The Effects of Fiscal Policy in an Estimated DSGE Model – The Case of the German Stimulus Packages during the Great Recession

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Macroeconomic Dynamics

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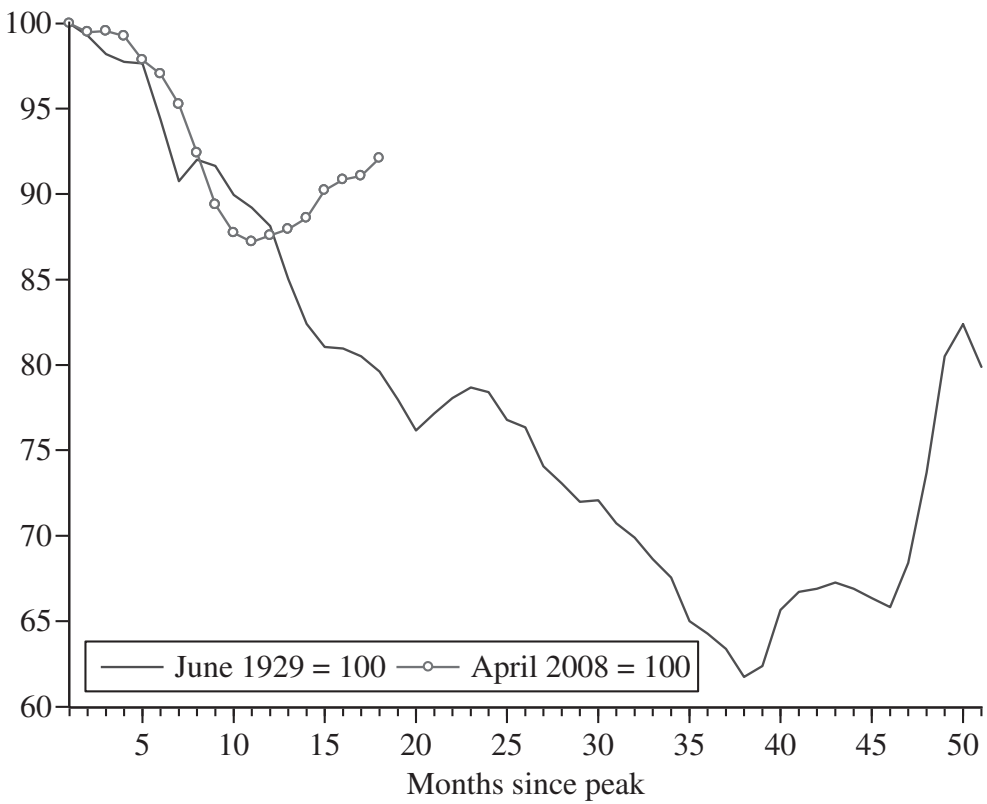
The Effects of Fiscal Policy

The Worldwide Financial Crisis

- Instable banking sector in mid 2007
  - Financial support by governments prevents individual failures
  - Whole banking sector in trouble
  - Market capitalization of large German banks shrinks by 75% between January 2007 and December 2008
- Negative impact on real economic activity
  - Decrease in trust, decrease in wealth, worse financial conditions
  - Cut in aggregate demand and international trade
  - Increase in public debt

Production 1929 and 2008



Almunia et al., Economic Policy, 2010, S. 225

- Since April 2008 production has been declining as fast as 1929
- Stabilisation
  - Stability measures for individual banks
  - Liquidity injection by central banks
  - Interest rate cuts
- What have been the effects of fiscal stimulus?

