The estimated general equilibrium effects of fiscal policy: the case of the euro area

Lorenzo Forni Libero Monteforte Luca Sessa

Banca d'Italia Research Dept.

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PRELIMINARY AND INCOMPLETE

MOTIVATION:

- Fiscal stance usually measured by change in (cyclically adjusted) budget balance
- Fiscal shock is a more general concept (expectations; composition of revenues and expenditures)
- With rational forward-looking agents, non-keynesian effects dominate
- RBC-style models predict that after a government spending increase ΔG: $C \downarrow \; L \uparrow \; W/P \downarrow$
- This is due to *negative wealth effect* of forward looking agents
- But: $Corr(G, C) < 0$ as $Corr(C, L) < 0$ and $Corr(L, W/P) < 0$ inconsistent with most empirical evidence
- In particular usually $Corr(G, C) \geq 0$

What do we do?

- We consider a NK DSGE model proven to match euro area data satisfactorily (Smets-Wouters '03)

- We add

  1. R-o-T's, non-Ricardian agents (to allow for keynesian effects)

  2. composition of revenues (distortionary taxes) and expenditures: G includes
     - *expenditure on good/services* (40% of G over 1980-2004)
     - *compensations of government employees* (60%)

  3. unique data set on fiscal (alongside standard macro) variables

What do we do?

- We consider three models, differing on fiscal side specification:

  1. Lump-sum taxes (responding smoothly to debt) and no distinction within government consumption
  2. Distortionary taxes (responding smoothly to debt) on labor and capital incomes and no distinction within government consumption
  3. Same as 2 but distinguishing b/w expenditure on good/services and government employment

RELATION WITH LITERATURE

- Galì et al. '05 introduce R-o-T consumers in a sticky prices model and show that this can deliver $Corr(G, C) > 0$. Based on calibration. We introduce R-o-T's in a similar way.

- Intuition: Gov. additional demand has to be met by firms which hire more workers $\Rightarrow$ higher real wages (e.g., if prices are sticky while wages are not) $\Rightarrow$ higher disposable income of R-o-T's!

- Coenen-Straub '05 estimate the share of R-o-T's around 0.25. Not able to deliver $Corr(G, C) > 0$.
  They consider lump-sum taxes and only government expenditures on good and services. They have sticky prices and wages (as we do).

Preview of main results

- The estimated share of rule-of-thumb ranges between 0.35-0.6 when assuming distortionary taxes

- It is much smaller when assuming lump-sum taxes

- Our model can deliver $Corr(G, C) \geq 0$

- In addition, IRF and fiscal multipliers with respect to a variety of fiscal shocks

OUTLINE:

- Motivation
- Preview of the results
- Model
- Solution and estimation
- Data and data treatment
- Results

The Model: some behavioral features

- Non Ricardian do not have access to capital markets
- Ricardian save in government bonds and capital
- Ricardian rent capital to firms
- HH's supply labor to firms in monopolistically competitive market
- They face an adjustment cost in setting their wages
- Firms are monopolistically competitive and produce differentiated goods
- In setting their prices they also face an adjustment cost

The model: Ricardian households

$$\max \quad E_0 \sum_{t=0}^{\infty} \beta^t \varepsilon_t^b \left[\frac{1}{1-\sigma_c} \left(c_t^R(i) - hC_{t-1}^R \right)^{1-\sigma_c} - \varepsilon_t^l \frac{1}{1+\sigma_l} l_t(i)^{1+\sigma_l} \right]$$

$$s.t. \quad (1-\tau_t^w) w_t l_t + (1-\tau_t^k) \left[R_t^k \overline{k}_t u_t + D_t \right] + B_t + Tr_t + \frac{\tau_t^c}{1+\tau_t^c} P_t I_t =$$

$$\left[P_t c_t^R + P_t I_t + \frac{B_{t+1}}{R_t} \right] + \left[P_t \psi(u_t) \overline{k}_t + \frac{\varphi}{2} \left(\frac{w_t}{w_{t-1}} - \pi \right)^2 W_t \right]$$

$$\overline{k}_{t+1} = (1-\delta)\, \overline{k}_t + \left[1 - s \left(\frac{\varepsilon_t^i I_t}{I_{t-1}} \right) \right] I_t$$

- External habit formation in consumption with $h \in [0, 1)$ where $C(i)$ is aggregate per capita consumption of Ricardian agents.

- Two demand shifters (preference shocks): ε_t^b affects intertemporal utility while ε_t^l affects consumption-leisure trade-off at t.

- Both shocks are assumed AR(1) with i.i.d. error term.

- $\overline{k}_t$ are physical unit of capital, while u_t is capacity utilization.

- D_t are dividends, distributed to Ricardians (firms owners).

- Adjustment costs on HH's choices of u_t and nominal wage w_t.

- $s(\cdot)$ is the cost of changing the investment level.

- ε_t^i is an AR(1) shock to the investment cost function.

The model: Non Ricardian households

$$P_t c_t^{NR} = (1 - \tau_t^w) w_t l_t + Tr_t$$

- Non Ricardian households are assumed to simply consume their after-tax disposable income.

The model: Firms

$$\max_{\{\tilde{p}_t\}} E_0 \sum_{t=0}^{\infty} \beta^t (1-\tau_t^k)\lambda_t \left(\tilde{p}_t(j) y_t(j) - MC_t(j) c_t(j) - \frac{\kappa}{2} \left(\frac{\tilde{p}_t(j)}{\tilde{p}_{t-1}(j)} - \pi \right)^2 \tilde{P}_t c_t \right)$$

- Firms maximize profits defined as the difference between total revenues and total costs (inclusive of the price adjustment cost), subject to constant price-elasticity (θ_c) demand.
- $\tilde{p}_t(j)$ indicates wholesale (producer) price, chosen by firm j; $p_t(j)$ indicates instead consumer price, inclusive of indirect taxes.
- $\beta^t \lambda_t$ is the utility weighted discount rate (from Ricardian's f.o.c.'s).
- Technology: $y_t(j) = k_t(j)^{\alpha} (l_t^p(j)\, z_t)^{1-\alpha}$, with shock z_t.

The model: Labor market

- Each household sets its wage in monopolistically competitive labor market

- Each type i Ricardian household is wage setter for type i labor, by solving his optimization problem given the labor demand constraint:

$$l_t^p(i) = \left(\frac{W_t}{w_t(i)}\right)^{\theta_L} L_t^p$$

- The labor demand comes from a perfectly competitive firm (basically a CES aggregator of differentiated labor services) that buys the differentiated individual labor services and transforms them into a homogeneous composite labor input that, in turn, is sold to firms producing the final goods.

- Each Ricardian household faces adjustment cost in setting its wage:

$$\frac{\varphi}{2}\left(\frac{w(i)_t}{w(i)_{t-1}} - \pi\right)^2 W_t$$

- The cost is expressed in terms of the equilibrium wage rate, W_t.

- Type i non Ricardian household sets his wage rate equal to the wage of Ricardian ones.

- Since all households face the same labor demand, each non Ricardian household will work the same number of hours as the Ricardian ones.

The model: Non Ricardian labor supply

- Should we assume Ricardian and Non Ricardian supply different types of labor? In this case, leaving aside the wage adjustment costs, we would get:

$$u'(l_t) = u'(c_t)w\left(\frac{\theta_L - 1}{\theta_L}\right)$$

where θ_L is the wage elasticity of labor demand.

- If wages are sticky (as in our case), any shock to Non Ricardian income and consumption would require them to adjust labor supply.

- Do we want to have Non Ricardian employment and wages much more volatile than the ones of Ricardian?

- We rather not. After all wages are very sticky.

Fiscal policy (Model III)

- Government budget constraint:

$$\left[\frac{B_{t+1}}{R_t} - B_t\right] = C_t^g + W_t L_t^g + TR_t - T_t$$

- Assume C_t^g, L_t^g and TR_t are given by exogenous AR(1) processes with i.i.d. error term.

- Total revenues T_t depend on tax rates and tax bases. Three tax rates: on labor income, on consumption and on capital income:

$$T_t = \tau_t^w w_t l_t + \frac{\tau_t^c}{1+\tau_t^c}\left[P_t C_t + G_t\right] + \tau_t^k \left[R_t^k k_t + D_t\right] + \varepsilon_t^t$$

- ε_t^t is a measurement error

- The government set tax rates. We would like some general formulation, for example:

$$\tau_t = f(\tau_{t-1}, G_t, B_t, y_t - y^*)$$

- Too many parameters. Moreover, estimates suggest we can restrict to:

$$\tau_t^w = \rho_{\tau^w} \tau_{t-1}^w + (1 - \rho_{\tau^w}) \left[\tau^w + \phi_{\tau^w}^b b_t \right] + \varepsilon_t^{\tau^w}$$

$$\tau_t^c = \rho_{\tau^c} \tau_{t-1}^c + (1 - \rho_{\tau^c}) \left[\tau^c + \phi_{\tau^c}^b b_t \right] + \varepsilon_t^{\tau^c}$$

$$\tau_t^k = \rho_{\tau^k} \tau_{t-1}^k + (1 - \rho_{\tau^k}) \left[\tau^k + \phi_{\tau^k}^b b_t \right] + \varepsilon_t^{\tau^k}$$

- $\varepsilon_t^{\tau^w}$, $\varepsilon_t^{\tau^c}$ and $\varepsilon_t^{\tau^k}$ are i.i.d. errors terms.

