{pref}	ε_w^0	$\varepsilon_w^{4,8}$	ε_z^0	$\varepsilon_z^{4,8}$	ε_x^0	$\varepsilon_x^{4,8}$	ε_{zI}^0	ε_a^0	$\varepsilon_a^{4,8}$	ξ^R	ε_g^0	$\varepsilon_g^{4,8}$	$\varepsilon_{\tau n}^0$	$\varepsilon_{\tau n}^{4,8}$	$\varepsilon_{\tau k}^0$	$\varepsilon_{\tau k}^{4,8}$
4 periods																	
GDP	10.5	0.0	3.4	10.4	7.4	17.8	6.2	0.7	1.4	1.5	7.1	0.0	1.1	7.8	22.5	0.8	0.8
Cons.	47.3	0.0	0.2	2.8	1.8	15.5	12.8	0.4	3.0	5.8	0.2	0.0	0.8	2.0	5.8	0.3	1.0
Invest.	0.6	0.0	5.1	11.3	8.2	5.6	1.2	1.1	7.6	11.1	11.8	0.0	0.7	8.6	24.6	0.9	0.7
Hours	1.1	0.0	3.4	10.4	5.2	3.4	4.7	0.5	10.7	10.0	8.1	0.0	0.6	8.7	17.1	13.0	2.5
Infl.	0.4	0.0	4.5	7.8	4.7	1.4	0.2	0.0	5.7	16.5	7.2	0.0	0.6	4.7	12.6	6.0	27.3
Cap. Tax	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	82.3	0.0
Lab. Tax	0.1	0.0	0.2	1.0	0.3	0.4	0.3	0.0	1.0	0.8	0.7	0.0	0.0	49.8	1.1	1.2	0.2
Gov. Spend.	0.0	0.0	0.0	0.0	0.0	97.0	0.0	0.0	0.9	0.0	0.1	1.8	0.0	0.0	0.0	0.0	0.0
16 periods																	
GDP	6.0	0.0	2.6	7.1	5.2	13.2	7.1	0.5	2.0	1.7	5.3	0.0	24.1	5.4	15.8	1.2	2.2
Cons.	41.3	0.0	0.2	2.9	1.9	17.6	15.0	0.5	3.1	6.0	0.2	0.0	0.9	2.2	6.3	0.4	1.1
Invest.	0.5	0.0	5.2	10.7	8.1	5.2	1.6	0.9	6.8	9.6	11.7	0.0	0.7	8.1	23.6	2.3	4.1
Hours	0.5	0.0	10.5	4.2	4.3	2.8	1.7	0.1	3.9	6.8	2.4	0.0	1.9	13.5	37.2	3.8	5.9
Infl.	0.4	0.0	4.4	7.1	4.9	1.2	0.2	0.0	5.9	17.4	6.6	0.0	0.6	4.8	13.3	5.4	27.2
Cap. Tax	0.0	0.0	0.3	0.8	0.7	0.0	0.0	0.0	0.3	0.6	0.1	0.0	0.1	0.7	2.1	25.0	66.0
Lab. Tax	0.1	0.0	11.8	0.7	4.0	0.4	0.3	0.1	6.2	9.6	1.5	0.0	0.3	24.0	26.9	1.2	0.9
Gov. Spend.	0.0	0.0	0.0	0.0	0.0	2.3	2.5	0.0	0.2	0.1	0.0	0.0	94.9	0.0	0.0	0.0	0.0
Uncond. Variance																	
GDP	5.6	0.0	3.9	8.1	6.1	12.5	6.7	0.5	2.4	3.4	5.0	0.0	22.4	6.2	11.0	1.7	3.8
Cons.	41.4	0.0	0.4	3.0	2.0	17.7	15.1	0.5	3.7	7.4	0.2	0.0	1.0	2.3	4.0	0.5	0.4
Invest.	0.6	0.0	7.2	11.6	9.2	5.3	1.7	0.7	6.4	11.3	9.6	0.0	0.7	8.8	15.7	2.8	7.5
Hours	0.4	0.0	12.1	3.5	3.6	4.6	4.2	1.5	6.2	12.5	2.1	0.0	7.4	8.8	15.4	2.7	14.1
Infl.	0.4	0.0	5.9	7.9	5.4	3.2	2.7	0.2	9.5	24.9	7.2	0.0	0.7	5.4	9.2	6.3	10.5
Cap. Tax	0.1	0.0	5.3	1.9	1.5	2.3	2.0	0.1	1.1	3.0	0.3	0.0	0.8	1.6	2.8	22.6	51.6
Lab. Tax	0.2	0.0	7.9	3.4	3.1	2.5	2.5	6.5	15.1	31.8	0.7	0.0	14.2	2.7	3.4	0.4	2.4
Gov. Spend.	0.0	0.0	0.1	0.0	0.0	2.3	2.7	0.0	0.5	0.8	0.0	0.0	93.4	0.0	0.0	0.0	0.0

Notes: See the notes to Table 3.

4 Stationary Equilibrium

In order to derive a state-space representation of the model, the model presented in the main text is solved by using a first-order perturbation method. However, due to the two integrated processes A_t and X_t, which grow with rates

$$\mu_t^a = \frac{A_t}{A_{t-1}}, \quad \mu_t^x = \frac{X_t}{X_{t-1}}, \tag{1}$$

the model has to be detrended first in order to induce stationarity and to have a well-defined steady state. Y_t, C_t and W_t inherit the trend $X_t^Y = A^{\frac{\alpha}{\alpha-1}} X_t$, which corresponds to a growth rate of

$$\mu_t^y = (\mu_t^a)^{\frac{\alpha}{\alpha-1}} \mu_t^x. \tag{2}$$

K_t and I_t inherit the trend $X_t^K = A^{\frac{1}{\alpha-1}} X_t$ and thus grow with

$$\mu_t^k = \mu_t^I = (\mu_t^a)^{\frac{1}{\alpha-1}} \mu_t^x. \tag{3}$$

G_t inherits $X_t^G = \left(X_{t-1}^G\right)^{\rho_{xg}} \left(X_{t-1}^Y\right)^{1-\rho_{xg}}$ due to the assumed cointegrated trend with output. It hence grows with rate

$$x_t^g = \frac{(x_{t-1}^g)^{\rho_{xg}}}{\mu_t^y}. \tag{4}$$

The detrending is performed by dividing the trending model variables by their respective trend. For the estimation of our structural model, these stationary model variables are matched to the data presented in Appendix 6.

5 Observation Equation

The observation equation describes how the empirical times series are matched to the corresponding model variables:

$$
OBS_t = \begin{bmatrix} \Delta\log\left(Y_t\right) \\ \Delta\log\left(C_t\right) \\ \Delta\log\left(z_t^I A_t I_t\right) \\ \log\left(\frac{L_t}{L}\right) \\ \Delta\log\left(G_t\right) \\ \Delta\log\left(z_t^I A_t\right) \\ \tau_t^k \\ \tau_t^n \\ \Delta\log\left(TFP_t\right) \\ \Delta\log\left(W_t\right) \\ \log\left(\frac{R_t}{R}\right) \\ \log\left(\frac{\Pi_t}{\Pi}\right) \end{bmatrix} \times 100 - \begin{bmatrix} \log\left(\mu^y\right) \\ \log\left(\mu^y\right) \\ \log\left(\mu^y\right) \\ 0 \\ \log\left(\mu^y\right) \\ \log\left(\mu^a\right) \\ 0 \\ 0 \\ (1-\alpha)\log\left(\mu^x\right) \\ \log\left(\mu^y\right) \\ 0 \\ 0 \end{bmatrix} \times 100
$$

$$
= \begin{bmatrix} \hat{y}_t - \hat{y}_{t-1} + \log\mu_t^y \\ \hat{c}_t - \hat{c}_{t-1} + \log\mu_t^y \\ \hat{i}_t - \hat{i}_{t-1} + \hat{z}_t^I - \hat{z}_{t-1}^I + \log\mu_t^y \\ \hat{L}_t \\ \hat{g}_t - \hat{g}_{t-1} + \hat{x}_t^g - \hat{x}_{t-1}^g + \log\mu_t^y \\ \hat{\mu}_t^a + \hat{z}_t^I - \hat{z}_{t-1}^I \\ \tau_t^k \\ \tau_t^n \\ \hat{z}_t - \hat{z}_{t-1} + (1-\alpha)\log\mu_t^x \\ \hat{w}_t + \hat{w}_{t-1} + \log\mu^y \\ \hat{R}_t \\ \hat{\Pi}_t \end{bmatrix} - \begin{bmatrix} \log\left(\mu^y\right) \\ \log\left(\mu^y\right) \\ \log\left(\mu^y\right) \\ 0 \\ \log\left(\mu^y\right) \\ \log\left(\mu^a\right) \\ 0 \\ 0 \\ (1-\alpha)\log\left(\mu^x\right) \\ \log\left(\mu^y\right) \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} \varepsilon_{y,t}^{me} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \varepsilon_{\tau k,t}^{me} \\ \varepsilon_{\tau n,t}^{me} \\ 0 \\ \varepsilon_{w,t}^{me} \\ 0 \\ 0 \end{bmatrix},
$$

where Δ denotes the temporal difference operator, L denotes the steady state of hours worked, μ^y is the steady state growth rate of output[3], μ^a is the steady state growth rate of the relative price of investment, $TFP_t = z_t X_t^{1-\alpha}$ is total factor productivity, and R is the steady state

[3]This is also the growth rate of the individual components of GDP along the balanced growth path.

interest rate. The hats above the variables denote log deviations from steady state.[4] Due to potential mismeasurement of tax rates and wages, we follow Sargent (1989) and Ireland (2004) allow for measurement error in those variables. Moreover, to avoid stochastic singularity of the model, we allow for measurement error in output.

6 Data construction

Unless otherwise noted, all data are from the Bureau of Economic Analysis (BEA)'s NIPA Tables and available in quarterly frequency from 1955Q1 until 2006Q4.

Capital and labor tax rates. Our approach to calculate average tax rates closely follows Mendoza et al. (1994), Jones (2002), and Leeper et al. (2010). We first compute the average personal income tax rate

$$\tau^p = \frac{IT}{W + PRI/2 + CI} \ ,$$

where IT is personal current tax revenues (Table 3.1 line 3), W is wage and salary accruals (Table 1.12 line 3), PRI is proprietor's income (Table 1.12 line 9), and $CI \equiv PRI/2 + RI + CP + NI$ is capital income. Here, RI is rental income (Table 1.12 line 12), CP is corporate profits (Table 1.12 line 13), and NI denotes the net interest income (Table 1.12 line 18).

The average labor and capital income tax rates can then be computed as

$$\tau^n = \frac{\tau^p(W + PRI/2) + CSI}{EC + PRI/2} \ ,$$

where CSI denotes contributions for government social insurance (Table 3.1 line 7), and EC is compensation of employees (Table 1.12 line 2), and

$$\tau^k = \frac{\tau^p CI + CT + PT}{CI + PT} \ ,$$

[4] The equation for L_t follows from

$$\log L_t = \log\left(L_t \frac{L}{L}\right) \approx \hat{L}_t + \log L \ .$$

The equation for government spending follows from

$$\log \frac{G_t}{G_{t-1}} = \log \frac{g_t X_t^g}{g_{t-1} X_{t-1}^g} = \log \frac{g_t x_t^g X_t^Y}{g_{t-1} x_{t-1}^g X_{t-1}^Y} = \log \frac{g_t x_t^g}{g_{t-1} x_{t-1}^g} \mu_t^y \ .$$

Note that the presence of x^g also implies that there is no perfect linear restriction between the GDP components following from the resource constraint. Hence, we do not need to add additional measurement error. For more on observation equations, see Pfeifer (2013).

where CT is taxes on corporate income (Table 3.1 line 5), and PT is property taxes (Table 3.3 line 8).

Government spending. Government spending is the sum of government consumption (Table 3.1 line 16) and government investment (Table 3.1 line 35) divided by the GDP deflator (Table 1.1.4 line 1) and the civilian noninstitutional population (BLS, Series LNU00000000Q).

Total factor productivity (TFP). The TFP series is taken from Fernald (2012), who closely follows Basu et al. (2006) and provides a quarterly series that is adjusted for capital and labor utilization.

Relative price of investment. The relative price of investment is taken from Schmitt-Grohé and Uribe (2011). They base their calculations on Fisher (2006).

Output. Nominal GDP (Table 1.1.5 line 1) divided by the GDP deflator (Table 1.1.4 line 1) and the civilian noninstitutional population (BLS, Series LNU00000000Q).

Investment. Sum of Residential fixed investment (Table 1.1.5 line 12) and nonresidential fixed investment (Table 1.1.5 line 9) divided by the GDP deflator (Table 1.1.4 line 1) and the civilian noninstitutional population (BLS, Series LNU00000000Q).

Consumption. Sum of personal consumption expenditures for nondurable goods (Table 1.1.5 line 5) and services (Table 1.1.5 line 6) divided by the GDP deflator (Table 1.1.4 line 1) and the civilian noninstitutional population (BLS, Series LNU00000000Q).

Real wage. Hourly compensation in the nonfarm business sector (BLS, Series PRS85006103) divided by the GDP deflator (Table 1.1.4 line 1).