International Fiscal Stimuli During the Crisis

	DE	JP	US
Impulse 2009 (% of GDP)	1,7	2,8	1,8
Nature of stimulus			
Infrastructure, social benefits, etc.	X	X	X
Tax cuts	X	X	X
Non-financial bail-outs	X	X	X
Financial support			
Liquidity injection	X	X	X
Loan guarantees	X	X	X
Capital injection	X	X	X
Asset purchases	X	X	X
Nationalisation	X		X

(IMF Fiscal Monitor, November 2010; `www.economist.com/stimulus`)

Rescue Efforts

(The Economist, 31 January 2009)

- Germany (Billion Euro)
  - Fiscal stimulus

    Infrastructure (23), social benefits, income and payroll tax (21), reduction of social security contributions, auto aid package (2), loan gurantees to non-financial firms
  - Key financial support

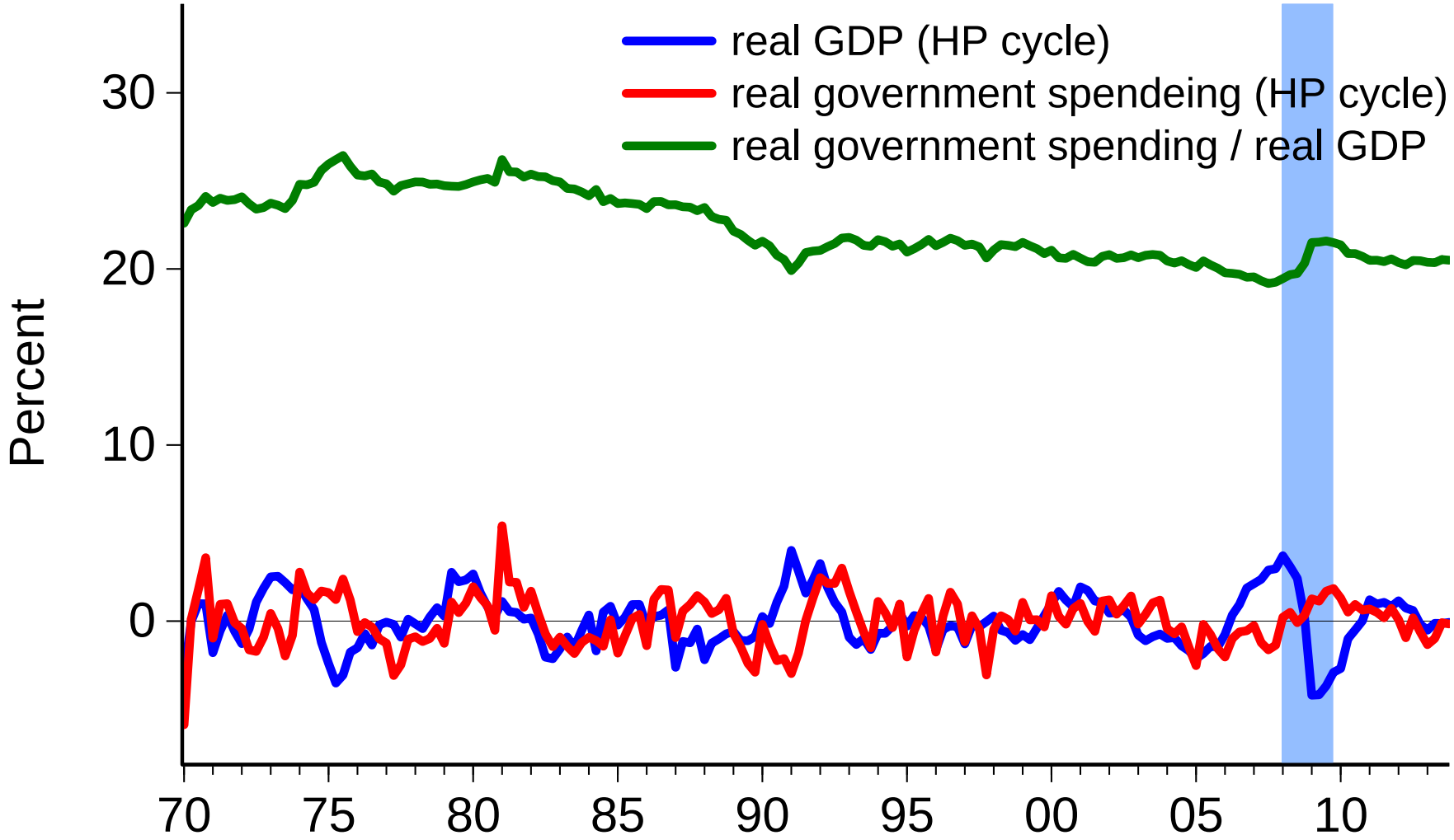
    Loan guarantees (520), capital injection (140), deposit guarantee
- USA (Billion US-Dollar)
  - Fiscal stimulus