The model: monetary policy

$$R_t = \rho_R R_{t-1} + (1-\rho_R)[\overline{\pi} + \rho_\pi(\pi_{t-1} - \overline{\pi}) + \rho_y(y_t - \overline{y})] + \rho_{\Delta\pi}\Delta\pi_t + \rho_{\Delta y}\Delta y_t + \varepsilon_t^m$$

- Standard Taylor rule.

- R_t is nominal interest rate; ε_t^m is an i.i.d. error term.

- Same as Smets-Wouters '03, but for the fact that we use $\overline{y}$ instead of the flexible prices equilibrium.

- Canova '05 has shown, with reference to the US, that this specification is robust to the sample period considered and fits the data better than alternative specifications.

Estimation

LIKELIHOOD

- Likelihood fn.: joint probability density of data $Y^T = y_1, ..., y_t$:

$$L(\theta|Y^T) = p(Y^T|\theta) = \prod_{t=1}^{T} p(y_t|Y^{t-1}, \theta)$$

- Log-linearized solution can be written as a state-space model:
  - measurement: $y_t = As_t$
  - state transition: $s_t = Bs_{t-1} + C\epsilon_t$

- Make distributional assumption: ϵ_t is $i.i.d.$ $N(0, \Sigma_\epsilon(\theta))$

LIKELIHOOD

- Only y_t's are observable: the vector s_t may have unobservable elements

- With s_t not fully observable, to obtain the likelihood fn. we need to use a filter, i.e. a recursive algorithm to calculate

$$p(y_t|Y^{t-1},\theta) \qquad t = 1,...,T$$

- Iterations:

  - Initialization of s at t_0; $p(s_0|y_{-1};\theta)$

  - Forecasting s_{t+1} given s_t:

    1. Transition eqn: $p(s_{t+1}|Y^t,\theta) = \int p(s_{t+1}|s_t, Y^t, \theta) p(s_t|Y^{t-1},\theta) ds_t$

    2. Measurement eqn:
$$p(y_{t+1}|Y^t,\theta) = \int p(y_{t+1}|s_{t+1}, Y^t, \theta) p(s_{t+1}|Y^t,\theta) ds_{t+1}$$

LIKELIHOOD

- Initialization: process s_t is stationary, we can initialize the filter with the unconditional distribution of s_t calculated from the transition equation

$$E[s_t s_t'] = BE[s_t s_t']B' + C\Sigma_\epsilon C'$$

- Iterations look difficult because they involve integrations. But:

  – If ϵ_t is normally distributed, all conditional distributions are also normal

  – At each step we only track means and covariance matrices $\rightarrow$ Kalman filter

POSTERIOR

- Conditioning on model m, for parameters specify a prior distribution $P(\theta)$ relying on earlier studies.

- The posterior distribution of the parameter vector θ is then obtained combining the likelihood function for Y^T with the prior distribution of θ, that is:

$$P(\theta|Y^T) = \frac{L(Y^T|\theta)P(\theta)}{\int L(Y^T|\theta)P(\theta)d\theta}$$

- The computation of integral at the denominator is impossible with many parameters.

- In order to obtain numerically a sequence from this unknown posterior distribution, we follow Schorfheide 2000 and Smets-Wouters 2003 and use the Metropolis-Hasting algorithm.

Data and data treatment

- We use data on consumption, investment, wages, inflation and nominal interest rate, government consumption, transfers, public employment, tax rates (on labor income, capital income and consumption) and total tax revenues.

- All at the euro area level.

- We detrend the logarithm of real variables with a linear trend.

- For tax rates, we simply subtract the sample mean.

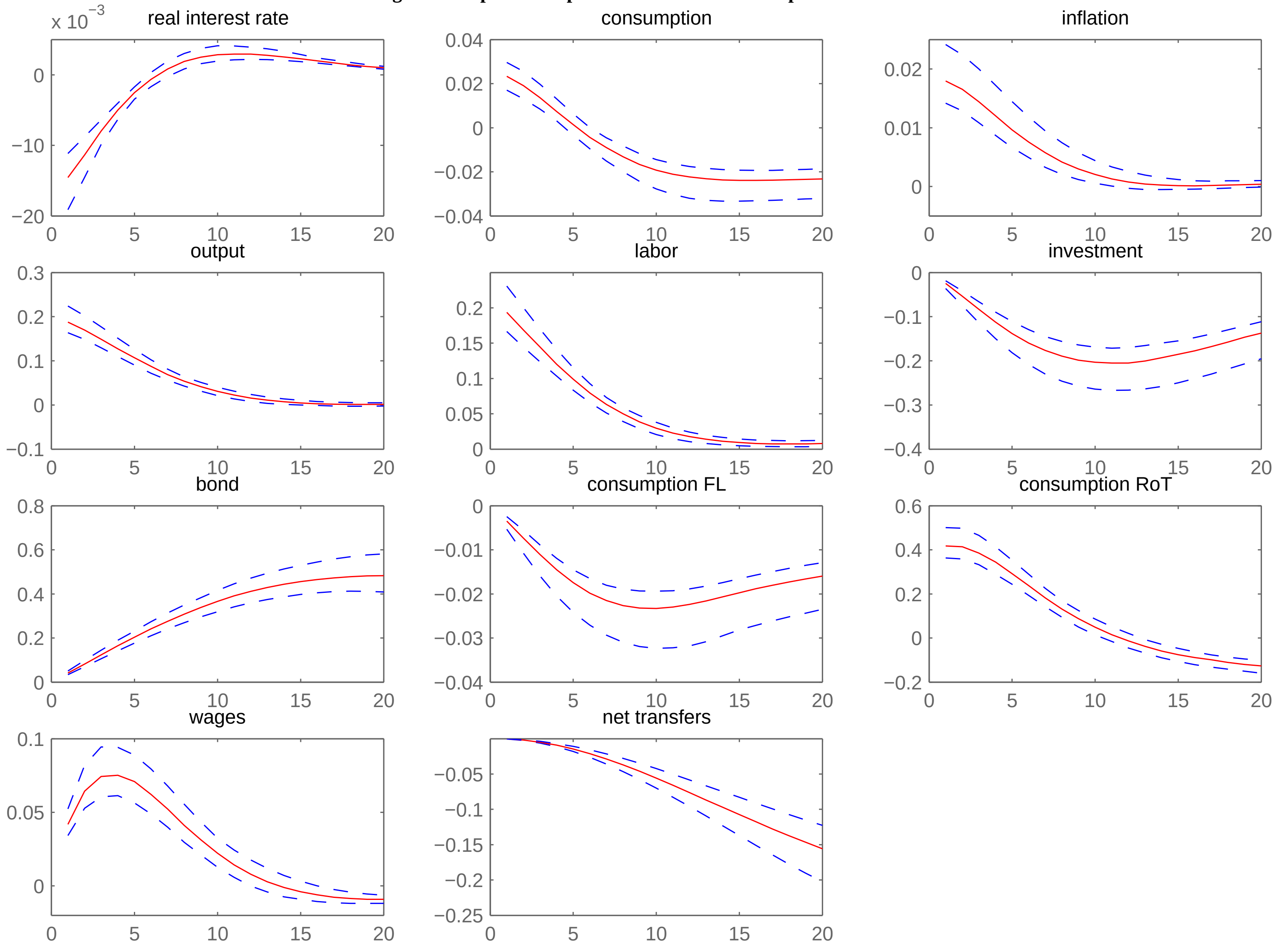
- As for the inflation rate we fit a linear spline for inflation until 1999:Q1 and assume a 2% target for annual inflation thereafter.

PARAMETER		PRIOR DISTRIBUTION		
Preferences and technology		Type	Mean	Var
inverse intertemporal subst. elasticity	σ_c	Gamma	2	0.0625
inverse labor supply wage elasticity	σ_l	Gamma	3	0.0625
fraction of non Ricardian	γ	Beta	0.5	0.01
habit parameter	h	Beta	0.7	0.0025
labor wage elasticity	θ_L	Gamma	6.5	0.05
Frictions				
investment adjustment cost	s''	Gamma	5	0.0625
price adjustment cost	φ	Gamma	100	500
wage adjustment cost	κ	Gamma	100	500
capital utilization adjustment cost	ψ''/ψ'	Gamma	0.2	0.01
Fiscal policy with lump-sum taxation				
lump-sum tax AR coefficient	ρ_{τ^w}	Beta	0.8	0.01
lump-sum tax debt coefficient	η_{τ_w}	Gamma	0.5	0.01
with distortionary taxation				
labor tax rate AR coefficient	ρ_{τ^w}	Beta	0.8	0.01
labor tax rate debt coefficient	η_{τ_w}	Gamma	0.5	0.01
consumption tax rate AR coeff.	ρ_{τ^c}	Beta	0.8	0.01
consumption tax rate debt coeff.	η_{τ_c}	Gamma	0.5	0.01
capital tax rate AR coefficient	ρ_{τ^k}	Beta	0.8	0.01
capital tax rate debt coefficient	η_{τ_k}	Gamma	0.5	0.01