Inflation. Computed as the log-difference of the GDP deflator (Table 1.1.4 line 1).

Nominal interest rate. Geometric mean of the effective Federal Funds Rate (St.Louis FED - FRED Database, Series FEDFUNDS).

Hours worked. Nonfarm business hours worked (BLS, Series PRS85006033) divided by the civilian noninstitutional population (BLS, Series LNU00000000Q)

Debt. Gross Federal Debt (St.Louis FED - FRED Database, Series FYGFD).

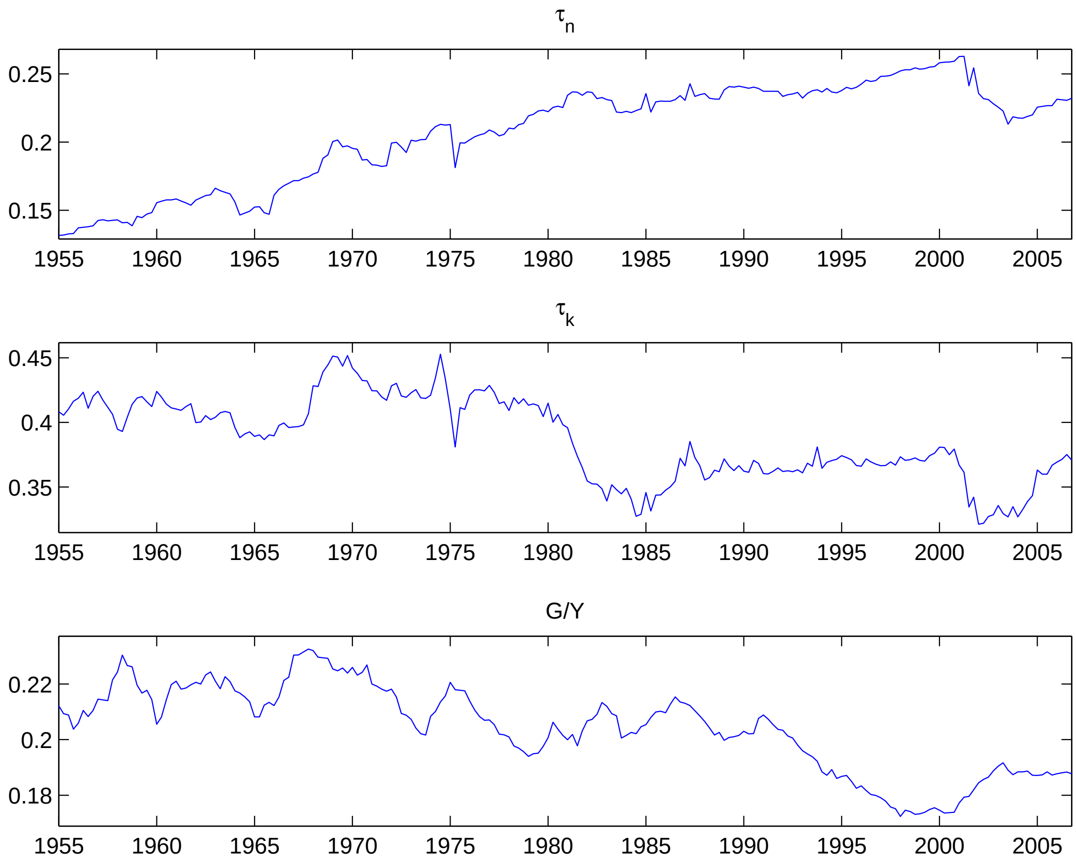

Figure 3: Evolution of the tax rates and the government spending to GDP ratio.

7 Baseline Model - Different Cholesky Ordering

When ordering the labor tax rate first, the labor tax shock affects the capital tax rate immediately, which now reacts with a relatively big drop that is again larger for the surprise shock. As a result, the total effective shock size increases and the IRFs are quantitatively bigger, but remain qualitatively similar. However, there is one major difference for the surprise labor shock: capital taxes now decrease by almost two percentage points and thus stronger than the labor tax rate. Due to the resulting drop in the rental-rate to wage ratio, firms initially substitute capital services for labor services. Thus, capital and labor services essentially switch roles compared to the IRFs plotted in Figure 4 of the paper, with the former now rising on impact and the latter falling.

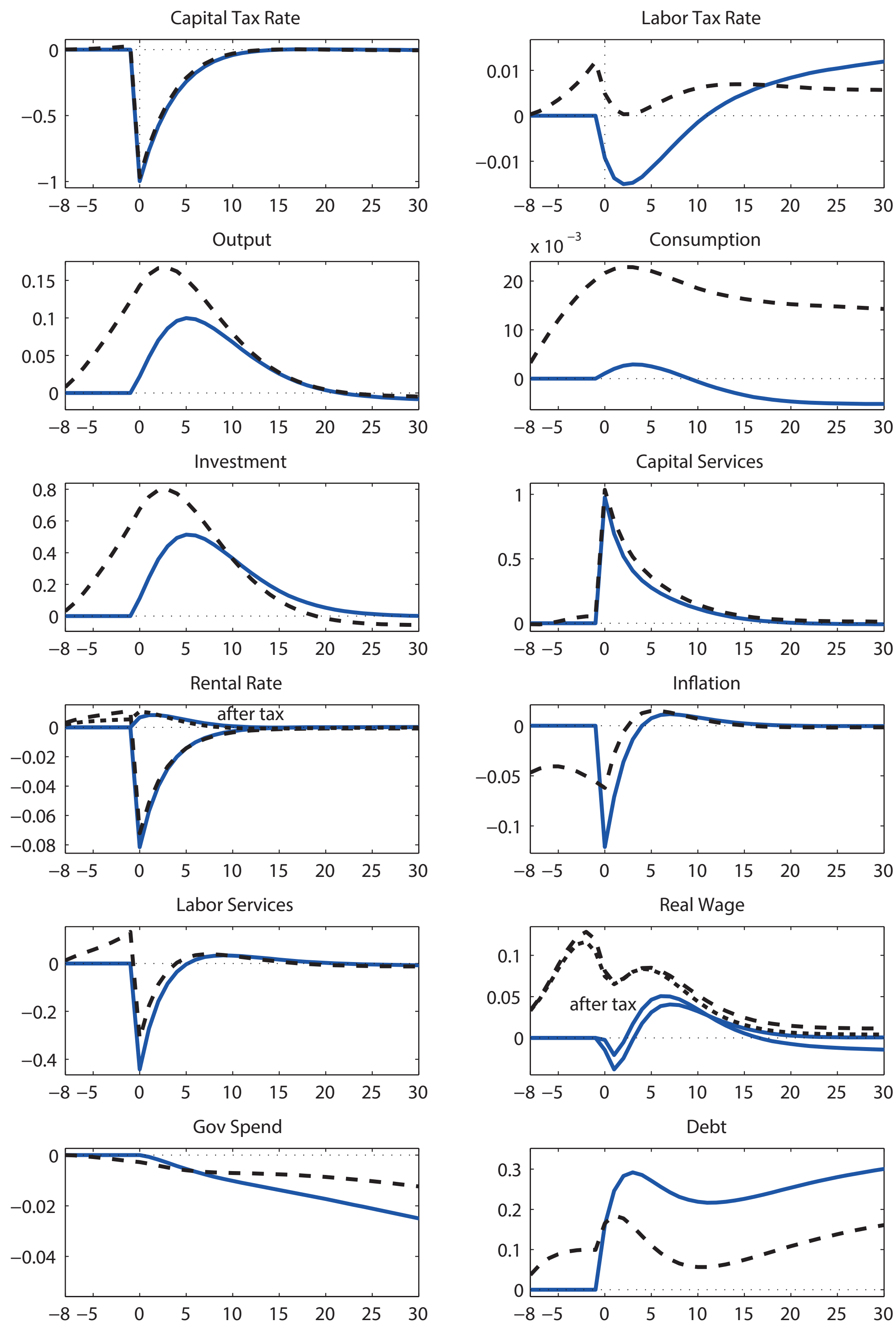

Figure 4: Impulse responses to unanticipated and anticipated capital tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the capital tax rate τ^k; dashed line (short-dashed for after-tax measures): impulse responses to an eight period anticipated 1 percentage point cut of the capital tax rate τ^k that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

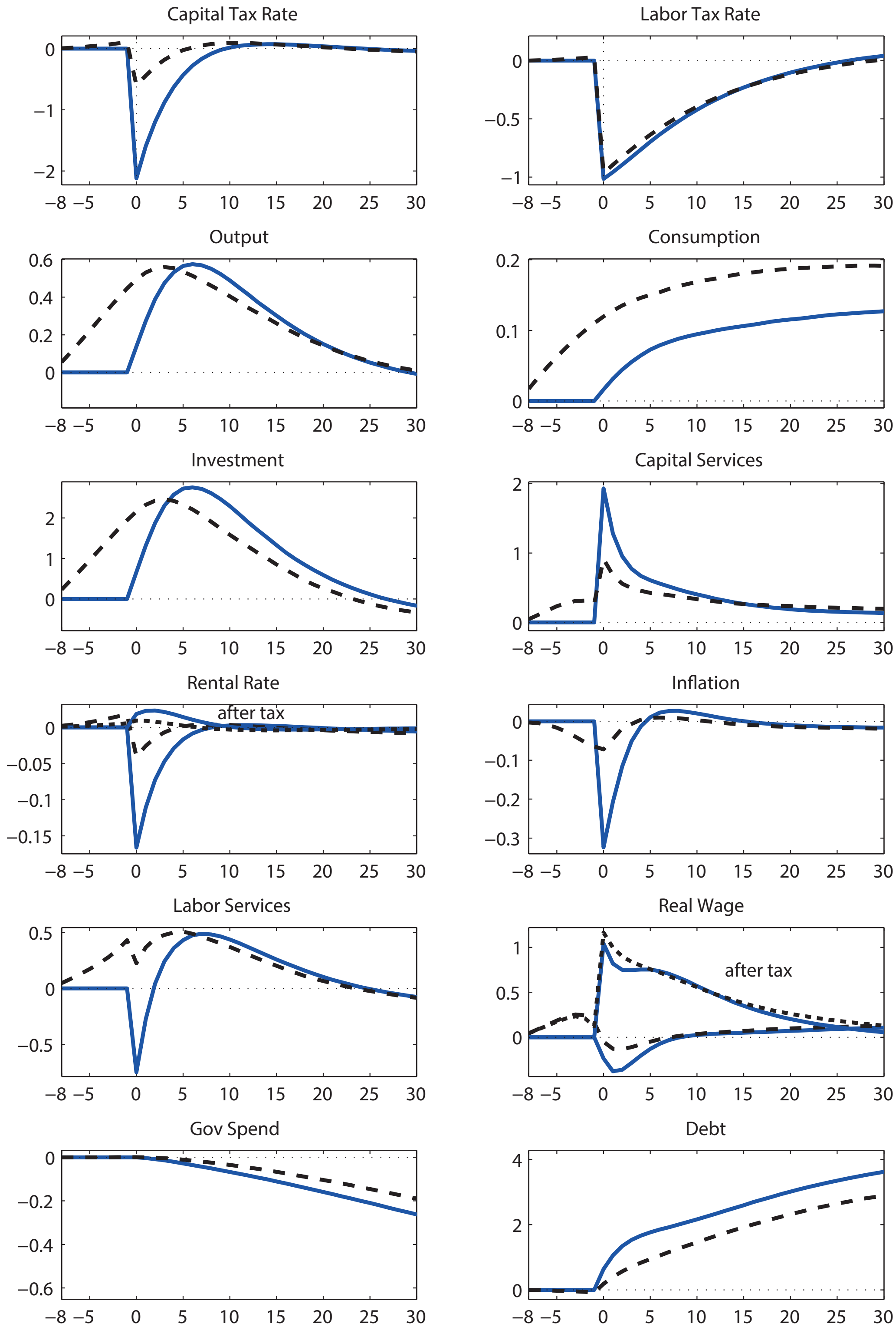

Figure 5: Impulse responses to unanticipated and anticipated labor tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the labor tax rate τ^n; dashed line (short-dashed for after-tax measures): impulse responses to an eight period anticipated 1 percentage point cut of the labor tax rate τ^n that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