    Energy (58), science (17), infrastructure (92), benefits (71), education (159), health (154), housing (13), tax cuts (275), loans for auto industry (21)
  - Key financial support

    Funding guarantees (1500), asset purchases (700), conservatorship (200), AIG (150), term programmes (900) commercial paper and money-market funds (2300)

Government Spending and Real GDP in Germany

(Federal Statistical Office Germany, own calculations)



(How Much) Did the Fiscal Stimulus Stabilize the Economy?

- Did fiscal packages have an impact at all?
- If yes, how large have been the effects?
- What are the channels?
- Challenge: Disentangle discretionary fiscal policies and automatic stabilizers

Overview

- Specify a medium-size DSGE-model with a detailed fiscal sector
- Bayesian estimation for Germany from 1999 to 2012
- Estimate the effect of German fiscal stimulus packages 2008-2009 on output
- Analyze the effectiveness of different policy measures

The Effects of Fiscal Policy

Related literature

- General equilibrium models
  - Christiano et al. (2005), Smets and Wouters (2003, 2007)
- Rule-of-Thumb consumers
  - Angeletos et al. (2001), Campbell and Mankiw (1990, 1991), Carroll (2001), Carroll and Kimball (2008), Coenen and Straub (2005), Gali et al. (2007)
- Domestic effects of fiscal stimulus packages
  - Coenen et al. (2012, 2013), Gadatsch (2016)

Households

- Two types of households
  - Optimizers (O) (share μ)
  - Non-Ricardian (NR) (share $1 - \mu$)

Optimizers

- Optimizing households maximize intertemporal utility

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{\epsilon_t^b (C_t^o - h C_{t-1}^o)^{1-\sigma}}{1-\sigma} - \psi_l \frac{\epsilon_t^l (L_t^o)^{1+\varphi}}{1+\varphi} \right)$$

subject to:

  - their budget constraint Detail
  - the law-of-motion of private capital Detail
  - capital utilization adjustment costs Detail

Optimizers

- Maximization of intertemporal utility results in optimal choices of:
  - consumption and investment expenditures
  - labor hours supplied
  - the size of next period's capital stock and its rate of utilization
  - domestic and foreign bond holdings

▸ FOCs ▸ FOCs (cont.)

Non-Ricardians

- Do not make intertemporal decisions
- Have no access to financial markets
- Budget constraint

$$(1+\tau_t^c)P_t C_t^{nr} = (1-\tau_t^w)L_t^{nr} W_t^{nr} + TR_t^{nr}$$

Aggregation

$$
\begin{aligned}
C_t &= \mu C_t^o + (1-\mu) C_t^{nr} \\
TR_t &= \mu TR_t^o + (1-\mu) TR_t^{nr} \\
I_t &= \mu I_t^o \\
K_t &= \mu K_t^o \\
B_t &= \mu B_t^o \\
LS_t &= \mu LS_t^o
\end{aligned}
$$

In steady state

$$\chi = C^{nr}/C^o \leq 1 \qquad \text{and} \qquad \xi = TR^o/TR^{nr} \leq 1$$

Wage Setting

- Households offer differentiated labor services (monopolistic wage setters)
- Fraction of $1 - \theta^w$ households optimize its wage
- Optimizing households set their wage to $\tilde{W}_t$ taking into account the demand for their individual labor service and the probability of future adjustments
- Remaining households adjust wage to inflation, with the degree of indexation measured by χ^w
- An employment agency bundles labor services and sells the composite labor service at the aggregate wage W_t

Firms

- Continuum $x \in [0,1]$ firms producing differentiated types of intermediate goods
- Each monopolistic firm takes factor prices as given and minimizes its costs subject to a Cobb-Douglas production function

$$Y_t^h(x) = Z_t L_t(x)^{1-\alpha}(u_t K_{t-1}(x))^{\alpha}(K_{t-1}^g)^{\zeta} - \Phi$$