Posterior	Lump-sum tax		Distortionary taxes			
	I Compens. of public empl. in G		**II** Compens. of public empl. in G		**III** Govt. empl. as a specific process	
	mean	st.dev.	mean	st.dev.	mean	st.dev.
σ_c	2.58	0.23	2.21	0.21	1.13	0.07
σ_l	2.60	0.18	2.59	0.19	2.43	0.18
γ	0.10	0.01	0.36	0.04	0.61	0.02
h	0.81	0.02	0.75	0.02	0.87	0.02
θ_L	6.33	0.21	6.47	0.20	6.19	0.22
s''	5.02	0.25	4.94	0.24	4.84	0.25
ϕ	198.67	24.05	116.37	11.34	245.17	31.17
κ	195.51	18.91	214.03	25.46	217.52	20.68
ψ''/ψ'	0.32	0.08	0.14	0.02	0.37	0.08
ρ_R	0.85	0.08	0.90	0.01	0.91	0.01
ρ_π	1.51	0.10	1.78	0.09	1.77	0.09
ρ_y	-0.05	0.01	0.15	0.02	0.19	0.03
$\rho_{\triangle\pi}$	0.48	0.08	0.41	0.08	0.30	0.09
$\rho_{\triangle y}$	-0.03	0.02	0.09	0.02	0.02	0.01
ρ_{tr}	0.95	0.00				
η_{tr}	0.06	0.01				
ρ_{τ^w}			0.93	0.01	0.91	0.01
η_{τ^w}			0.20	0.02	0.17	0.02
ρ_{τ^c}			0.98	0.00	0.99	0.00
η_{τ^c}			0.47	0.09	0.54	0.07
ρ_{τ^k}			0.92	0.01	1.00	0.00
η_{τ^k}			0.51	0.03	0.48	0.07
Marg.lik.	2422.9		3603.8		3847.7	

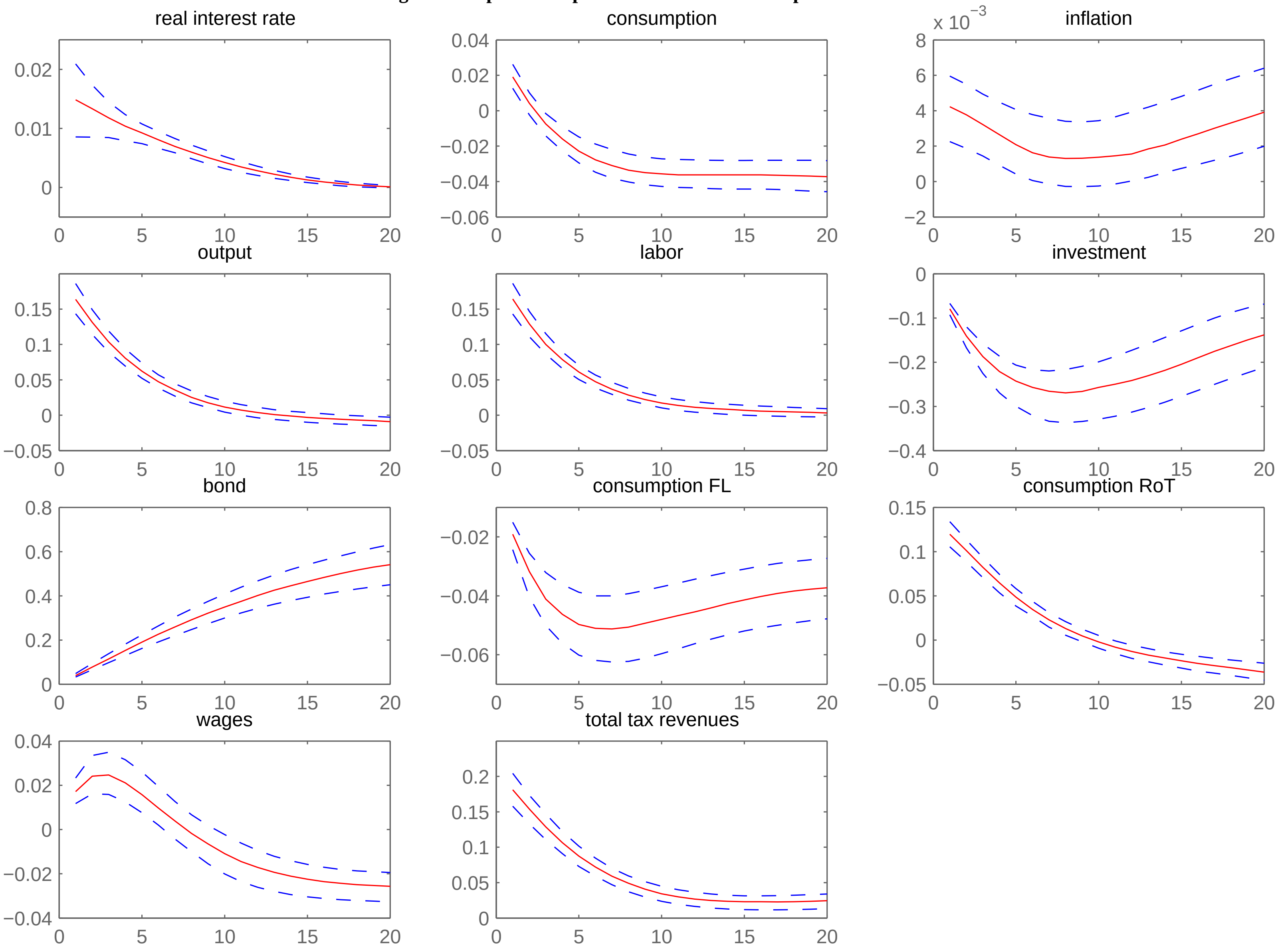
Impulse response from a shock to G (Model I)

Figure 5: Impulses Responses from a real Gov. expend. shock

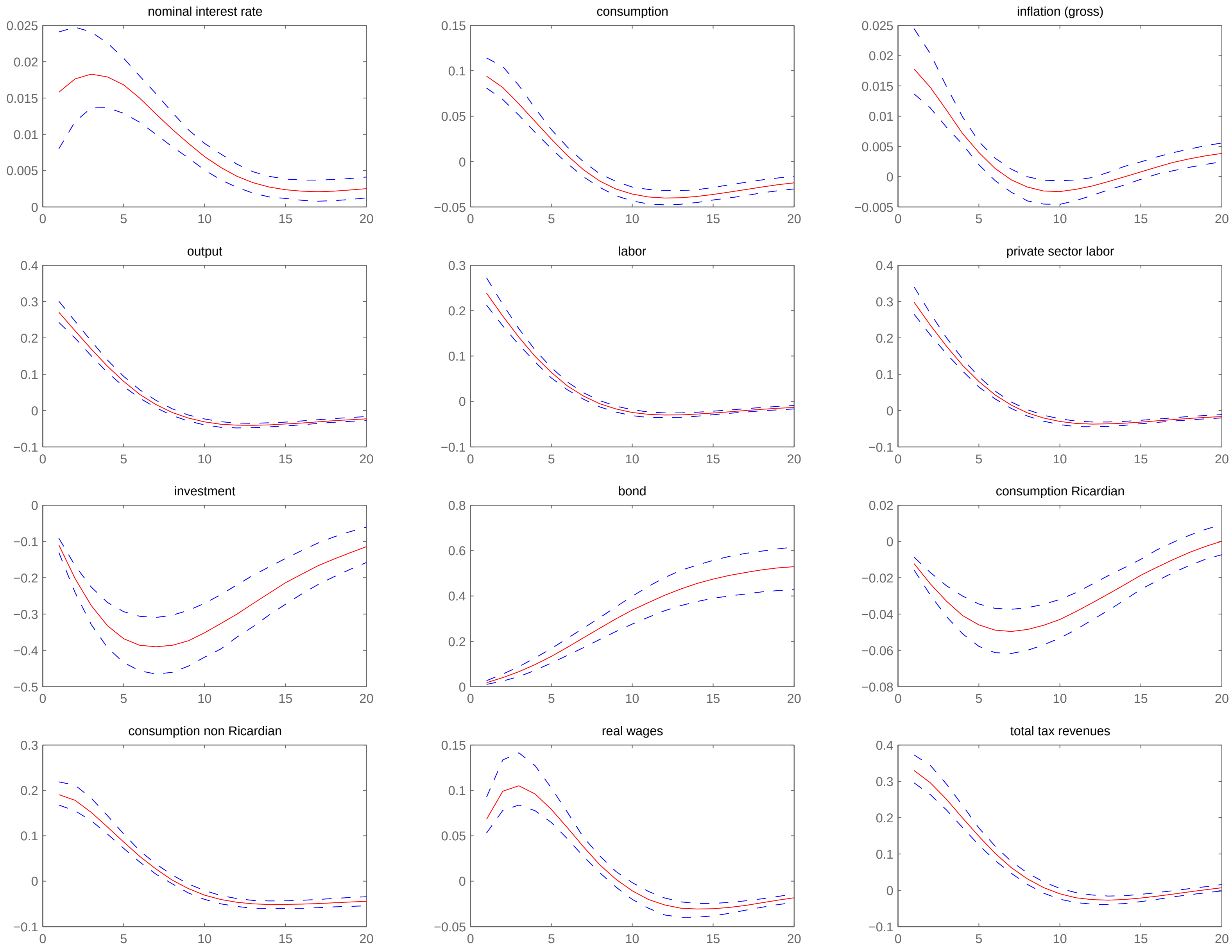


Impulse response from a shock to G (Model II)