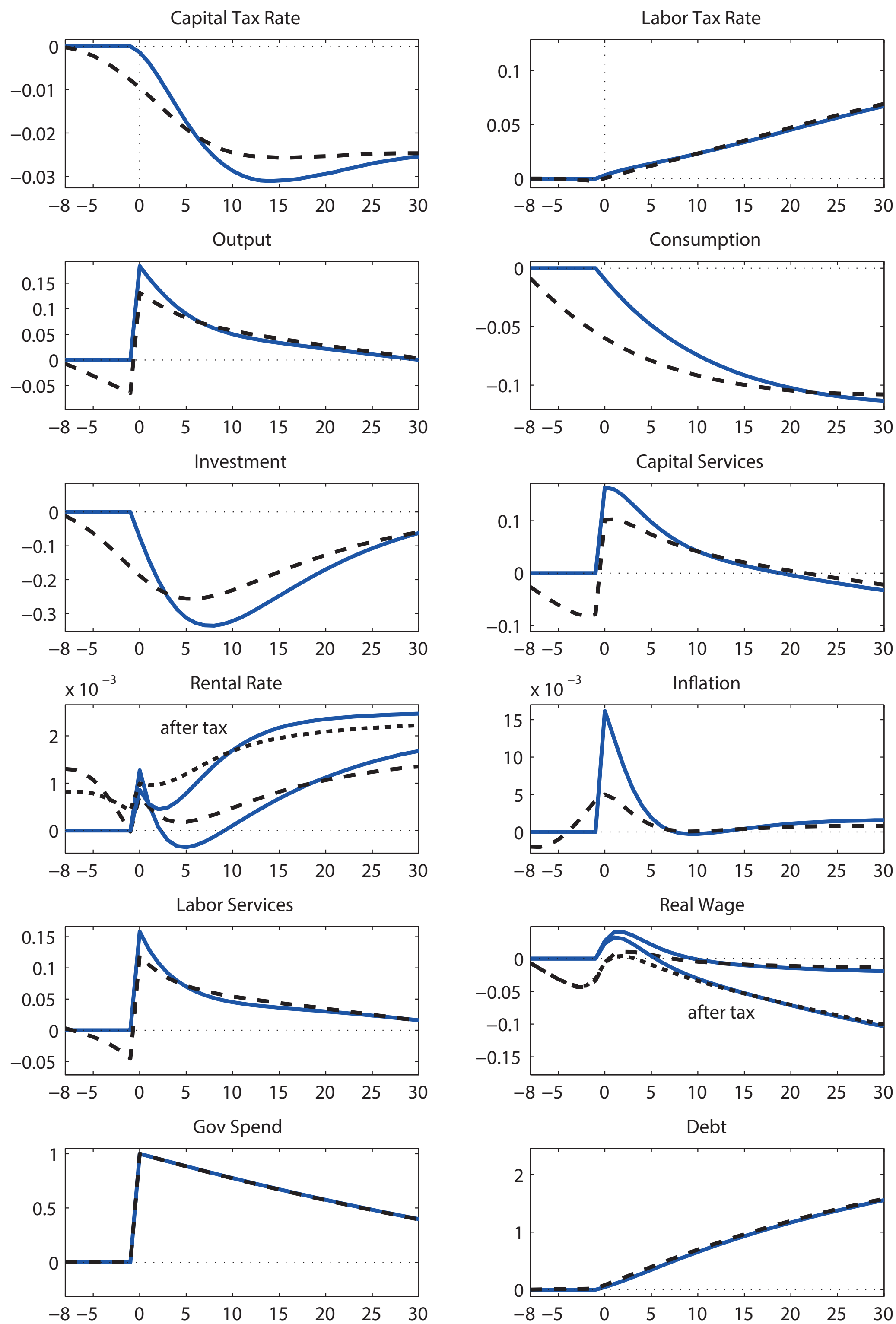

Figure 6: Impulse responses to unanticipated and anticipated government spending shocks. *Notes*: solid line: impulse responses to an unanticipated 1 percent increase in government spending g_t; dashed line (short-dashed for after-tax measures): impulse responses to an eight period anticipated 1 percent increase in government spending g_t that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

8 Baseline Model - Detailed Variance Decomposition

Table 5: Variance Decomposition Output Growth Baseline (in percent)

	1	4	8	12	16	20	Inf
ξ^0_{pref}	25.44	11.57	8.88	6.88	6.59	6.45	6.24
ε^0_w	8.22	9.13	7.64	5.89	5.76	5.77	5.84
$\varepsilon^{4,8}_w$	1.12	1.69	2.40	2.26	2.18	2.19	2.42
ε^0_z	12.83	13.66	11.11	8.58	8.42	8.46	8.62
$\varepsilon^{4,8}_z$	11.53	15.32	16.34	13.51	13.15	13.31	14.31
ε^0_x	21.95	28.24	27.33	21.92	21.05	20.59	19.91
$\varepsilon^{4,8}_x$	8.88	12.73	17.66	18.33	19.39	19.35	18.76
ε^0_{zI}	0.16	0.75	0.65	0.50	0.49	0.48	0.48
$\varepsilon^{4,8}_{zI}$	0.00	0.00	0.01	0.01	0.01	0.01	0.01
ε^0_a	0.10	0.75	1.99	2.17	2.30	2.32	2.26
$\varepsilon^{4,8}_a$	1.65	1.02	1.33	2.09	3.25	3.86	4.11
ξ^R	6.96	3.44	2.72	2.17	2.09	2.04	1.97
ε^0_g	0.04	0.02	0.01	0.01	0.01	0.01	0.01
$\varepsilon^{4,8}_g$	0.09	0.16	0.25	14.18	13.64	13.38	13.02
$\varepsilon^0_{\tau n}$	0.40	0.42	0.34	0.27	0.27	0.28	0.25
$\varepsilon^{4,8}_{\tau n}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^0_{\tau k}$	0.21	0.34	0.26	0.23	0.24	0.25	0.50
$\varepsilon^{4,8}_{\tau k}$	0.14	0.55	0.84	0.79	0.91	1.04	1.07
$\varepsilon^{me}_{w,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau n,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau k,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{y,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00

9 Comparing Models

The following section traces out some of the differences between the Schmitt-Grohé and Uribe (2012) (SGU) model and the model used in the paper. For this purpose, we estimated a basic RBC version that is very close to the original SGU model and an intermediate RBC version that is already closer to our specification.

9.1 Basic RBC

The basic RBC version differs from the baseline model in that we eliminated the nominal block and estimated a real version of our model on the same data as Schmitt-Grohé and Uribe (2012), except for using the Fernald (2012) TFP-series, which also corrects for labor utilization, instead of the Beaudry and Lucke (2010) series used in SGU that only corrects for capital utilization. Moreover, we added the two tax rate series as observables. In contrast to the baseline model and following SGU, we also allow for anticipation in the preference shocks.

As Table 6 shows, this basic version of the model fits the data already quite well. Its greatest weaknesses are that it significantly overpredicts i) the comovement of output and TFP growth rates (a weakness it shares with the SGU model), ii) the autocorrelation of government spending, and iii) the autocorrelation of TFP. At the same time it underpredicts the autocorrelation of investment-specific technology growth. Looking specifically at the fiscal variables, we see that the model is able to match the moments of labor and capital taxes and government spending well. The only disadvantage compared to the SGU model is that the autocorrelation of government spending in the basic RBC version is a bit too high.

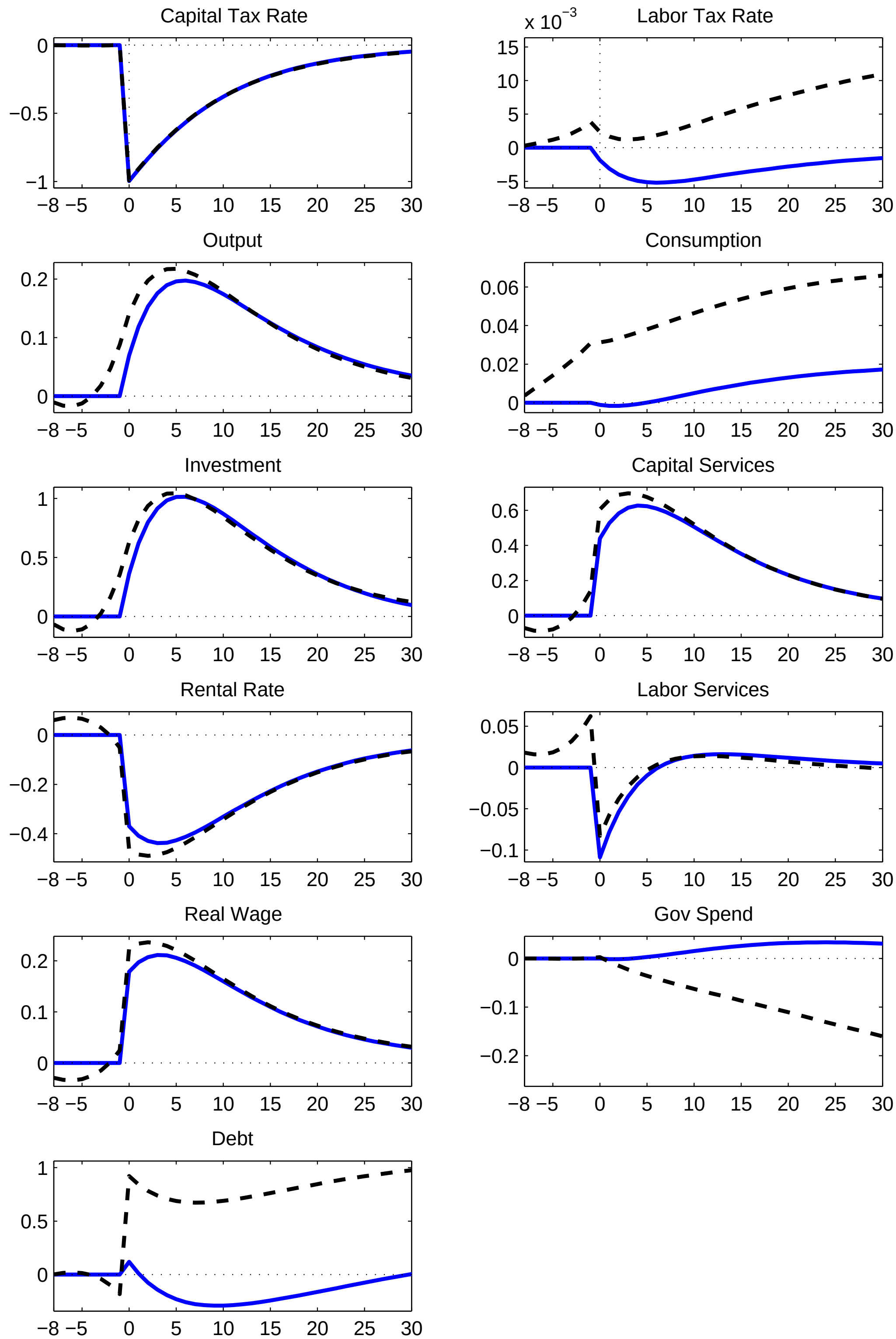

Figure 7: Impulse responses to unanticipated and anticipated capital tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the capital tax rate τ^k; dashed line: impulse responses to an eight period anticipated 1 percentage point cut of the capital tax rate τ^k that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

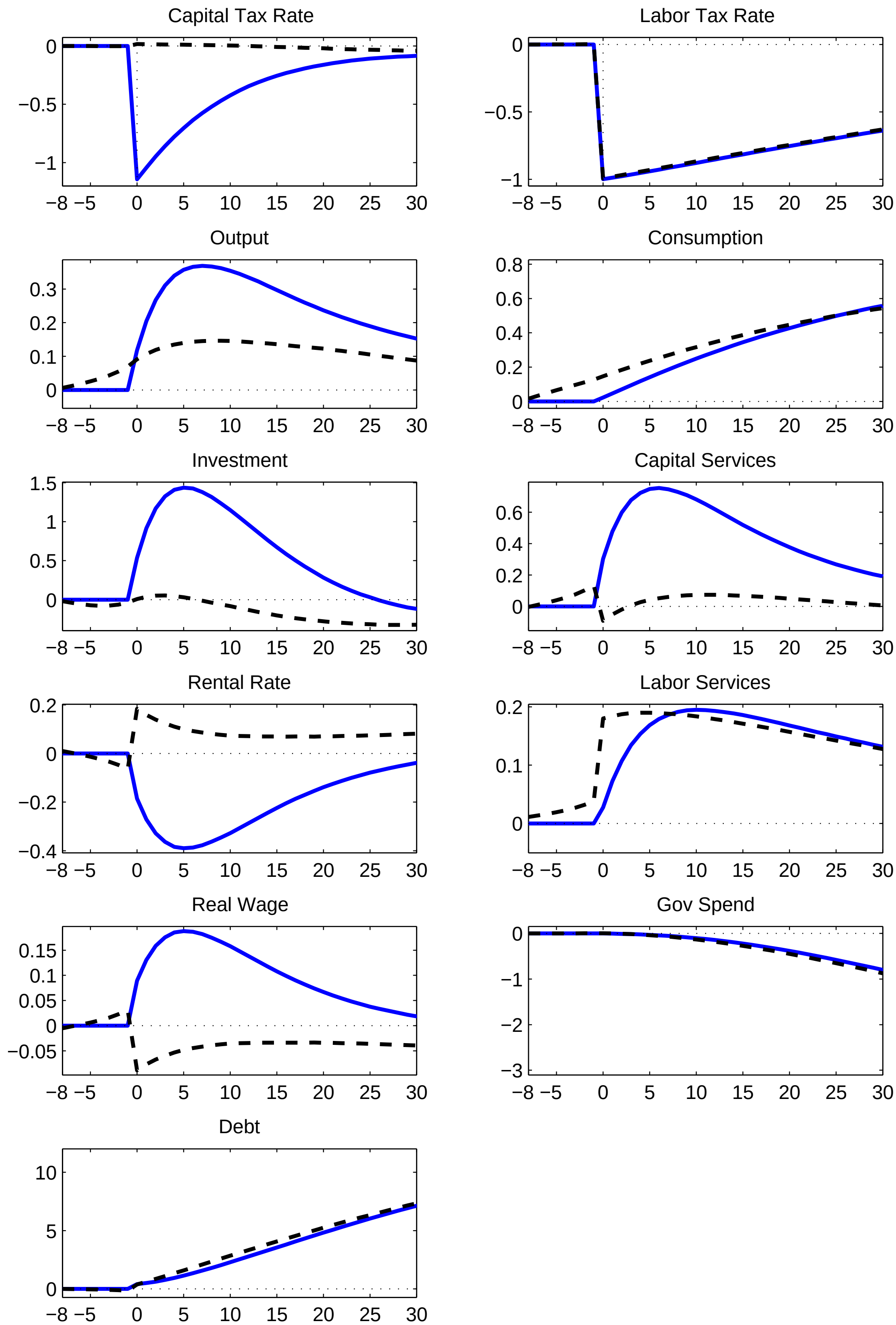

Figure 8: Impulse responses to unanticipated and anticipated labor tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the labor tax rate τ^n; dashed line: impulse responses to an eight period anticipated 1 percentage point cut of the labor tax rate τ^n that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