- Optimal choice of factor inputs

$$L_t = \frac{1-\alpha}{\alpha} K_{t-1} \frac{r_{k_t}}{W_t},$$

Price Setting

- Random fraction of $(1 - \theta^h)$ intermediate goods firms optimizes its price
- Optimizing firms set their wage to $\tilde{P}_t^h$ taking into account the demand for their good and the probability of future adjustments
- Remaining firms adjusts their price to inflation, with the degree of indexation measured by χ^h
- A final good producer bundles intermediate goods and sells the composite final good at the aggregate price P_t^h

International Trade

- Exports and imports depend on total demand, relative prices and the degrees of home bias
- Demand for domestic goods abroad is given by:

$$X_t = (1 - \omega^*) \frac{1 - n}{n} \left(\frac{P_t^x}{P_t^*} \right)^{-\eta^*} Y_t^*,$$

- Domestic demand for foreign goods is restricted to private consumption and investment:

$$M_t = (1 - \omega) \left(\frac{P_t^m}{P_t} \right)^{-\eta} (C_t + I_t),$$

Fiscal Sector

- Government expenditures: gov. consumption, gov. investment, transfers
- Government revenues: taxes on consumption, labor and capital incomes
- Budget is balanced by lump-sum taxes LS_t

$$\begin{aligned} B_{t-1}R_{t-1} + TR_t + P_t G_t^c + P_t G_t^i &= \tau_t^c P_t C_t + \tau_t^k (r_t^k u_t - (a(u_t) + \delta)) P_t K_{t-1} \\ &\quad + \tau_t^w W_t L_t + LS_t + B_t \end{aligned}$$

- Public capital

$$K_t^g = \left(1 - \delta^g\right) K_{t-1}^g + G_t^i$$

Fiscal rules: Expenditures

- Government expenditures: *gov. consumption*, *gov. investment*, *transfers*
- Spending variables evolve according to reaction functions to output (hours worked) and government debt
- Allow for persistence and announcement effects with weight ψ (Leeper et al. 2009)

$$
\begin{aligned}
g_t^c &= \rho_{gc} g_{t-1}^c + (1-\rho_{gc})\left(\varphi_{gc,y} y_t + \rho_{gc,b} b_{t-1}\right) + (1-\psi_{gc})\eta_{gc,t} + \psi_{gc}\eta_{gi,t-1} \\
g_t^i &= \rho_{gi} g_{t-1}^i + (1-\rho_{gi})\left(\varphi_{gi,y} y_t + \rho_{gi,b} b_{t-1}\right) + (1-\psi_{gi})\eta_{gi,t} + \psi_{gc}\eta_{gi,t-1} \\
tr_t &= \rho_{tr} tr_{t-1} + (1-\rho_{tr})\left(\varphi_{tr,y} l_t + \rho_{tr,b} b_{t-1}\right) + (1-\psi_{tr})\eta_{tr,t} + \psi_{tr}\eta_{tr,t-1}
\end{aligned}
$$

Fiscal rules: Revenues

- Taxes on *consumption*, *wage income* and *capital income*
- Reaction functions of tax rates to output (hours worked/private investment) and government debt (Kliem and Kriwoluzky 2014)
- Allow for persistence and announcement effects ψ (Leeper et al. 2009)

$$\tau_t^c = \rho_{tc}\tau_{t-1}^c + (1-\rho_{tc})\left(\varphi_{tc,y} y_t + \rho_{tc,b} b_{t-1}\right) + (1-\psi_{tc})\eta_{tc,t} + \psi_{tc}\eta_{tc,t-1}$$

$$\tau_t^w = \rho_{tw}\tau_{t-1}^w + (1-\rho_{tw})\left(\varphi_{tw,y} l_t + \rho_{tw,b} b_{t-1}\right) + (1-\psi_{tw})\eta_{tw,t} + \psi_{tw}\eta_{tw,t-1}$$

$$\tau_t^k = \rho_{tk}\tau_{t-1}^k + (1-\rho_{tk})\left(\varphi_{tk,y} i_t + \rho_{tk,b} b_{t-1}\right) + (1-\psi_{tk})\eta_{tk,t} + \psi_{tk}\eta_{tk,t-1}$$