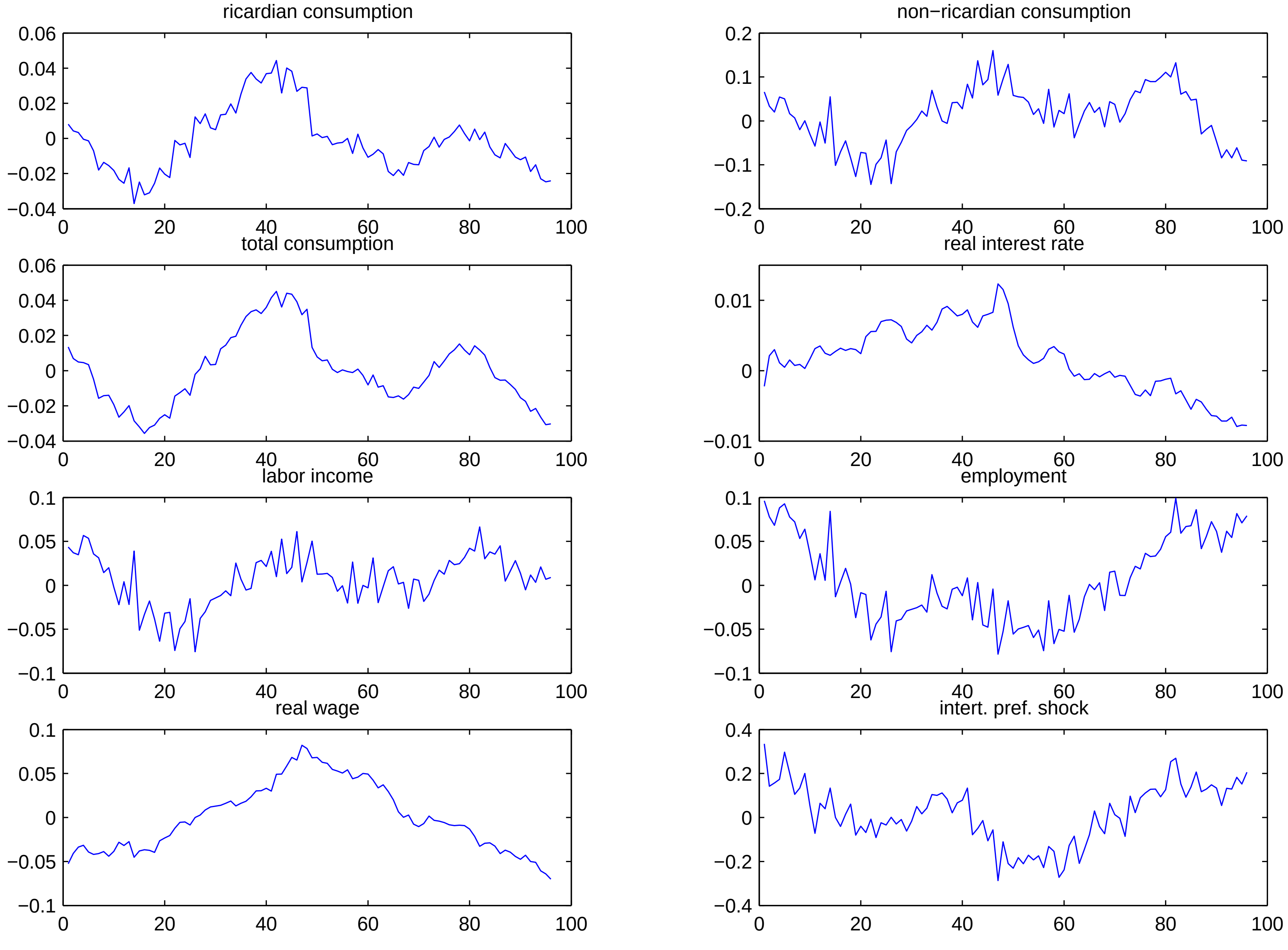
Figure 5: Impulses Responses from a real Gov. expend. shock



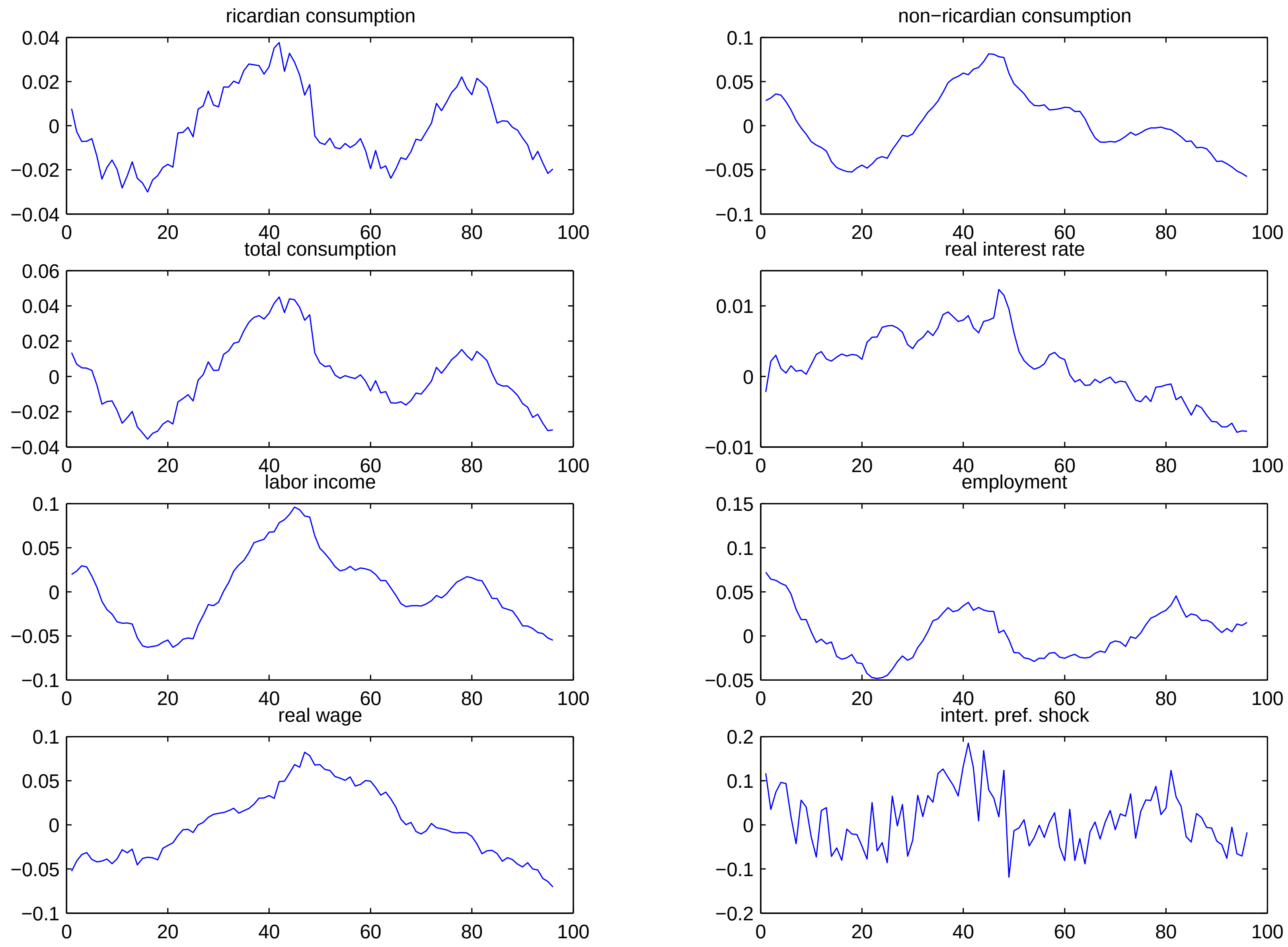
Impulse response from a shock to C^g (Model III)



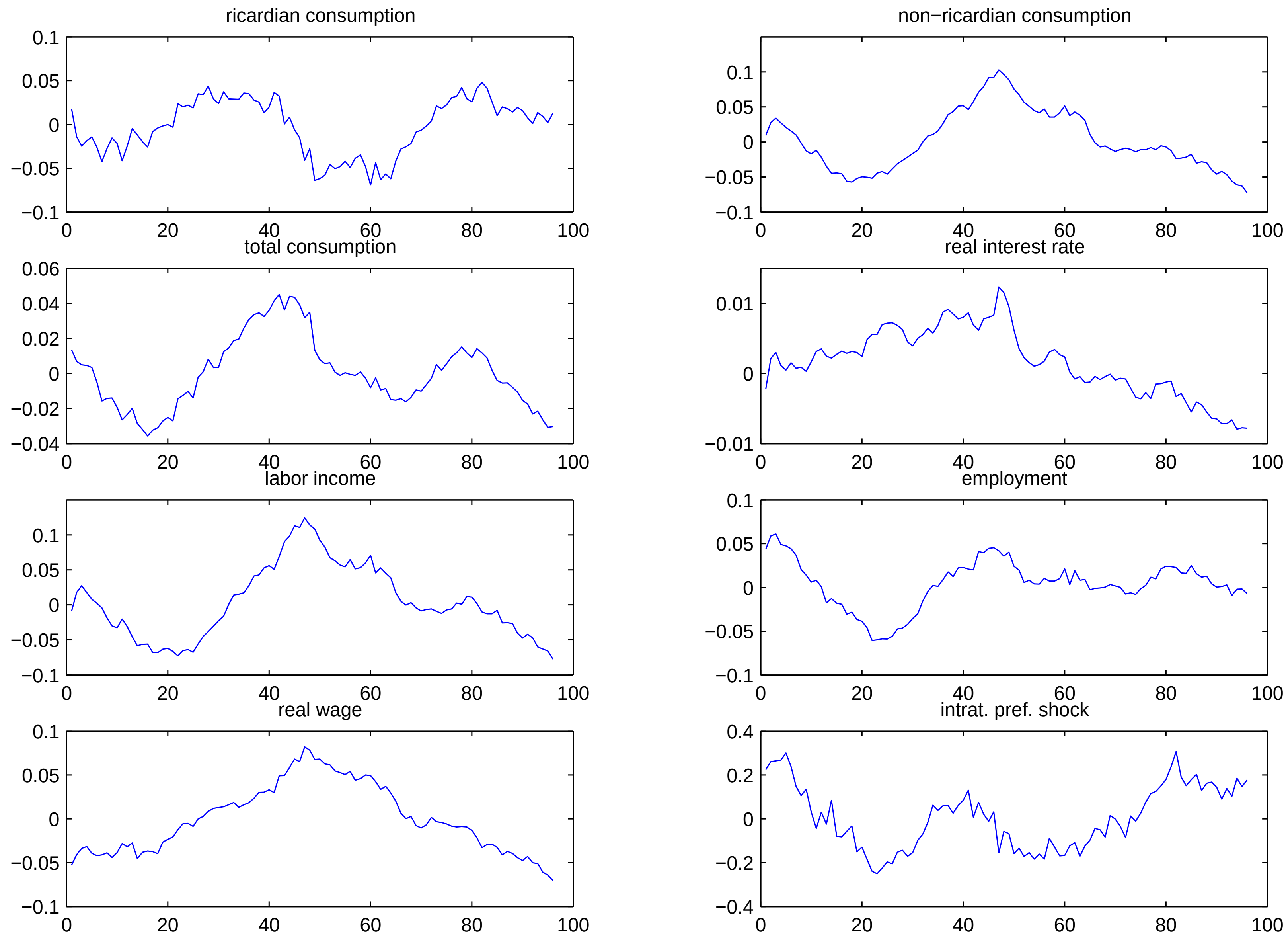
Latent variables (Model I)