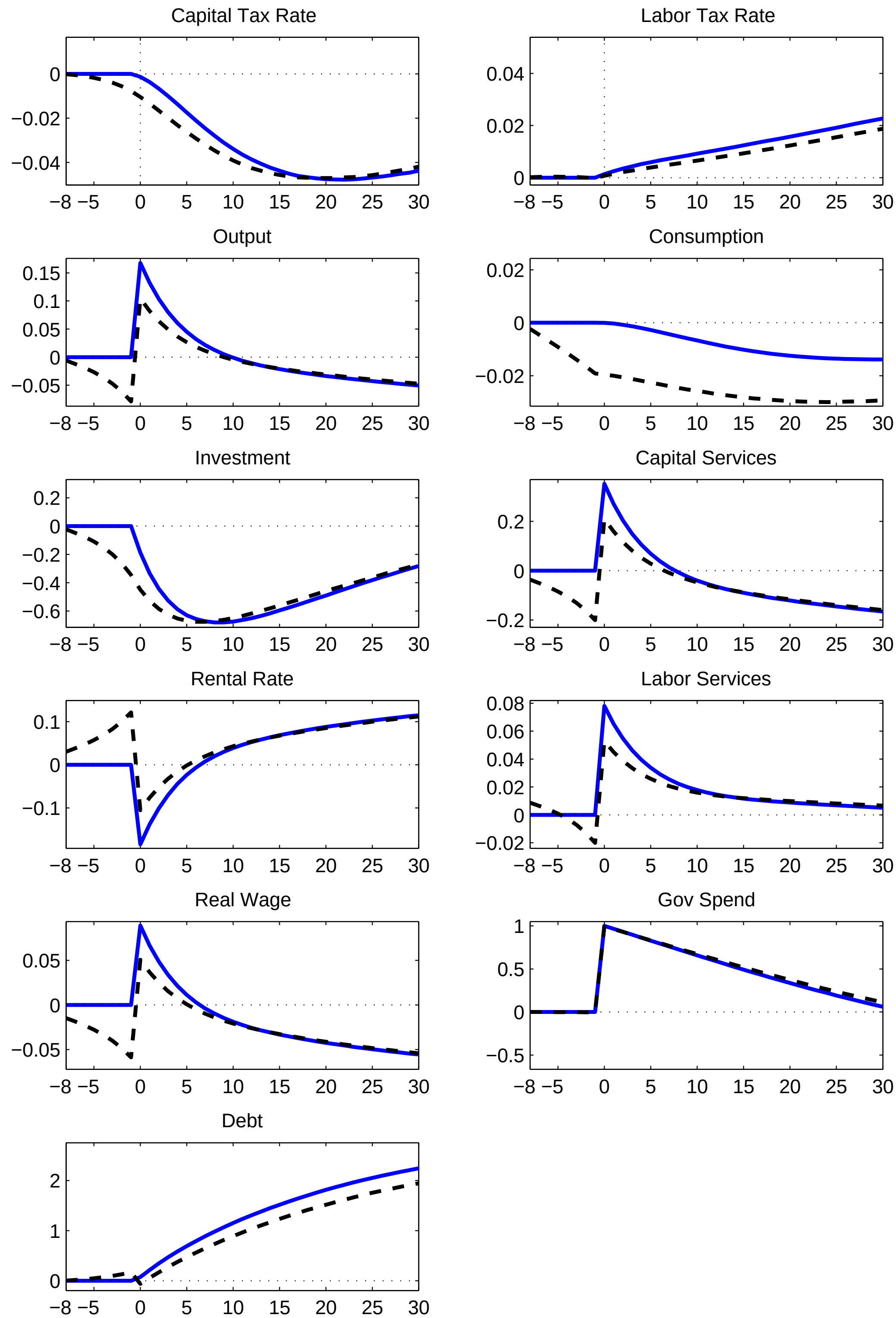

Figure 9: Impulse responses to unanticipated and anticipated government spending shocks. *Notes*: solid line: impulse responses to an unanticipated 1 percent increase in government spending g_t; dashed line: impulse responses to an eight period anticipated 1 percent increase in government spending g_t that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

Table 6: Model and Data Moments

	Model	Data	Model	Data	Model	Data
	$\rho(x_t, y_t)$		$\sigma(x_t)$		$\rho(x_t, x_{t-1})$	
$\Delta\log(Y_t)$	1.000	1.000	0.942	0.907	0.798	0.276
$\Delta\log(C_t)$	0.618	0.507	0.579	0.504	0.582	0.221
$\Delta\log\left(z_t^I A_t I_t\right)$	0.829	0.691	3.577	2.272	0.806	0.527
$\log\left(\frac{L_t}{L}\right)$	0.083	0.053	5.972	4.015	0.988	0.978
$\Delta\log(G_t)$	0.497	0.252	1.413	1.125	0.392	0.061
$\Delta\log\left(z_t^I A_t\right)$	0.030	-0.036	1.234	0.408	-0.001	0.493
τ^n	-0.030	-0.058	4.634	3.641	0.995	0.991
τ^k	0.090	-0.132	3.379	3.173	0.972	0.968
$\Delta\log(TFP_t)$	0.571	0.075	1.089	0.848	0.334	-0.075

Notes: Time Series x_t are the growth rates of output ($\Delta\log(Y_t)$, denoted by y_t in the first column), consumption ($\Delta\log(C_t)$), investment ($\Delta\log\left(z_t^I A_t I_t\right)$), percentage deviations of hours worked from steady state ($\log\left(\frac{L_t}{L}\right)$), the growth rates of government spending ($\Delta\log(G_t)$) and investment-specific technology ($\Delta\log\left(z_t^I A_t\right)$), the level of labor and capital taxes (τ_t^n and τ_t^k), the growth rates of wages ($\Delta\log(W_t)$) and TFP ($\Delta\log(TFP_t)$), the level of the net nominal interest rate ($\log(R_t)$), and the level of net inflation ($\log(\Pi_t)$). Model moments are computed at the posterior median of the parameters.

Table 7: Prior and Posterior Distributions of the Shock Processes

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
			Preference and Technology Parameters				
σ_l	Gamma	2.00	0.75	6.085	0.408	5.408	6.742
σ_s	Beta	0.50	0.20	0.003	0.000	0.002	0.004
κ	Gamma	4.00	1.50	9.583	0.508	8.807	10.493
δ_2/δ_1	Inverse-Gamma	0.50	0.15	0.280	0.021	0.246	0.315
ϕ_c	Beta	0.70	0.10	0.978	0.003	0.972	0.982
			Preference Shock				
ρ_{pref}	Beta	0.50	0.20	0.160	0.034	0.105	0.219
σ_{pref}	Inverse-Gamma	0.10	2.00	0.032	0.014	0.023	0.054
σ^4_{pref}	Inverse-Gamma	0.10	2.00	36.256	4.549	28.434	43.391
σ^8_{pref}	Inverse-Gamma	0.10	2.00	0.034	0.029	0.024	0.065
			Wage Markup Shock				
ρ_w	Beta	0.50	0.20	0.961	0.007	0.949	0.971
σ_w	Inverse-Gamma	0.10	2.00	51.134	3.774	44.752	57.465
σ^4_w	Inverse-Gamma	0.10	2.00	0.036	0.024	0.023	0.071
σ^8_w	Inverse-Gamma	0.10	2.00	54.250	3.857	48.253	60.806
			Stationary Technology Shock				
ρ_z	Beta	0.50	0.20	0.947	0.017	0.916	0.970
σ_z	Inverse-Gamma	0.10	2.00	0.032	0.014	0.024	0.056
σ^4_z	Inverse-Gamma	0.10	2.00	0.745	0.026	0.700	0.786
σ^8_z	Inverse-Gamma	0.10	2.00	0.041	0.049	0.024	0.085
			Non-Stationary Technology Shock				
ρ_x	Beta	0.50	0.20	0.669	0.023	0.629	0.705
σ_x	Inverse-Gamma	0.10	2.00	0.688	0.035	0.630	0.746
σ^4_x	Inverse-Gamma	0.10	2.00	0.035	0.021	0.024	0.073
σ^8_x	Inverse-Gamma	0.10	2.00	0.517	0.041	0.449	0.587
			Stationary Investment-Specific Productivity Shock				
ρ_{zI}	Beta	0.50	0.20	0.989	0.003	0.985	0.993
σ_{zI}	Inverse-Gamma	0.10	2.00	0.666	0.033	0.611	0.718
σ^4_{zI}	Inverse-Gamma	0.10	2.00	0.535	0.059	0.391	0.604

Table 7: Prior and Posterior Distributions of the Shock Processes - Continued

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
σ_{zI}^8	Inverse-Gamma	0.10	2.00	0.093	0.131	0.025	0.431
	Non-Stationary Investment-Specific Productivity Shock						
ρ_a	Beta	0.50	0.20	0.004	0.003	0.001	0.009
σ_a	Inverse-Gamma	0.10	2.00	0.591	0.031	0.537	0.643
σ_a^4	Inverse-Gamma	0.10	2.00	0.044	0.048	0.024	0.145
σ_a^8	Inverse-Gamma	0.10	2.00	0.649	0.030	0.596	0.696
	Government Spending Shock						
ρ_g	Beta	0.50	0.20	0.966	0.006	0.955	0.974
ρ_{xg}	Beta	0.50	0.20	0.870	0.020	0.836	0.902
σ_g	Inverse-Gamma	0.10	2.00	1.078	0.038	1.014	1.140
σ_g^4	Inverse-Gamma	0.10	2.00	0.033	0.018	0.025	0.059
σ_g^8	Inverse-Gamma	0.10	2.00	0.035	0.019	0.025	0.073
ϕ_{gD}	Normal	0.00	1.00	-0.010	0.002	-0.013	-0.007
	Labor Tax Shock						
$\rho_{\tau n}$	Beta	0.70	0.20	0.991	0.003	0.985	0.997
$\sigma_{\tau n}$	Inverse-Gamma	0.10	2.00	0.387	0.029	0.341	0.433
$\sigma_{\tau n}^4$	Inverse-Gamma	0.10	2.00	0.042	0.038	0.024	0.104
$\sigma_{\tau n}^8$	Inverse-Gamma	0.10	2.00	0.037	0.025	0.023	0.083
ϕ_{nD}	Normal	0.00	1.00	0.000	0.000	0.000	0.001
ϕ_{nl}	Normal	0.00	1.00	0.017	0.003	0.010	0.022
	Capital Tax Shock						
$\rho_{\tau k}$	Beta	0.70	0.20	0.917	0.011	0.897	0.935
$\sigma_{\tau k}$	Inverse-Gamma	0.10	2.00	0.745	0.037	0.686	0.807
$\sigma_{\tau k}^4$	Inverse-Gamma	0.10	2.00	0.033	0.015	0.025	0.056
$\sigma_{\tau k}^8$	Inverse-Gamma	0.10	2.00	0.037	0.021	0.025	0.078
ϕ_{kD}	Normal	0.00	1.00	-0.000	0.000	-0.001	0.000
ϕ_{kI}	Normal	0.00	1.00	0.008	0.001	0.006	0.010
	Tax Shock Correlations						
$\{\varepsilon_{\tau k}^0, \varepsilon_{\tau n}^0\}$	Beta*	0.00	0.30	0.597	0.046	0.526	0.673
$\{\varepsilon_{\tau k}^4, \varepsilon_{\tau n}^4\}$	Beta*	0.00	0.30	0.013	0.231	-0.383	0.390

Table 7: Prior and Posterior Distributions of the Shock Processes - Continued

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
$\{\varepsilon^8_{\tau k}, \varepsilon^8_{\tau n}\}$	Beta*	0.00	0.30	0.000	0.230	-0.380	0.379
				Measurement Error			
σ^{me}_{y}	Uniform	0.01	0.01	0.018	0.000	0.018	0.018
$\sigma^{me}_{\tau n}$	Uniform	0.46	0.26	0.177	0.022	0.141	0.210
$\sigma^{me}_{\tau k}$	Uniform	0.40	0.23	0.138	0.071	0.000	0.239

Notes: The standard deviations of the shocks and measurement errors have been transformed into percentages by multiplying with 100. Beta* indicates that the correlations follow a beta-distribution stretched to the interval [-1,1].