Monetary Policy

- Monetary authority sets the nominal interest rate according to a reaction function (Taylor 1993)
- Central bank reacts to GDP-weighted inflation rates and output gaps of Germany and the rest of the euro area (REA):

$$r_t = \rho_r r_{t-1} + (1-\rho_r)(\rho_\pi \pi_t^{EA} + \rho_y y_t^{EA}) + \eta_t^r,$$

with

$$\begin{aligned} \pi_t^{EA} &= n\pi_t + (1-n)\,\pi_t^{REA} \\ y_t^{EA} &= n y_t + (1-n)\,y_t^{REA}, \end{aligned}$$

n is the share of German production in Euro area GDP

Rest of the Euro Area

- Output and inflation are modeled as VAR(2) processes

$$\begin{bmatrix} y_t^{REA} \\ \pi_t^{REA} \end{bmatrix} = \rho_1 \begin{bmatrix} y_{t-1}^{REA} \\ \pi_{t-1}^{REA} \\ r_{t-1} \end{bmatrix} + \rho_2 \begin{bmatrix} y_{t-2}^{REA} \\ \pi_{t-2}^{REA} \\ r_{t-2} \end{bmatrix} + \begin{bmatrix} \eta_t^{y^{REA}} \\ \eta_t^{\pi^{REA}} \end{bmatrix},$$

where ρ_1 and ρ_2 are 2×3 matrices of coefficients

The Effects of Fiscal Policy

Data

- 14 domestic time series
  - GDP, private and government consumption, private and government investment, government transfers, effective tax rates for consumption, labor and capital income, hours, wages, CPI inflation, short-term interest rate
- 2 rest of the euro area time series
  - GDP, inflation
  - output-weighted
- Effective tax are calculated following Mendoza et al. (1994)
- Series are linearly detrended prior to estimation
- Quarterly data from 1999:1 till 2012:4

The German Stimulus Packages

- Government consumption & investment
  - public building renovations, repair of existing infrastructure, concessions for infrastructure investments, creation of positions for job center facilitators
  - credits and guarantees
- Transfers
  - depreciation allowances
  - car scrapping incentive
  - increase in children's allowance
- Tax changes
  - decrease in unemployment insurance premium
  - improved deductibility of health insurance premia
  - decrease in income tax
  - decrease in state health insurance premia
  - reintroduction of tax-deductibility of commuting expenses

Calibrated Parameters

Private and public capital depreciation rates	δ, δ_G	0.0150
Share of capital in production function	α	0.3000
Share of public capital in production function	ζ	0.1000
Steady-state wage markup parameter	λ_w	1.3500
Steady-state labor tax rate	τ_w	0.4511
Steady-state consumption tax rate	τ_c	0.1543
Steady-state capital tax rate	τ_k	0.2754
Steady-state public consumption to GDP ratio	G^C/Y	0.1860
Steady-state public investment to GDP ratio	G^I/Y	0.0220
Steady-state transfer payments to GDP ratio	TR/Y	0.1783
Steady-state public debt to GDP ratio	B/Y	2.4000
Discount factor	β	0.9950
Steady-state return on capital	r^K	0.0219
Share Germany in Euro area	n	0.2800
Degree of domestic home bias	ω	0.5523
Degree of foreign home bias	ω^*	0.8259
Debt-elastic interest rate premium	κ	0.0100

Bayesian Estimation

- Pre-sample information about parameters is summarized by a prior distribution $Pr(\theta)$

$$\underbrace{Pr(\theta|m)}_{Posterior} \propto \underbrace{Pr(m|\theta)}_{Likelihood} \underbrace{Pr(\theta)}_{Prior}$$

- Markov chain Monte Carlo methods (MCMC) generate draws from the posterior to numerically approximate moments from the posterior
- The shift from prior to posterior can be a an indicator of tensions between different sources of information ...
- ... and informs about identification problems

The Effects of Fiscal Policy

Estimation: Selected Results

- Non-Ricardian households (43%) receive 70% of total transfers and consume 91% of optimizers level
- High persistence in fiscal, especially spending variables (AR coefficients $>$0.7)
- High relevance of announcement effects (except government consumption and capital tax rate)
- Systematic stabilization of the business cycle via government transfers
- No systematic stabilization of government debt via fiscal policy rules