Latent variables (Model II)



Latent variables (Model III)

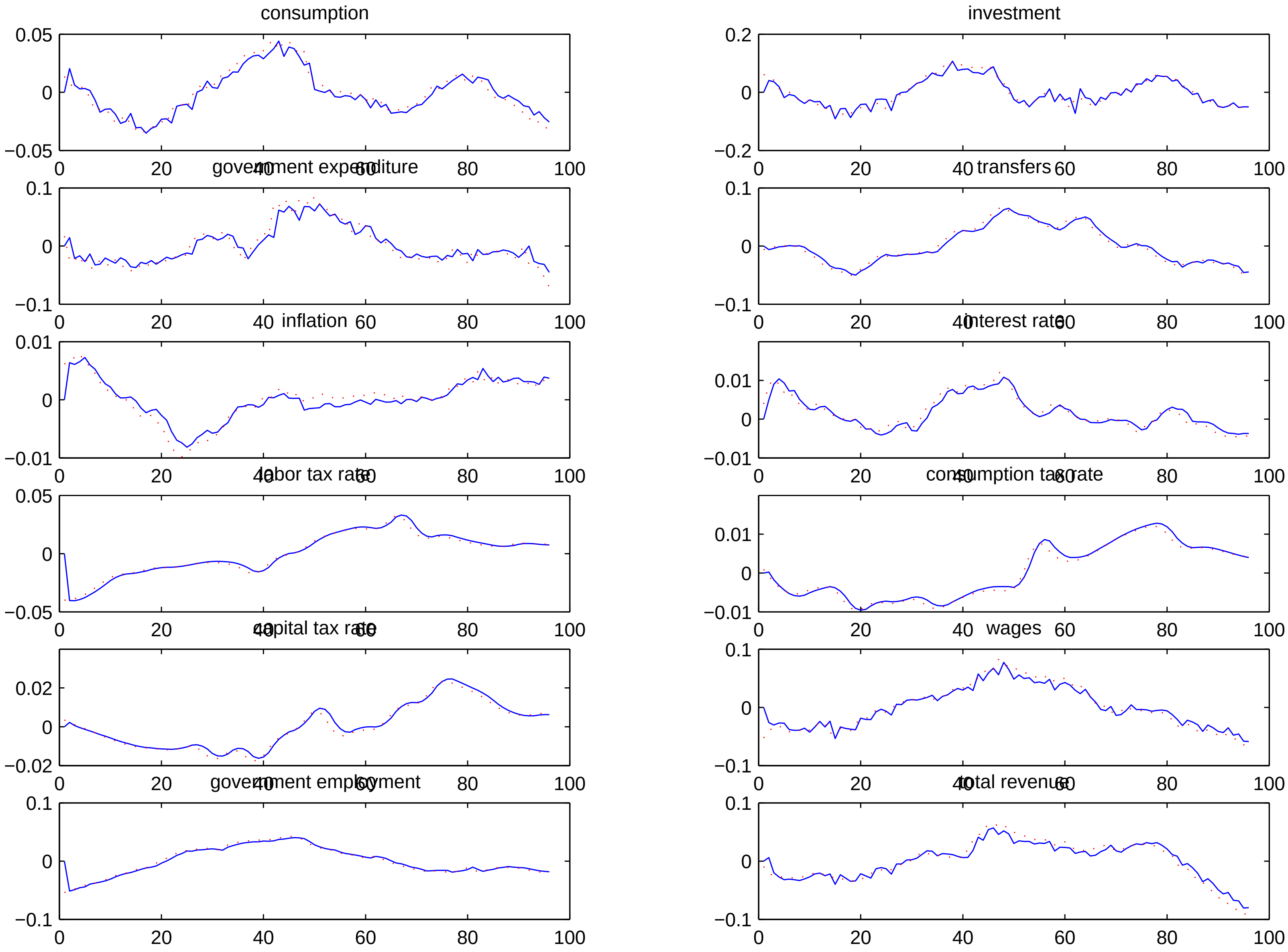


Diagnostics

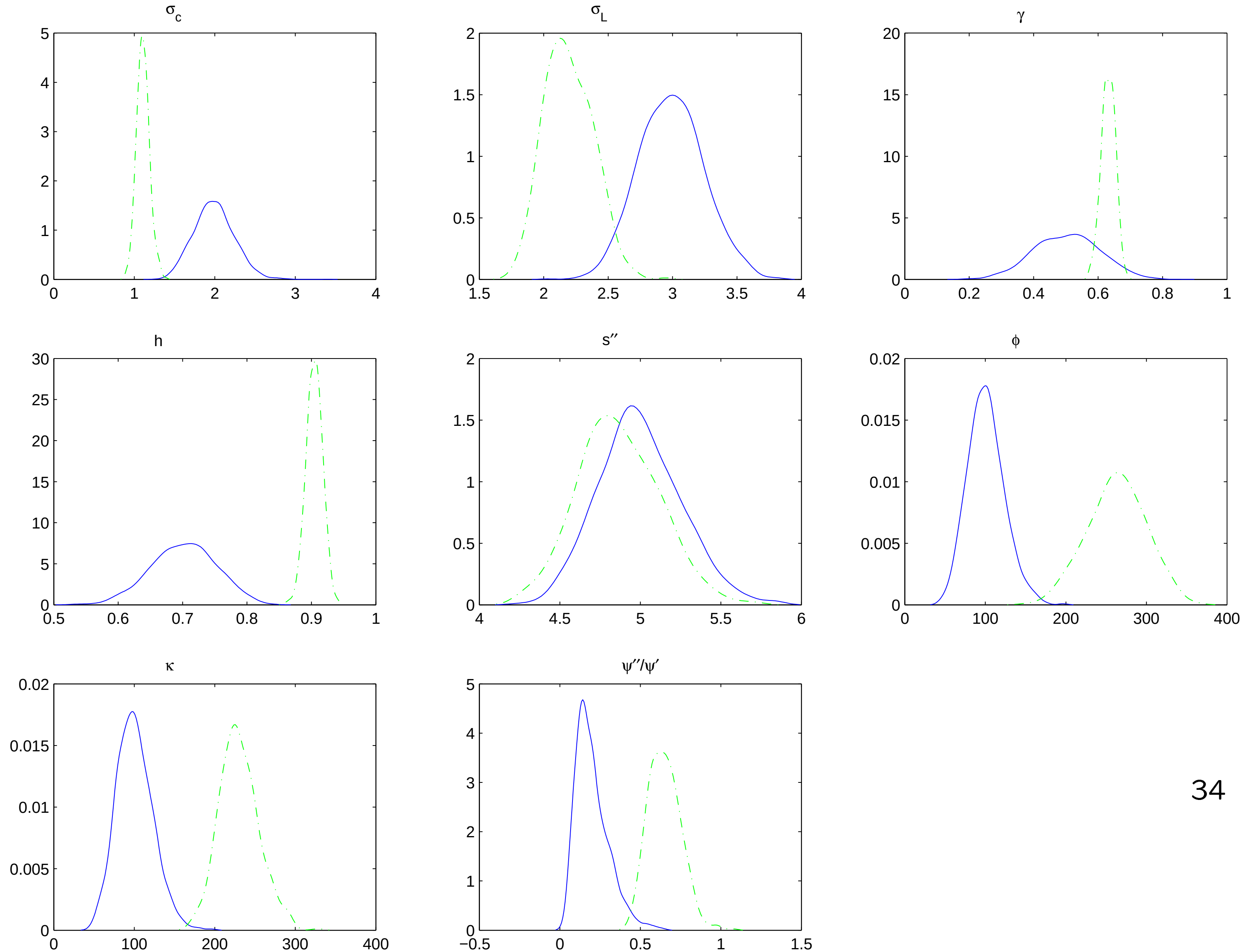
- After max posterior:
  1. Gradient and (conditioning number of) Hessian
  2. $Cov(param_i, param_j)$ implicit in Hessian
  3. Slices of the likelihood around the mode