Table 8: Variance Decomposition Output Growth RBC (in percent)

	1	4	8	12	16	20	Inf
ξ^0_{pref}	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\xi^{4,8}_{pref}$	0.11	0.20	2.90	2.48	2.36	2.32	2.28
ε^0_w	9.00	6.36	4.70	3.95	3.77	3.76	3.86
$\varepsilon^{4,8}_w$	0.25	0.43	1.50	3.03	2.94	2.92	3.27
ε^0_z	0.05	0.03	0.03	0.02	0.02	0.02	0.02
$\varepsilon^{4,8}_z$	3.40	6.16	7.81	6.67	6.38	6.42	6.69
ε^0_x	62.13	73.66	69.42	62.13	59.53	58.80	57.94
$\varepsilon^{4,8}_x$	0.96	1.49	4.47	12.60	16.25	17.07	17.12
ε^0_{zI}	1.57	1.19	0.91	0.77	0.73	0.72	0.73
$\varepsilon^{4,8}_{zI}$	0.10	0.15	0.27	0.33	0.32	0.32	0.33
ε^0_a	1.39	2.05	1.72	1.49	1.42	1.40	1.38
$\varepsilon^{4,8}_a$	0.09	0.14	0.45	1.54	1.57	1.56	1.54
ε^0_g	18.99	6.96	4.87	4.11	3.89	3.83	3.78
$\varepsilon^{4,8}_g$	0.00	0.00	0.04	0.05	0.05	0.05	0.05
$\varepsilon^0_{\tau n}$	0.14	0.10	0.08	0.07	0.06	0.06	0.51
$\varepsilon^{4,8}_{\tau n}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^0_{\tau k}$	1.50	0.94	0.66	0.56	0.56	0.56	0.36
$\varepsilon^{4,8}_{\tau k}$	0.00	0.00	0.01	0.01	0.01	0.01	0.01
$\varepsilon^{me}_{\tau n,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau k,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{y,t}$	0.20	0.07	0.05	0.04	0.04	0.04	0.03

9.2 Intermediate RBC

The Intermediate RBC model moves a further step to our own baseline specification by omitting anticipated preference shocks, which only have a weak structural interpretation, and adding wages as an observable (including measurement error). This hardly changes the model fit (see Table 9). Most importantly, the autocorrelations of government spending and TFP move closer to the data. As a comparison of Tables 7 10 shows, the model estimation now assigns a higher standard deviation to temporary TFP instead of permanent TFP shocks and estimates both a lower debt feedback to government spending and a smoother cointegration relationship with output. Associated with these changes in the deep parameters is an increase in the importance of the anticipated government spending shock and a shift of importance from the permanent TFP shock to the temporary one (see Tables 8 and 11). Moreover, the importance of the preference shock increases. Adding wages as an observable shows that the model has problems fitting the observed behavior of wage growth, but hardly affects the conclusions regarding the importance of wage markup shocks.

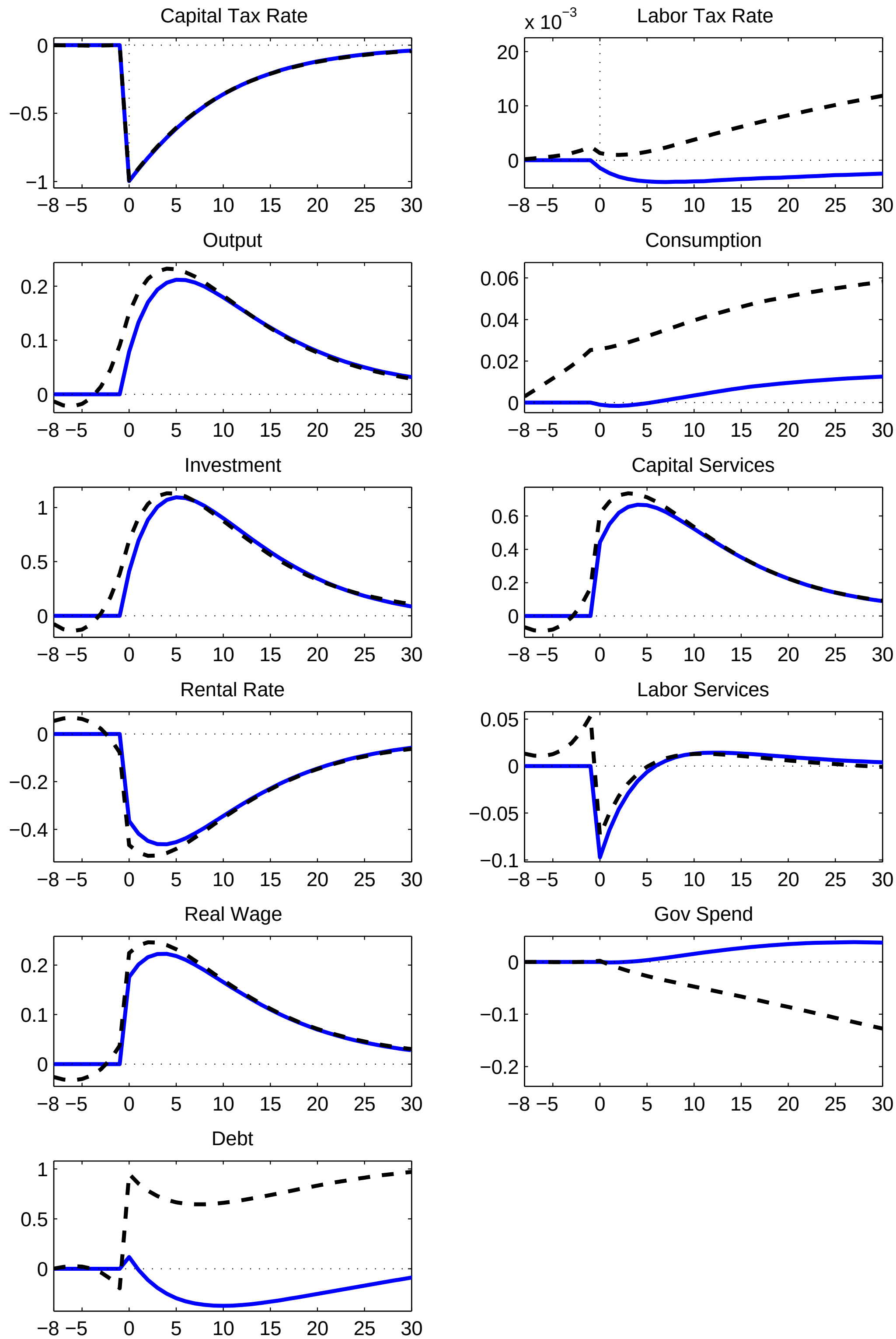

Figure 10: Impulse responses to unanticipated and anticipated capital tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the capital tax rate τ^k; dashed line: impulse responses to an eight period anticipated 1 percentage point cut of the capital tax rate τ^k that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

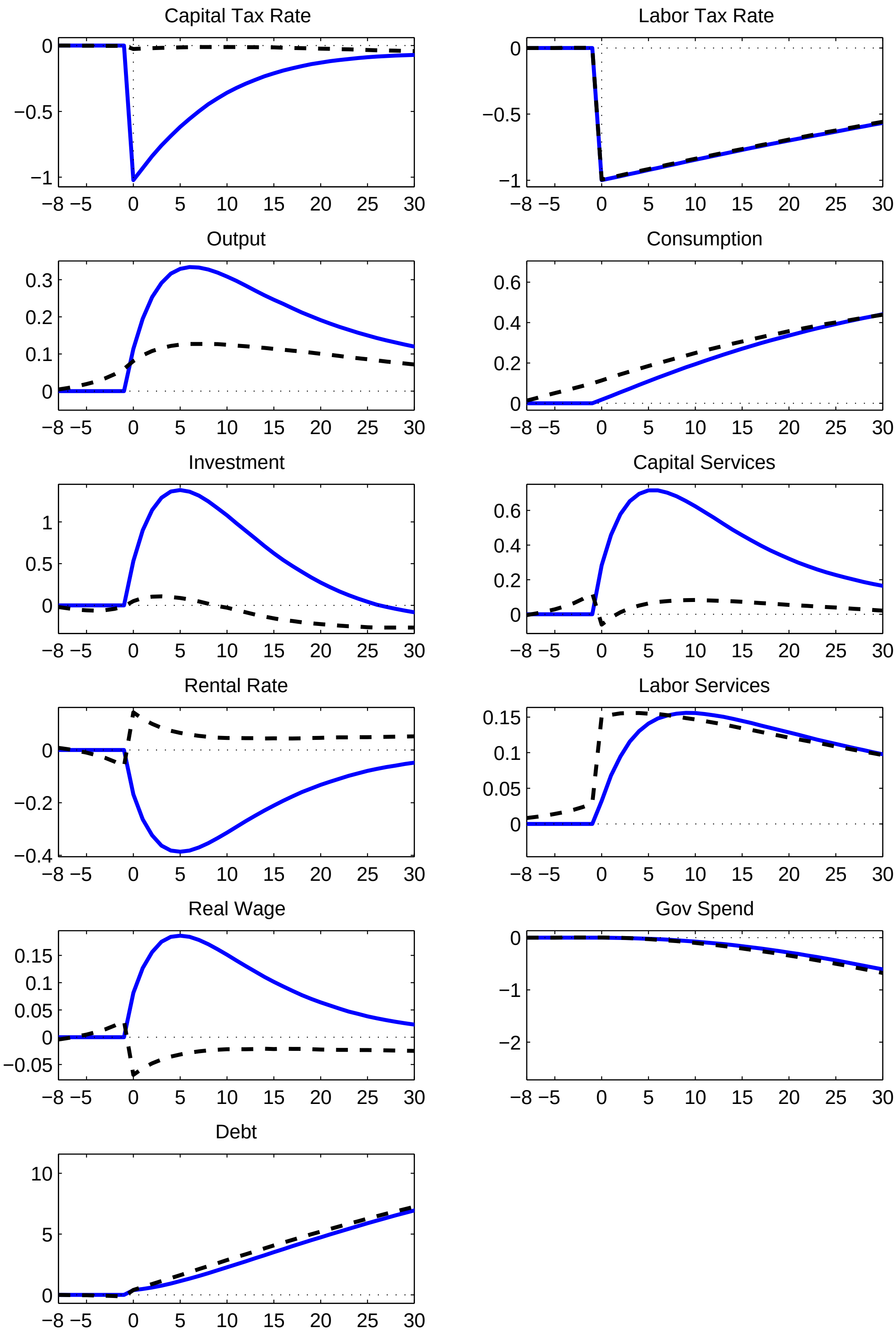

Figure 11: Impulse responses to unanticipated and anticipated labor tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the labor tax rate τ^n; dashed line: impulse responses to an eight period anticipated 1 percentage point cut of the labor tax rate τ^n that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

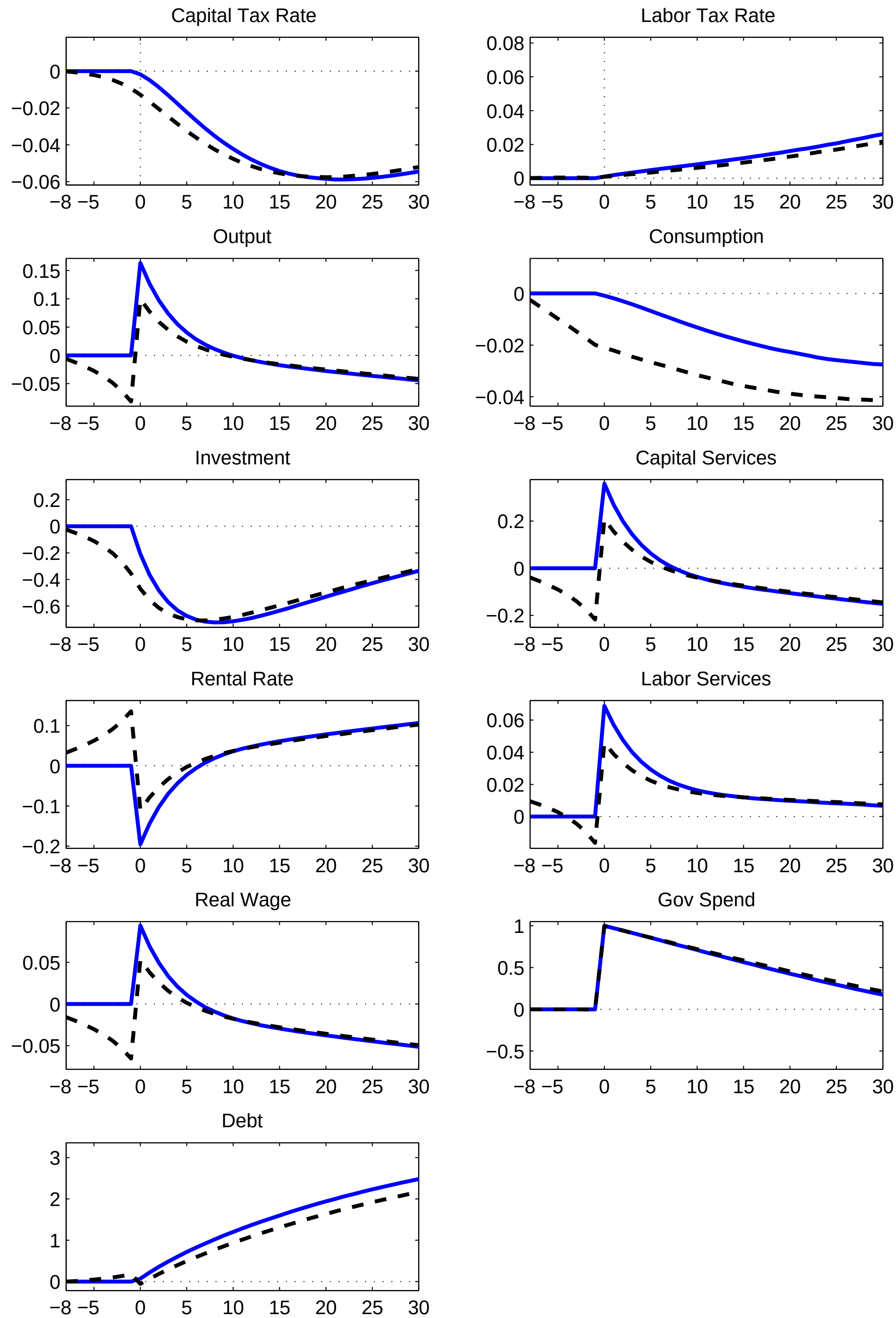

Figure 12: Impulse responses to unanticipated and anticipated government spending shocks. *Notes*: solid line: impulse responses to an unanticipated 1 percent increase in government spending g_t; dashed line: impulse responses to an eight period anticipated 1 percent increase in government spending g_t that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

Table 9: Model and Data Moments

	Model	Data	Model	Data	Model	Data
	$\rho(x_t, y_t)$		$\sigma(x_t)$		$\rho(x_t, x_{t-1})$	
$\Delta\log(Y_t)$	1.000	1.000	0.783	0.907	0.752	0.276
$\Delta\log(C_t)$	0.538	0.507	0.511	0.504	0.488	0.221
$\Delta\log\left(z_t^I A_t I_t\right)$	0.808	0.691	3.244	2.272	0.779	0.527
$\log\left(\frac{L_t}{L}\right)$	0.036	0.053	6.368	4.015	0.994	0.978
$\Delta\log(G_t)$	0.382	0.252	1.257	1.125	0.276	0.061
$\Delta\log\left(z_t^I A_t\right)$	0.027	-0.036	1.217	0.408	-0.000	0.493
τ^n	-0.014	-0.058	4.061	3.641	0.993	0.991
τ^k	0.080	-0.132	3.372	3.173	0.972	0.968
$\Delta\log(W_t)$	0.667	-0.043	0.939	0.573	0.402	0.087
$\Delta\log(TFP_t)$	0.524	0.075	1.045	0.848	0.235	-0.075

Notes: Time Series x_t are the growth rates of output ($\Delta\log(Y_t)$, denoted by y_t in the first column), consumption ($\Delta\log(C_t)$), investment ($\Delta\log\left(z_t^I A_t I_t\right)$), percentage deviations of hours worked from steady state ($\log\left(\frac{L_t}{L}\right)$), the growth rates of government spending ($\Delta\log(G_t)$) and investment-specific technology ($\Delta\log\left(z_t^I A_t\right)$), the level of labor and capital taxes (τ_t^n and τ_t^k), the growth rates of wages ($\Delta\log(W_t)$) and TFP ($\Delta\log(TFP_t)$), the level of the net nominal interest rate ($\log(R_t)$), and the level of net inflation ($\log(\Pi_t)$). Model moments are computed at the posterior median of the parameters.

Table 10: Prior and Posterior Distributions of the Shock Processes

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
			Preference and Technology Parameters				
σ_l	Gamma	2.00	0.75	7.354	0.475	6.558	8.082
σ_s	Beta	0.50	0.20	0.001	0.000	0.001	0.001
κ	Gamma	4.00	1.50	8.440	0.421	7.772	9.152
δ_2/δ_1	Inverse-Gamma	0.50	0.15	0.237	0.019	0.207	0.269
ϕ_c	Beta	0.70	0.10	0.982	0.003	0.978	0.986
			Preference Shock				
ρ_{pref}	Beta	0.50	0.20	0.146	0.027	0.102	0.192
σ_{pref}	Inverse-Gamma	0.10	2.00	42.497	6.045	33.734	52.208
			Wage Markup Shock				
ρ_w	Beta	0.50	0.20	0.972	0.005	0.963	0.980
σ_w	Inverse-Gamma	0.10	2.00	47.002	3.298	41.600	52.573
σ_w^4	Inverse-Gamma	0.10	2.00	41.649	2.816	37.022	46.308
σ_w^8	Inverse-Gamma	0.10	2.00	0.035	0.025	0.024	0.071
			Stationary Technology Shock				
ρ_z	Beta	0.50	0.20	0.916	0.036	0.843	0.957
σ_z	Inverse-Gamma	0.10	2.00	0.035	0.022	0.025	0.062
σ_z^4	Inverse-Gamma	0.10	2.00	0.748	0.026	0.707	0.787
σ_z^8	Inverse-Gamma	0.10	2.00	0.045	0.056	0.025	0.114
			Non-Stationary Technology Shock				
ρ_x	Beta	0.50	0.20	0.548	0.030	0.498	0.598
σ_x	Inverse-Gamma	0.10	2.00	0.701	0.034	0.648	0.758
σ_x^4	Inverse-Gamma	0.10	2.00	0.032	0.012	0.024	0.052
σ_x^8	Inverse-Gamma	0.10	2.00	0.538	0.040	0.474	0.606
			Stationary Investment-Specific Productivity Shock				
ρ_{zI}	Beta	0.50	0.20	0.989	0.002	0.985	0.993
σ_{zI}	Inverse-Gamma	0.10	2.00	0.646	0.028	0.601	0.689
σ_{zI}^4	Inverse-Gamma	0.10	2.00	0.501	0.097	0.310	0.614
σ_{zI}^8	Inverse-Gamma	0.10	2.00	0.206	0.188	0.025	0.484
			Non-Stationary Investment-Specific Productivity Shock				

Table 10: Prior and Posterior Distributions of the Shock Processes - Continued

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
ρ_a	Beta	0.50	0.20	0.005	0.003	0.001	0.010
σ_a	Inverse-Gamma	0.10	2.00	0.594	0.024	0.553	0.635
σ_a^4	Inverse-Gamma	0.10	2.00	0.038	0.029	0.023	0.076
σ_a^8	Inverse-Gamma	0.10	2.00	0.646	0.023	0.607	0.681
				Government Spending Shock			
ρ_g	Beta	0.50	0.20	0.972	0.003	0.967	0.978
ρ_{xg}	Beta	0.50	0.20	0.937	0.013	0.915	0.958
σ_g	Inverse-Gamma	0.10	2.00	0.927	0.319	0.027	1.129
σ_g^4	Inverse-Gamma	0.10	2.00	0.228	0.367	0.024	1.072
σ_g^8	Inverse-Gamma	0.10	2.00	0.036	0.023	0.025	0.074
ϕ_{gD}	Normal	0.00	1.00	-0.007	0.002	-0.011	-0.006
				Labor Tax Shock			
$\rho_{\tau n}$	Beta	0.70	0.20	0.985	0.004	0.977	0.990
$\sigma_{\tau n}$	Inverse-Gamma	0.10	2.00	0.391	0.032	0.343	0.442
$\sigma_{\tau n}^4$	Inverse-Gamma	0.10	2.00	0.041	0.033	0.025	0.084
$\sigma_{\tau n}^8$	Inverse-Gamma	0.10	2.00	0.040	0.031	0.024	0.087
ϕ_{nD}	Normal	0.00	1.00	0.001	0.000	0.000	0.001
ϕ_{nl}	Normal	0.00	1.00	0.014	0.004	0.007	0.021
				Capital Tax Shock			
$\rho_{\tau k}$	Beta	0.70	0.20	0.918	0.010	0.901	0.933
$\sigma_{\tau k}$	Inverse-Gamma	0.10	2.00	0.704	0.036	0.645	0.768
$\sigma_{\tau k}^4$	Inverse-Gamma	0.10	2.00	0.035	0.017	0.025	0.068
$\sigma_{\tau k}^8$	Inverse-Gamma	0.10	2.00	0.035	0.018	0.024	0.070
ϕ_{kD}	Normal	0.00	1.00	-0.000	0.000	-0.001	-0.000
ϕ_{kI}	Normal	0.00	1.00	0.009	0.001	0.007	0.011
				Tax Shock Correlations			
$\{\varepsilon_{\tau k}^0, \varepsilon_{\tau n}^0\}$	Beta*	0.00	0.30	0.571	0.047	0.498	0.648
$\{\varepsilon_{\tau k}^4, \varepsilon_{\tau n}^4\}$	Beta*	0.00	0.30	0.013	0.233	-0.377	0.404
$\{\varepsilon_{\tau k}^8, \varepsilon_{\tau n}^8\}$	Beta*	0.00	0.30	0.010	0.233	-0.375	0.394
				Measurement Error			

Table 10: Prior and Posterior Distributions of the Shock Processes - Continued

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
σ_w^{me}	Uniform	0.07	0.04	0.142	0.000	0.142	0.142
σ_y^{me}	Uniform	0.01	0.01	0.018	0.000	0.018	0.018
$\sigma_{\tau n}^{me}$	Uniform	0.46	0.26	0.173	0.025	0.129	0.212
$\sigma_{\tau k}^{me}$	Uniform	0.40	0.23	0.236	0.045	0.164	0.308

Notes: The standard deviations of the shocks and measurement errors have been transformed into percentages by multiplying with 100. Beta* indicates that the correlations follow a beta-distribution stretched to the interval [-1,1].

Table 11: Variance Decomposition Output Growth RBC intermed. (in percent)

	1	4	8	12	16	20	Inf
ξ^0_{pref}	31.08	15.06	11.75	10.32	9.98	9.89	9.73
ε^0_w	7.00	6.60	5.33	4.66	4.52	4.50	4.61
$\varepsilon^{4,8}_w$	0.47	1.18	2.02	1.82	1.75	1.75	1.86
ε^0_z	0.04	0.03	0.02	0.02	0.02	0.02	0.02
$\varepsilon^{4,8}_z$	2.74	6.87	9.39	8.25	8.26	8.51	8.80
ε^0_x	42.14	57.03	53.59	48.44	46.98	46.59	46.07
$\varepsilon^{4,8}_x$	0.64	1.35	4.91	13.19	15.52	15.91	15.91
ε^0_{zI}	1.69	1.64	1.35	1.18	1.14	1.13	1.15
$\varepsilon^{4,8}_{zI}$	0.21	0.43	0.62	0.56	0.54	0.54	0.56
ε^0_a	0.85	2.28	2.10	1.89	1.83	1.81	1.78
$\varepsilon^{4,8}_a$	0.11	0.22	0.74	2.25	2.31	2.31	2.28
ε^0_g	10.38	5.09	3.90	3.42	3.30	3.27	3.23
$\varepsilon^{4,8}_g$	0.06	0.14	2.77	2.45	2.36	2.34	2.31
$\varepsilon^0_{\tau n}$	0.09	0.09	0.07	0.06	0.06	0.06	0.70
$\varepsilon^{4,8}_{\tau n}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^0_{\tau k}$	1.73	1.40	1.06	0.96	0.96	0.97	0.64
$\varepsilon^{4,8}_{\tau k}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{w,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau n,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau k,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{y,t}$	0.18	0.08	0.06	0.05	0.05	0.05	0.05

9.3 Baseline model

The next step performed in the paper is to add back the nominal sector. Adding interest rates and inflation as observables helps bringing the model closer to the data in some key aspects (see Table 3 of the paper). The correlation of TFP with output drops by 0.2 compared to the basic model, but is still somewhat too high. Moreover, the autocorrelations of government spending and investment-specific technology growth are roughly on target, while they were too high and too low, respectively, in the real models. The autocorrelation of TFP also moves closer to the data.

This change in the autocorrelation of TFP growth rates is achieved in the model estimation by further shifting importance from the permanent to the temporary TFP shock (see Tables 2 and 4 of the paper). The increase in autocorrelation of investment-specific technology growth stems from a shift of variance from temporary to permanent shocks and a large increase in the autocorrelation of the latter. This increase in persistence alone would imply a higher autocorrelation of investment growth. Thus, to keep the moments of investment in line with the data, the model assigns lower values to the investment adjustment and capital utilization costs. The further decrease in the contemporaneous autocorrelation of government spending growth rates is achieved by a lower degree of debt feedback and a shift in the importance of surprise to anticipated government spending shocks. Finally, given the implied changes for capital services variability resulting from lower capital adjustment and utilization costs, the Frisch elasticity of labor supply is estimated to increase considerably, thus lowering the autocorrelation of hours, which was extremely high before at 0.993 in the intermediate RBC model.