- After MH:
  1. Cumulative median and std of parameters
  2. Plots of path of $param_i$ from the MH
  3. Plot of priors vs. posteriors
  4. % of accepted draws
  5. Variance decomposition
  6. Model fit
  7. Plot of non observables

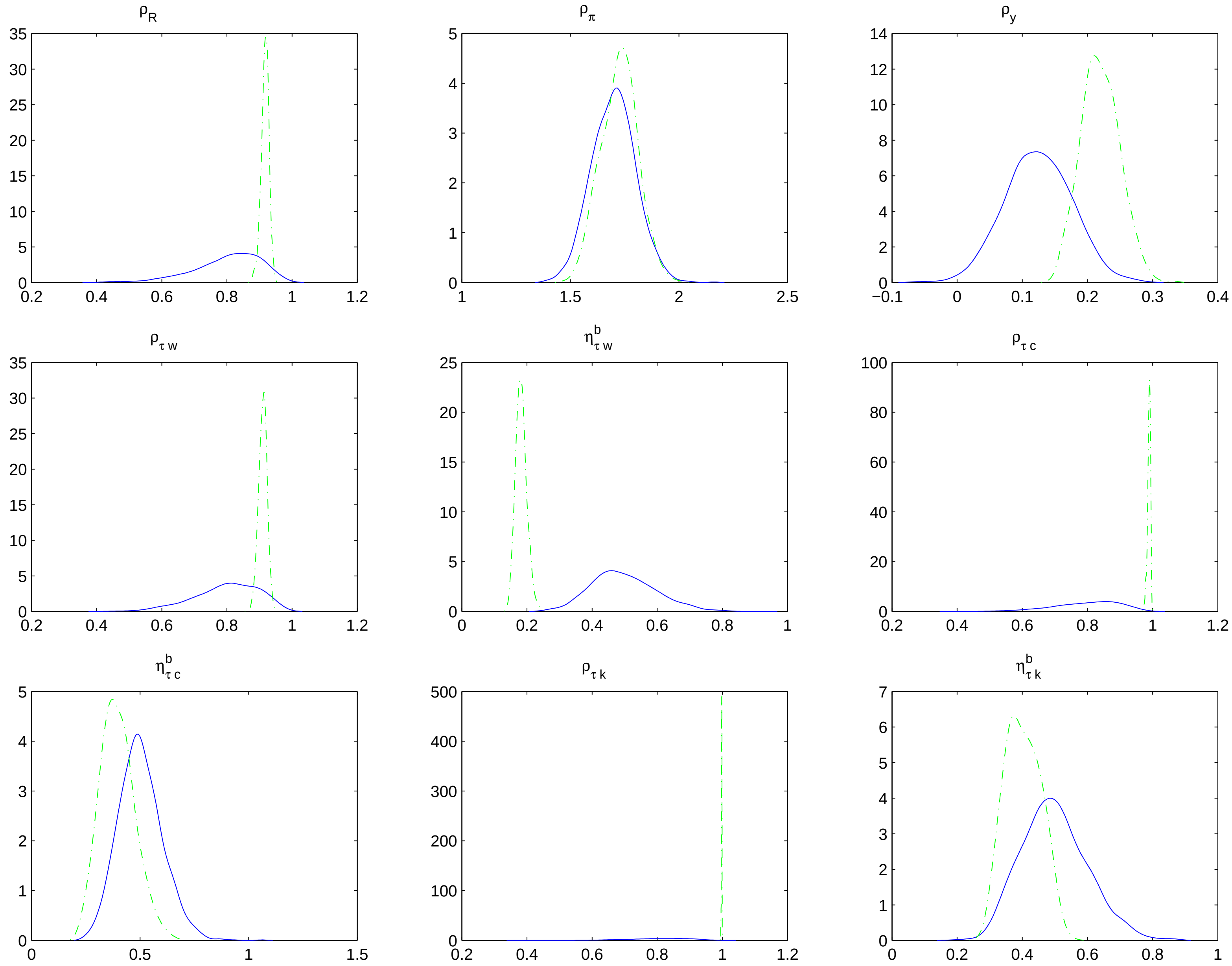
Model fit


consumption
investment
government expenditure
transfers
inflation
interest rate
labor tax rate
consumption tax rate
capital tax rate
wages
government employment
total revenue
0.05
0
−0.05
0.2
−0.2
0.1
−0.1
0.01
−0.01
0.02
−0.02
0
20
40
60
80
100

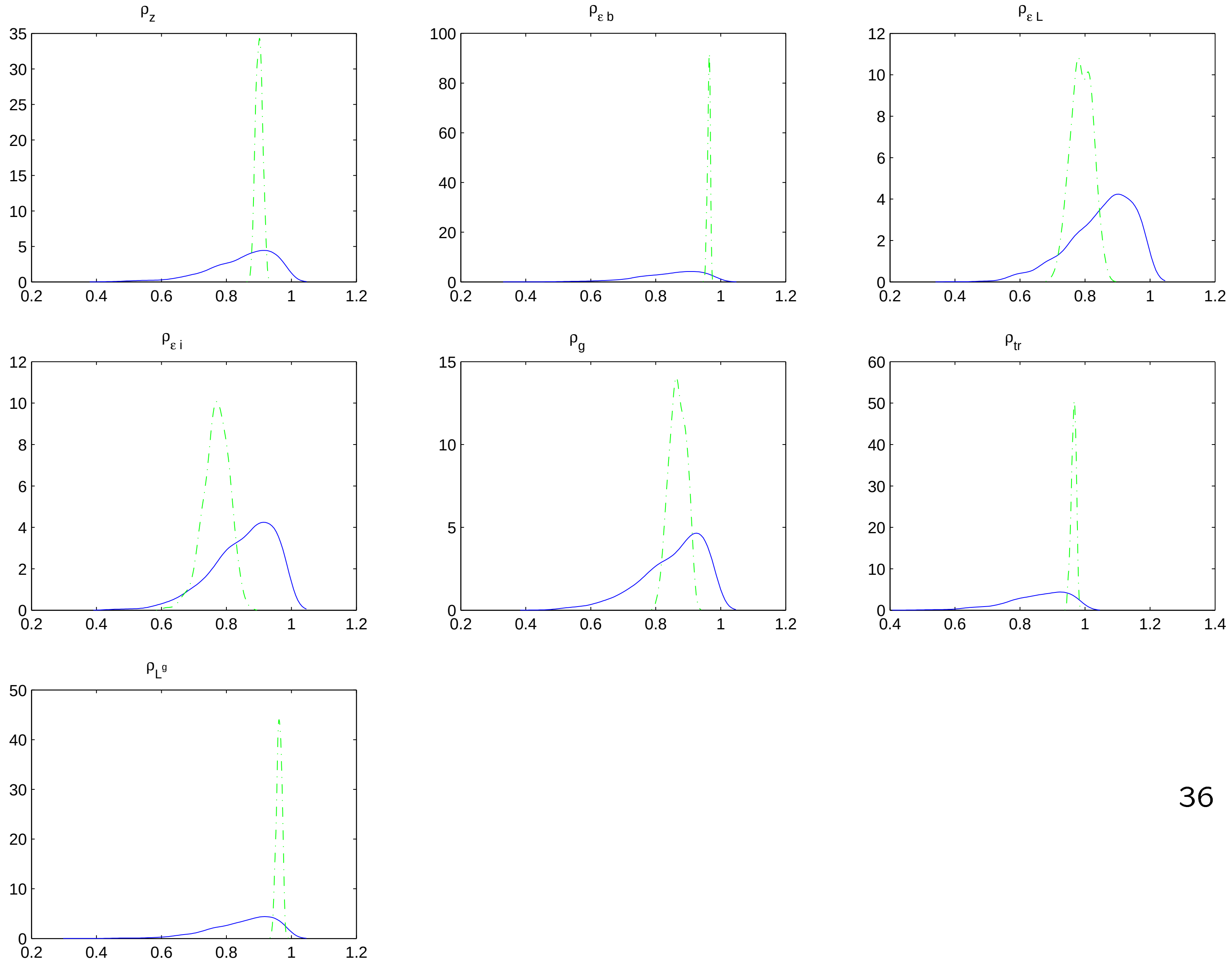
Priors (blue/solid line) vs. posterior (green/dashed line) distributions I



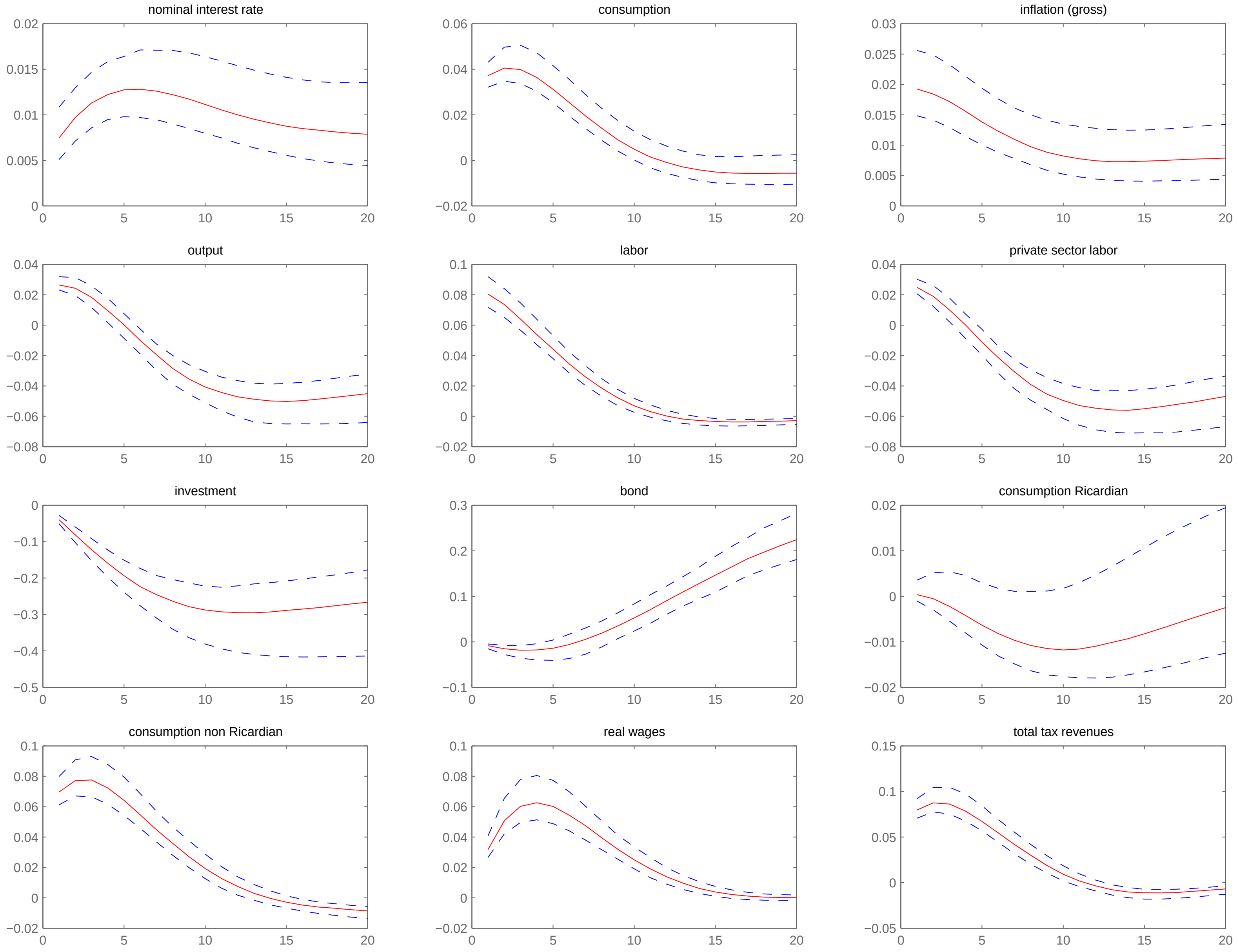
Priors (blue/solid line) vs. posterior (green/dashed line) distributions II



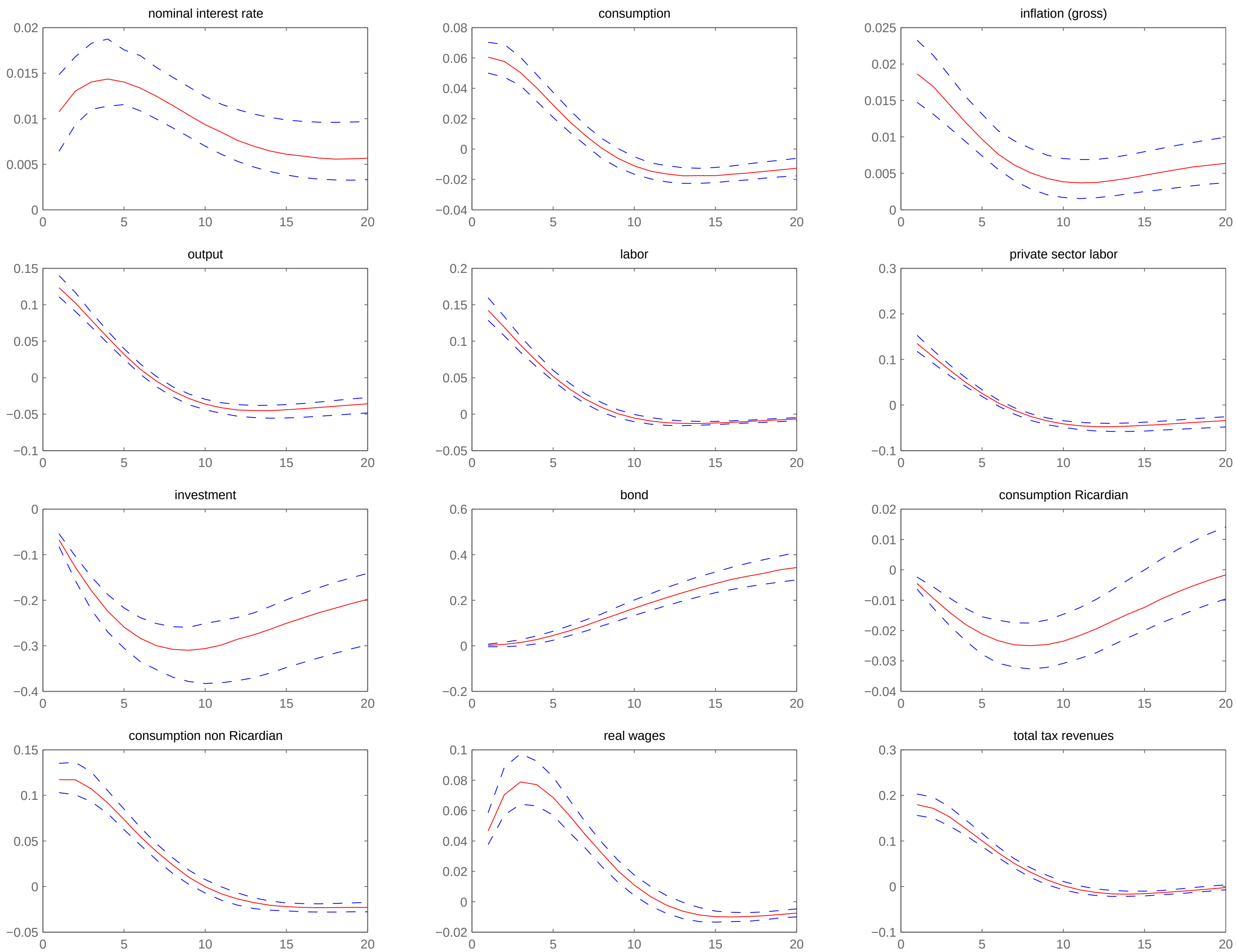
Priors (blue/solid line) vs. posterior (green/dashed line) distributions III



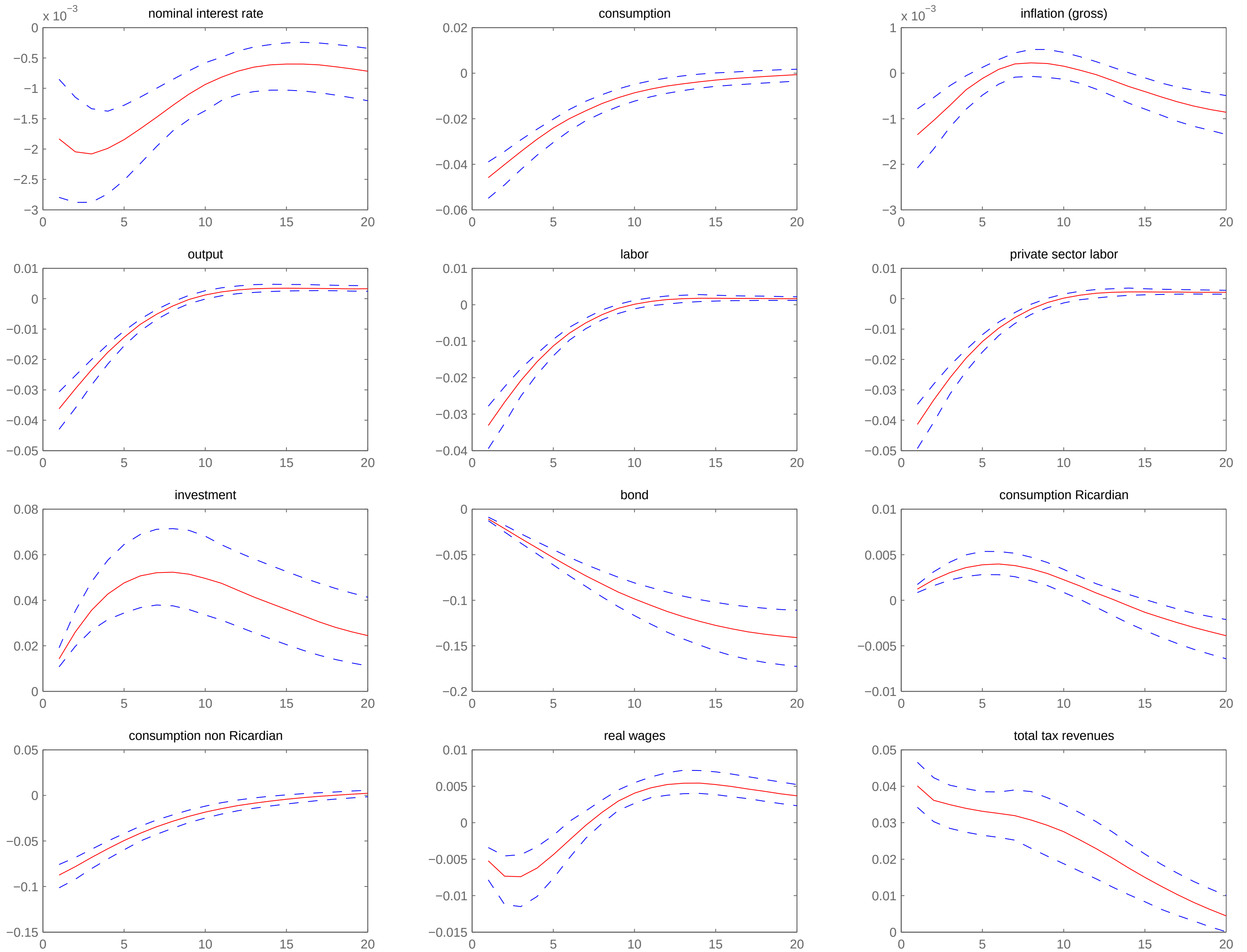
Impulse response from a government employment shock