At the same time, given the estimated moderate degree of nominal rigidities, the nominal model is able to match the moments of the policy rate and inflation well without impairing the fit of the other variables too much. The covariance of wages with output growth decreases a bit with the introduction of wage rigidities and the higher Frisch elasticity, but is still too high. The only drawback is the drop in the autocorrelation of the capital tax rate.

Thus, given the better fit of some key moments of the data, we ultimately believe that the monetary model used as our benchmark model delivers a more realistic picture.

10 NK Federal

This section presents additional IRFs and tables for the federal government only model of section 4.3.

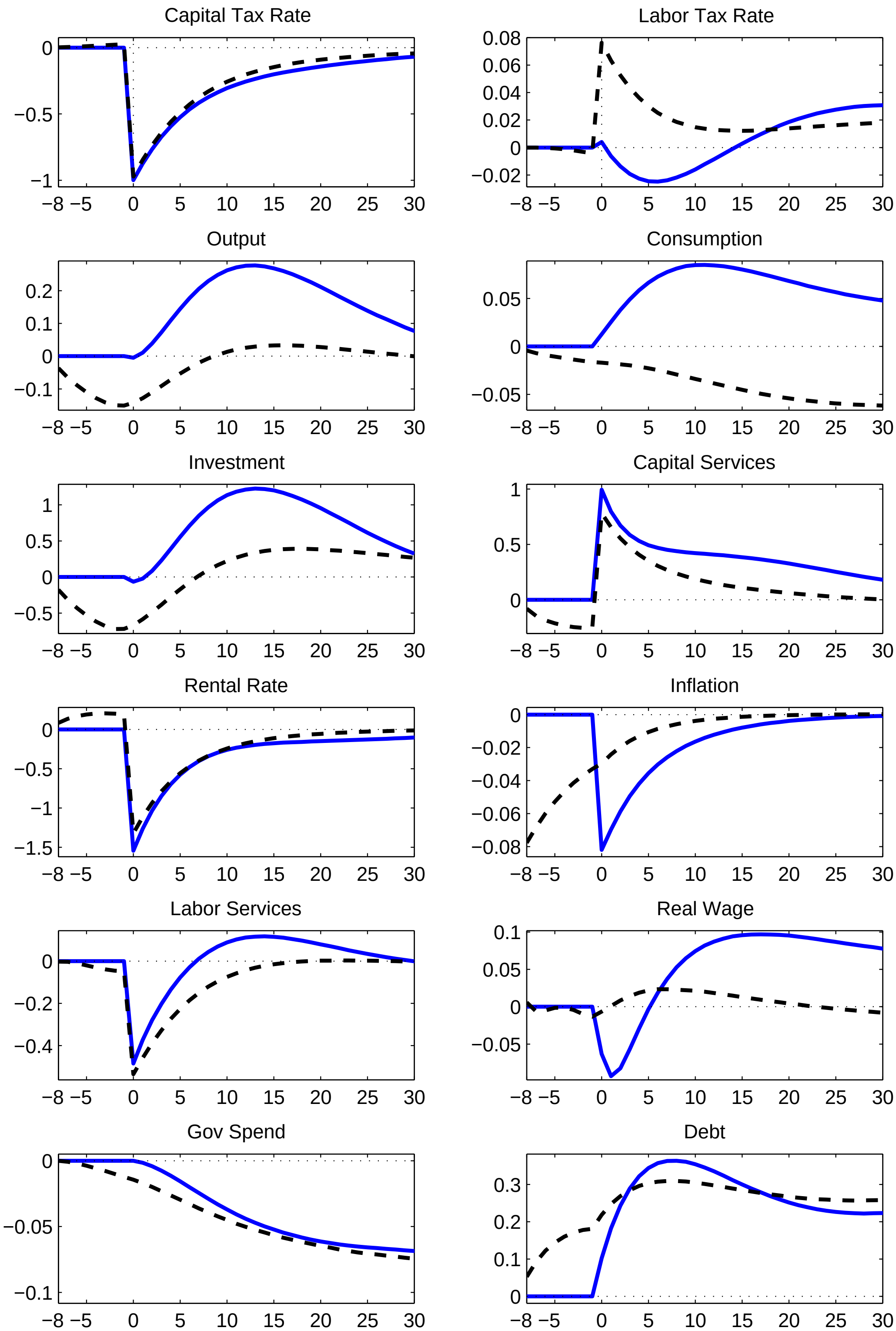

Figure 13: Impulse responses to unanticipated and anticipated capital tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the capital tax rate τ^k; dashed line: impulse responses to an eight period anticipated 1 percentage point cut of the capital tax rate τ^k that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

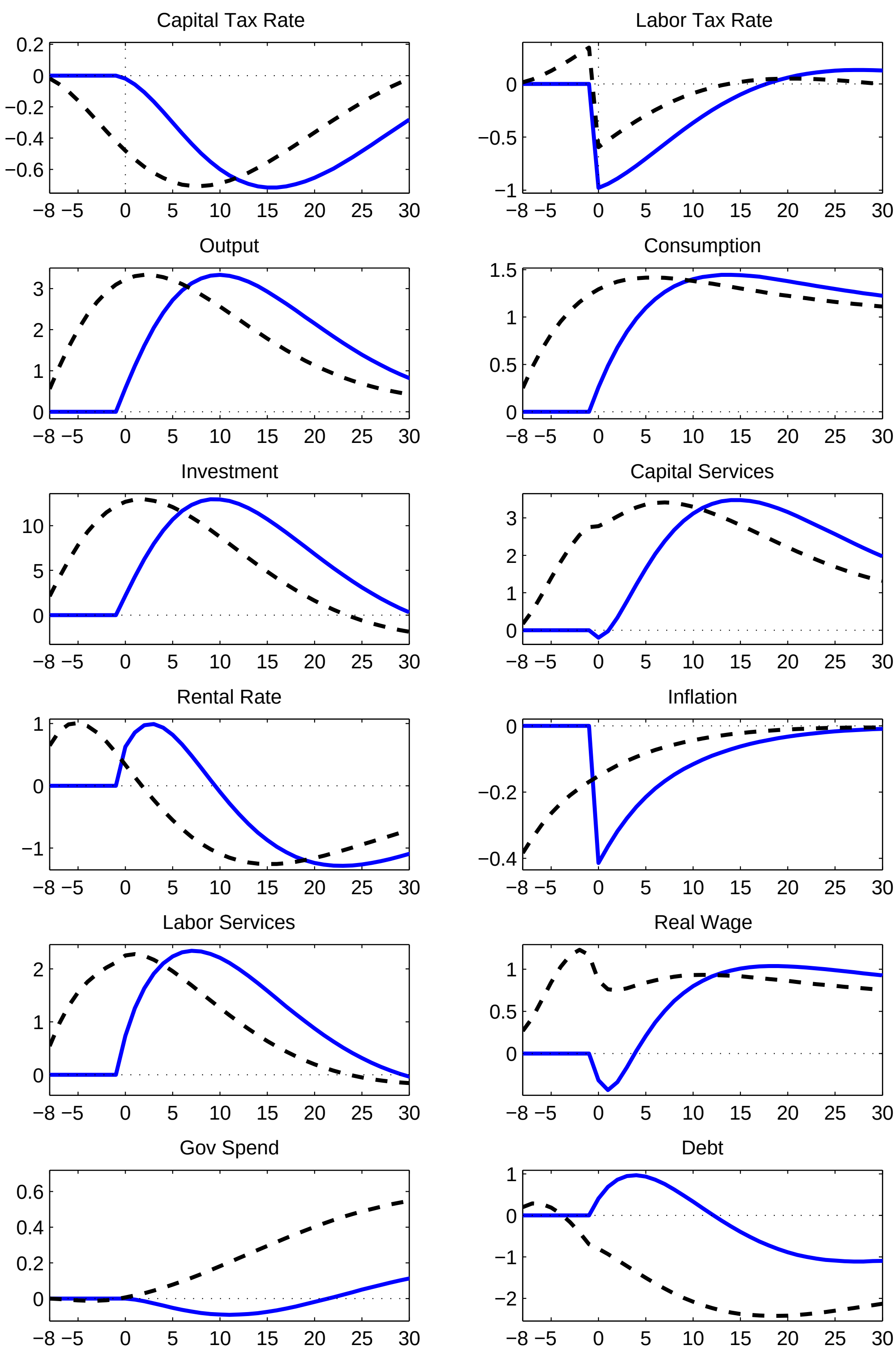

Figure 14: Impulse responses to unanticipated and anticipated labor tax shocks.
Notes: solid line: impulse responses to an unanticipated 1 percentage point cut of the labor tax rate τ^n; dashed line: impulse responses to an eight period anticipated 1 percentage point cut of the labor tax rate τ^n that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are semi-elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

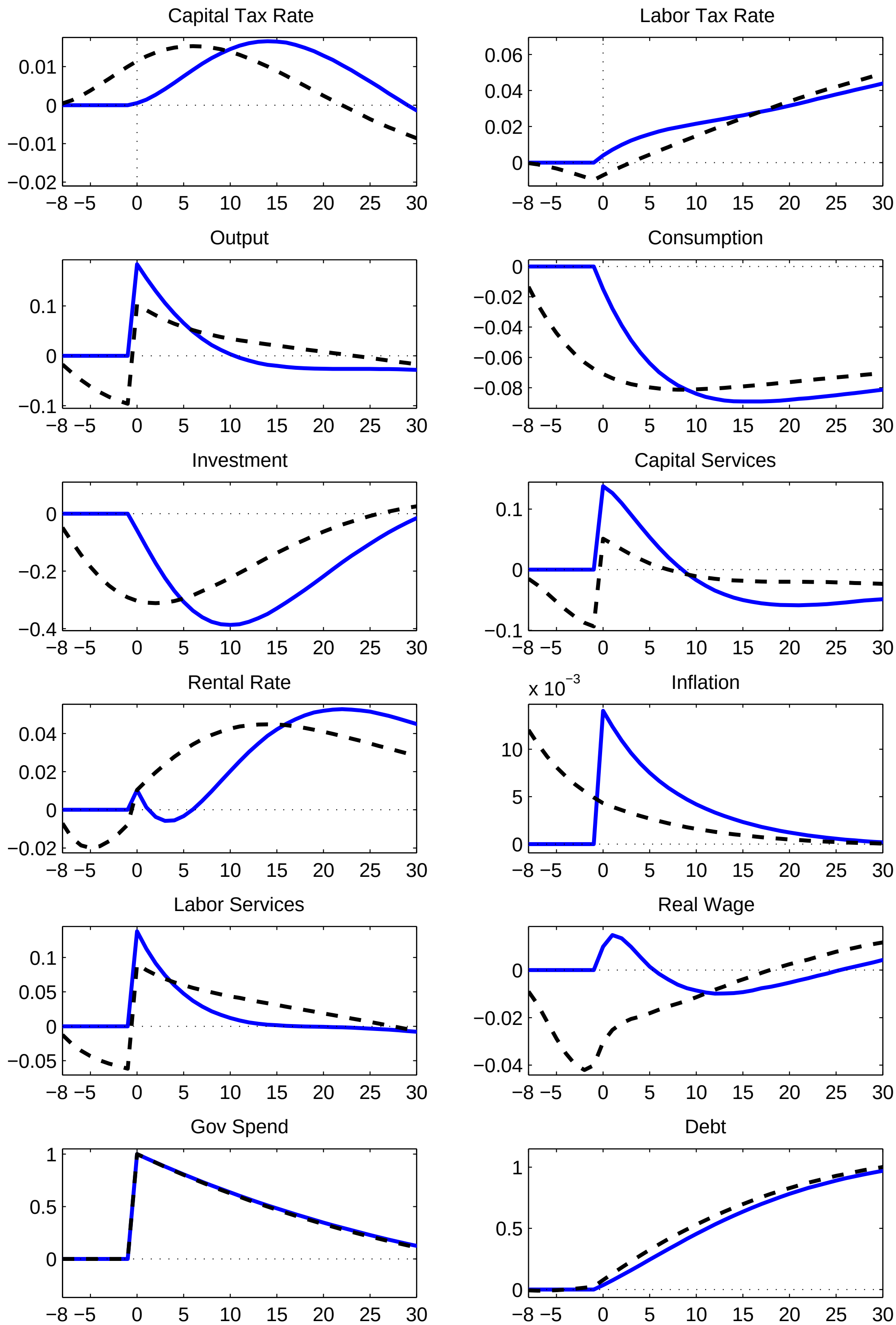

Figure 15: Impulse responses to unanticipated and anticipated government spending shocks. *Notes*: solid line: impulse responses to an unanticipated 1 percent increase in government spending g_t; dashed line: impulse responses to an eight period anticipated 1 percent increase in government spending g_t that becomes known at $t = -8$ and effective at $t = 0$. All impulse responses are elasticities and measured in percentage deviations from steady state, with the exception of inflation and the rental rate, which are measured as percentage point deviations from steady state.