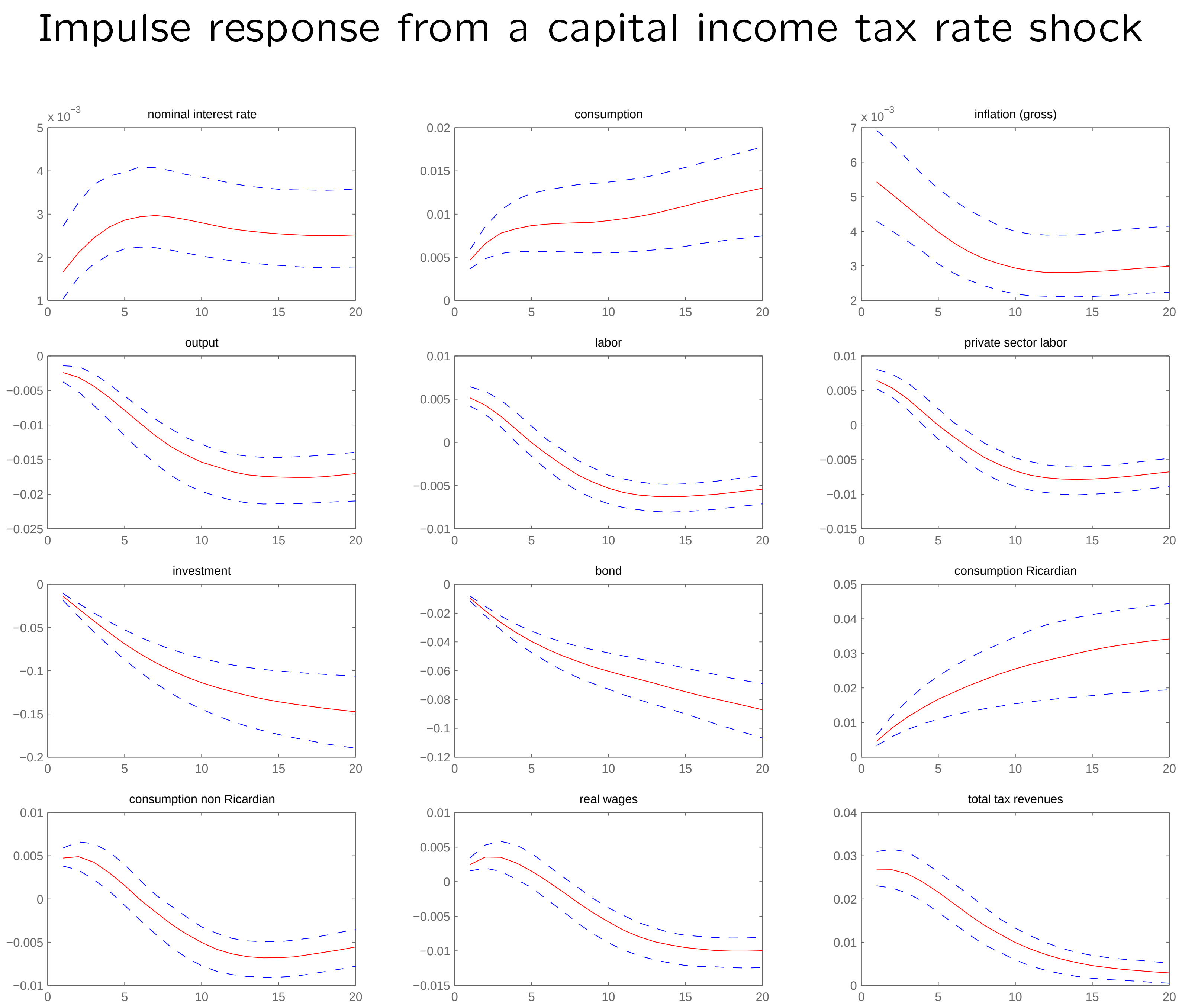


Impulse response from a combined govt. spending-employment shock



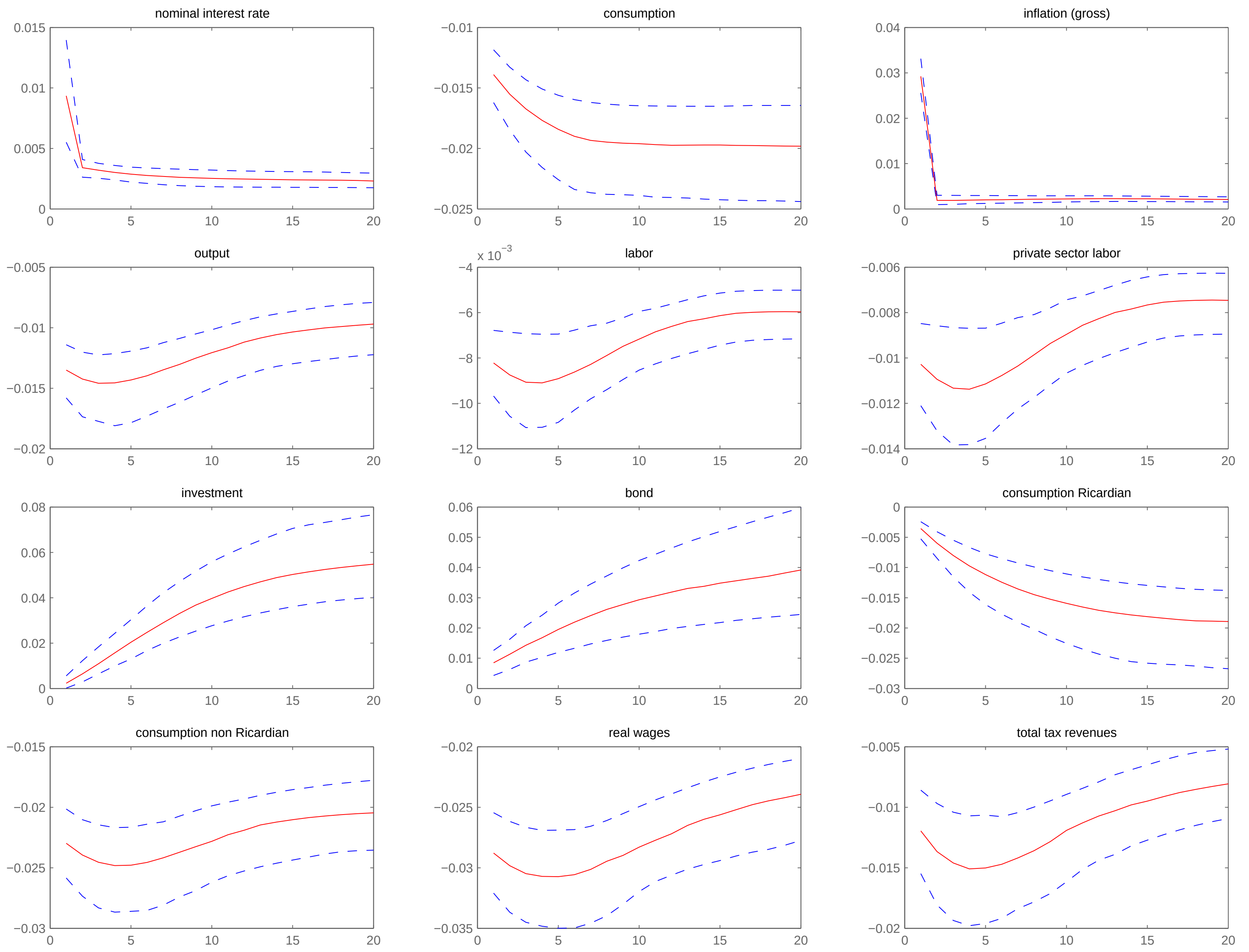
Impulse response from a labor income tax rate shock





Impulse response from a capital income tax rate shock
nominal interest rate
consumption
inflation (gross)
output
labor
private sector labor
investment
bond
consumption Ricardian
consumption non Ricardian
real wages
total tax revenues

Impulse response from a consumption tax rate shock



FISCAL MULTIPLIERS

VARIATION	AVERAGE IN YEAR 1	
	$\frac{\Delta C}{C}$	$\frac{\Delta Y}{Y}$
$\Delta C^g = 1\%$ PIL	0.3	0.6
ΔL^g : $\Delta L^g w = 1\%$ PIL	0.3/0.4	0.25
$\Delta \tau^w$: $\Delta \tau^w (wL) = 1\%$ PIL	-0.3	-0.2
$\Delta \tau^k$: $\Delta \tau^k (R^k k + D) = 1\%$ PIL	$\simeq$ 0.0	$\simeq$ 0.0
$\Delta \tau^c$: $\Delta \tau^c (C + C^g) = 1\%$ PIL	-0.15	-0.15

Future steps

- models horse-race (nesting; correlation analysis)
- decision over wage taken by union representing both Ricardian and non-Ricardian agents
- cast in open economy