Table 12: Model and Data Moments

	Model	Data	Model	Data	Model	Data
	$\rho(x_t, y_t)$		$\sigma(x_t)$		$\rho(x_t, x_{t-1})$	
$\Delta \log (Y_t)$	1.000	1.000	1.007	0.907	0.616	0.276
$\Delta \log (C_t)$	0.566	0.507	0.604	0.504	0.513	0.221
$\Delta \log \left(z_t^I A_t I_t\right)$	0.777	0.691	3.508	2.272	0.861	0.527
$\log \left(\frac{L_t}{L}\right)$	0.115	0.053	5.405	4.015	0.955	0.978
$\Delta \log (G_t)$	0.535	0.184	2.517	2.051	0.046	-0.044
$\Delta \log \left(z_t^I A_t\right)$	-0.102	-0.036	0.598	0.408	0.611	0.493
τ^n	-0.094	-0.062	3.687	2.982	0.987	0.987
τ^k	-0.009	-0.119	4.766	3.833	0.874	0.972
$\Delta \log (W_t)$	0.303	-0.043	0.703	0.573	0.290	0.087
$\Delta \log (TFP_t)$	0.221	0.075	1.021	0.848	0.172	-0.075
$\log (R_t)$	-0.231	-0.183	1.310	0.809	0.967	0.959
$\log (\Pi_t)$	-0.259	-0.263	0.703	0.578	0.891	0.854

Notes: Time Series x_t are the growth rates of output ($\Delta \log (Y_t)$, denoted by y_t in the first column), consumption ($\Delta \log (C_t)$), investment ($\Delta \log \left(z_t^I A_t I_t\right)$), percentage deviations of hours worked from steady state ($\log \left(\frac{L_t}{L}\right)$), the growth rates of government spending ($\Delta \log (G_t)$) and investment-specific technology ($\Delta \log \left(z_t^I A_t\right)$), the level of labor and capital taxes (τ_t^n and τ_t^k), the growth rates of wages ($\Delta \log (W_t)$) and TFP ($\Delta \log (TFP_t)$), the level of the net nominal interest rate ($\log (R_t)$), and the level of net inflation ($\log (\Pi_t)$). Model moments are computed at the posterior median of the parameters.

Table 13: Prior and Posterior Distributions of the Shock Processes

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
	Preference and Technology Parameters						
χ_w	Beta	0.50	0.20	0.661	0.106	0.482	0.824
χ_p	Beta	0.50	0.20	0.004	0.002	0.001	0.008
θ_p	Beta	0.50	0.20	0.881	0.001	0.879	0.884
θ_w	Beta	0.50	0.20	0.486	0.019	0.456	0.517
σ_l	Gamma	2.00	0.75	2.598	0.205	2.290	2.961
σ_s	Beta	0.50	0.20	0.020	0.003	0.016	0.025
κ	Gamma	4.00	1.50	3.901	0.182	3.621	4.214
δ_2/δ_1	Inverse-Gamma	0.50	0.15	0.090	0.004	0.085	0.097
ϕ_c	Beta	0.70	0.10	0.864	0.009	0.848	0.878
	Preference Shock						
ρ_{pref}	Beta	0.50	0.20	0.106	0.047	0.038	0.192
σ_{pref}	Inverse-Gamma	0.10	2.00	5.488	0.463	4.695	6.257
	Wage Markup Shock						
ρ_w	Beta	0.50	0.20	0.988	0.001	0.985	0.990
σ_w	Inverse-Gamma	0.10	2.00	0.031	0.014	0.023	0.052
σ_w^4	Inverse-Gamma	0.10	2.00	7.786	0.617	6.779	8.805
σ_w^8	Inverse-Gamma	0.10	2.00	0.031	0.017	0.025	0.053
	Stationary Technology Shock						
ρ_z	Beta	0.50	0.20	0.908	0.006	0.899	0.918
σ_z	Inverse-Gamma	0.10	2.00	0.553	0.034	0.496	0.608
σ_z^4	Inverse-Gamma	0.10	2.00	0.128	0.118	0.025	0.332
σ_z^8	Inverse-Gamma	0.10	2.00	0.502	0.033	0.448	0.556
	Non-Stationary Technology Shock						
ρ_x	Beta	0.50	0.20	0.455	0.031	0.402	0.506
σ_x	Inverse-Gamma	0.10	2.00	0.588	0.041	0.522	0.657
σ_x^4	Inverse-Gamma	0.10	2.00	0.591	0.066	0.481	0.691
σ_x^8	Inverse-Gamma	0.10	2.00	0.245	0.167	0.025	0.458
	Stationary Investment-Specific Productivity Shock						
ρ_{zI}	Beta	0.50	0.20	0.998	0.000	0.998	0.998

Table 13: Prior and Posterior Distributions of the Shock Processes - Continued

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
σ_{zI}	Inverse-Gamma	0.10	2.00	0.354	0.025	0.305	0.389
σ_{zI}^4	Inverse-Gamma	0.10	2.00	0.083	0.076	0.024	0.230
σ_{zI}^8	Inverse-Gamma	0.10	2.00	0.031	0.011	0.023	0.053
	Non-Stationary Investment-Specific Productivity Shock						
ρ_a	Beta	0.50	0.20	0.955	0.004	0.948	0.961
σ_a	Inverse-Gamma	0.10	2.00	0.086	0.008	0.074	0.099
σ_a^4	Inverse-Gamma	0.10	2.00	0.065	0.011	0.045	0.080
σ_a^8	Inverse-Gamma	0.10	2.00	0.092	0.008	0.079	0.104
	Government Spending Shock						
ρ_g	Beta	0.50	0.20	0.960	0.007	0.947	0.970
ρ_{xg}	Beta	0.50	0.20	0.826	0.042	0.754	0.891
σ_g	Inverse-Gamma	0.10	2.00	0.030	0.013	0.024	0.048
σ_g^4	Inverse-Gamma	0.10	2.00	0.033	0.015	0.025	0.057
σ_g^8	Inverse-Gamma	0.10	2.00	2.404	0.050	2.322	2.484
ϕ_{gD}	Normal	0.00	1.00	-0.009	0.001	-0.012	-0.007
	Labor Tax Shock						
$\rho_{\tau n}$	Beta	0.70	0.20	0.998	0.002	0.994	1.000
$\sigma_{\tau n}$	Inverse-Gamma	0.10	2.00	0.174	0.023	0.136	0.209
$\sigma_{\tau n}^4$	Inverse-Gamma	0.10	2.00	0.215	0.023	0.176	0.252
$\sigma_{\tau n}^8$	Inverse-Gamma	0.10	2.00	0.270	0.019	0.238	0.303
ϕ_{nD}	Normal	0.00	1.00	0.001	0.000	0.001	0.001
ϕ_{nl}	Normal	0.00	1.00	0.028	0.001	0.026	0.031
	Capital Tax Shock						
$\rho_{\tau k}$	Beta	0.70	0.20	0.875	0.006	0.866	0.884
$\sigma_{\tau k}$	Inverse-Gamma	0.10	2.00	1.060	0.066	0.953	1.164
$\sigma_{\tau k}^4$	Inverse-Gamma	0.10	2.00	1.173	0.061	1.073	1.276
$\sigma_{\tau k}^8$	Inverse-Gamma	0.10	2.00	1.298	0.057	1.201	1.387
ϕ_{kD}	Normal	0.00	1.00	-0.001	0.000	-0.001	-0.001
ϕ_{kI}	Normal	0.00	1.00	-0.009	0.001	-0.010	-0.008
	Tax Shock Correlations						

Table 13: Prior and Posterior Distributions of the Shock Processes - Continued

Parameter	Prior distribution			Posterior distribution			
	Distribution	Mean	Std. Dev.	Mean	Std. Dev.	5 Percent	95 Percent
$\{\varepsilon^0_{\tau k}, \varepsilon^0_{\tau n}\}$	Beta*	0.00	0.30	-0.103	0.108	-0.271	0.089
$\{\varepsilon^4_{\tau k}, \varepsilon^4_{\tau n}\}$	Beta*	0.00	0.30	-0.727	0.061	-0.825	-0.625
$\{\varepsilon^8_{\tau k}, \varepsilon^8_{\tau n}\}$	Beta*	0.00	0.30	-0.456	0.057	-0.544	-0.357
				Monetary Policy			
ρ_R	Beta	0.50	0.20	0.864	0.005	0.856	0.871
σ_R	Inverse-Gamma	0.10	2.00	0.317	0.013	0.297	0.338
ϕ_{R_Π}	Gamma	1.50	3.00	2.392	0.037	2.338	2.454
ϕ_{R_Y}	Gamma	0.50	3.00	0.000	0.000	0.000	0.000
				Measurement Error			
σ^{me}_y	Uniform	0.01	0.01	0.000	0.000	0.000	0.000
σ^{me}_w	Uniform	0.07	0.04	0.142	0.000	0.142	0.142
$\sigma^{me}_{\tau n}$	Uniform	0.46	0.26	0.318	0.019	0.287	0.350
$\sigma^{me}_{\tau k}$	Uniform	0.40	0.23	0.792	0.000	0.792	0.792

Notes: The standard deviations of the shocks and measurement errors have been transformed into percentages by multiplying with 100. Beta* indicates that the correlations follow a beta-distribution stretched to the interval [-1,1].

Table 14: Variance Decomposition Output Growth Federal (in percent)

	1	4	8	12	16	20	Inf
ξ^0_{pref}	23.14	10.52	8.59	6.17	5.97	5.75	5.58
ε^0_w	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{4,8}_w$	2.53	3.38	3.20	2.33	2.59	3.00	3.87
ε^0_z	8.31	10.42	9.88	7.09	7.14	7.38	8.06
$\varepsilon^{4,8}_z$	5.76	7.36	7.21	5.20	5.24	5.47	6.11
ε^0_x	11.40	17.80	18.49	13.68	13.24	12.78	12.50
$\varepsilon^{4,8}_x$	5.29	6.24	8.18	7.07	7.13	6.90	6.74
ε^0_{zI}	0.33	0.67	0.70	0.53	0.51	0.49	0.48
$\varepsilon^{4,8}_{zI}$	0.01	0.04	0.15	0.14	0.14	0.13	0.13
ε^0_a	2.57	1.36	1.47	1.61	1.99	2.16	2.43
$\varepsilon^{4,8}_a$	2.31	1.54	1.25	1.15	1.67	2.17	3.44
ξ^R	12.69	7.09	6.04	5.10	5.25	5.09	5.03
ε^0_g	0.02	0.01	0.01	0.00	0.00	0.00	0.00
$\varepsilon^{4,8}_g$	0.87	1.09	1.09	24.77	24.06	23.13	22.38
$\varepsilon^0_{\tau n}$	6.18	7.80	7.59	5.45	5.41	5.53	6.17
$\varepsilon^{4,8}_{\tau n}$	17.71	22.50	22.13	15.97	15.80	16.11	11.02
$\varepsilon^0_{\tau k}$	0.01	0.80	1.55	1.25	1.22	1.25	1.75
$\varepsilon^{4,8}_{\tau k}$	0.32	0.84	2.02	2.14	2.18	2.16	3.83
$\varepsilon^{me}_{w,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau n,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{\tau k,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$\varepsilon^{me}_{y,t}$	0.00	0.00	0.00	0.00	0.00	0.00	0.00

References

Auerbach, Alan J., 1989. Tax Reform and Adjustment Costs: The Impact on Investment and Market Value. International Economic Review 30, 939–962.

Basu, Susanto, Fernald, John G., Kimball, Miles S., 2006. Are Technology Improvements Contractionary? American Economic Review 96, 1418–1448.

Beaudry, Paul, Lucke, Bernd, 2010. Letting Different Views about Business Cycles Compete, in: NBER Macroeconomics Annual 2009, Volume 24, pp. 413–455.

Fernald, John, 2012. A Quarterly, Utilization-Adjusted Series on Total Factor Productivity. Federal Reserve Bank of San Francisco Working Paper 2012-19.

Fisher, Jonas D.M., 2006. The Dynamic Effects of Neutral and Investment Specific Technology Shocks. Journal of Political Economy 114, 413–451.

Ireland, Peter N., 2004. A Method for Taking Models to the Data. Journal of Economic Dynamics and Control 28, 1205–1226.

Jones, John Bailey, 2002. Has Fiscal Policy Helped Stabilize the Postwar U.S. Economy? Journal of Monetary Economics 49, 709–746.

Leeper, Eric M., Plante, Michael, Traum, Nora, 2010. Dynamics of Fiscal Financing in the United States. Journal of Econometrics 156, 304–321.

Mendoza, Enrique G., Razin, Assaf, Tesar, Linda L., 1994. Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption. Journal of Monetary Economics 34, 297–323.

Pfeifer, Johannes, 2013. A guide to specifying observation equations for the estimation of DSGE models. Tech. rep. University of Mannheim.

Ramey, Valerie A., 2011. Identifying Government Spending Shocks: It's all in the Timing. Quarterly Journal of Economics 126, 1–50.

Sargent, Thomas J, 1989. Two Models of Measurements and the Investment Accelerator. Journal of Political Economy 97, 251–87.

Schmitt-Grohé, Stephanie, Uribe, Martín, 2011. Business Cycles With A Common Trend in Neutral and Investment-Specific Productivity. Review of Economic Dynamics 14, 122–135.

— 2012. What's News in Business Cycles. Econometrica 80, 2733–2764.