Stimulus Effects on GDP Growth

- Positive effects of fiscal policy shocks in all quarters of 2009 and 2010Q3
- Overall impact on GDP growth relatively small (cumulative contribution during 2009 and 2010: about 1 percentage point)
- Largest positive effects from government consumption, transfers and labor taxes (incl. social security contributions), on impact smaller from government investment
- Fiscal stimulus largest in 2009Q2 (contribution to q-o-q GDP growth of 0.5 pps)

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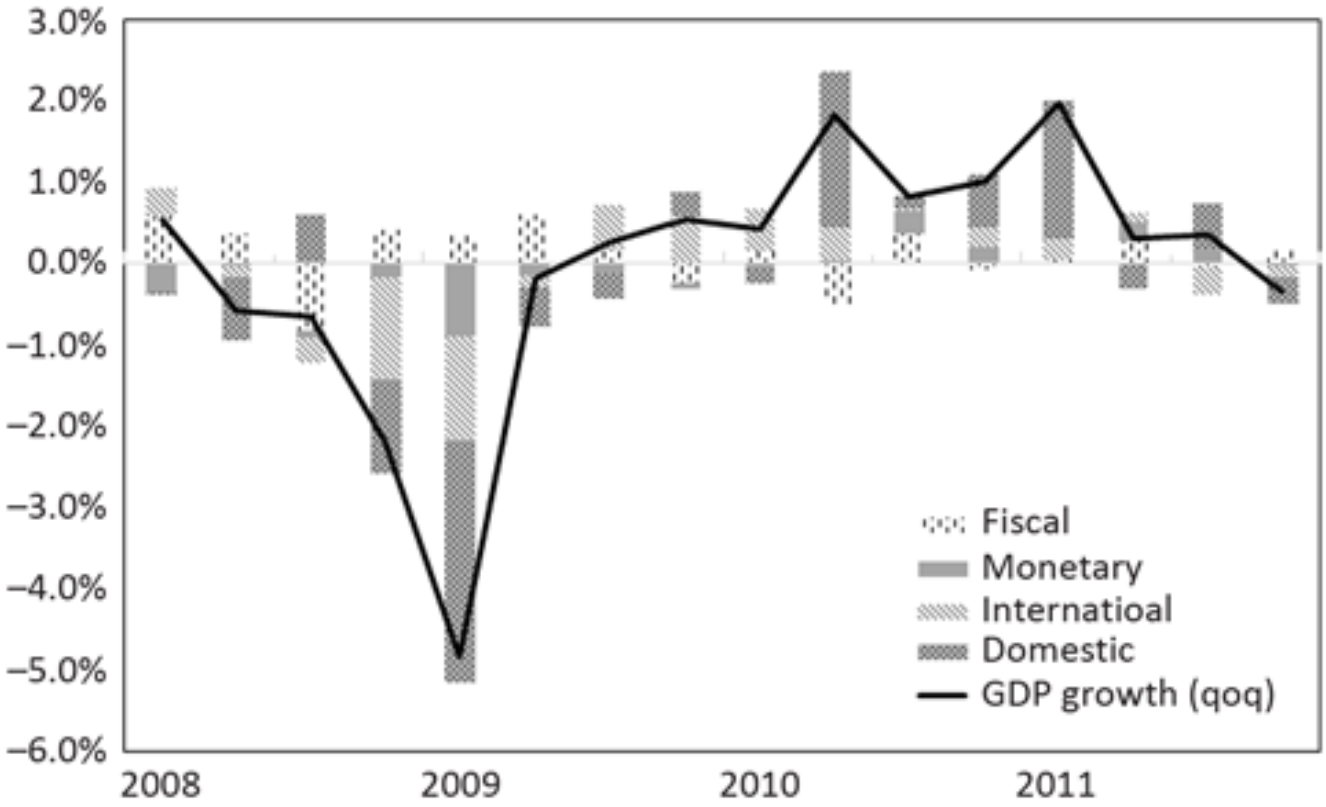
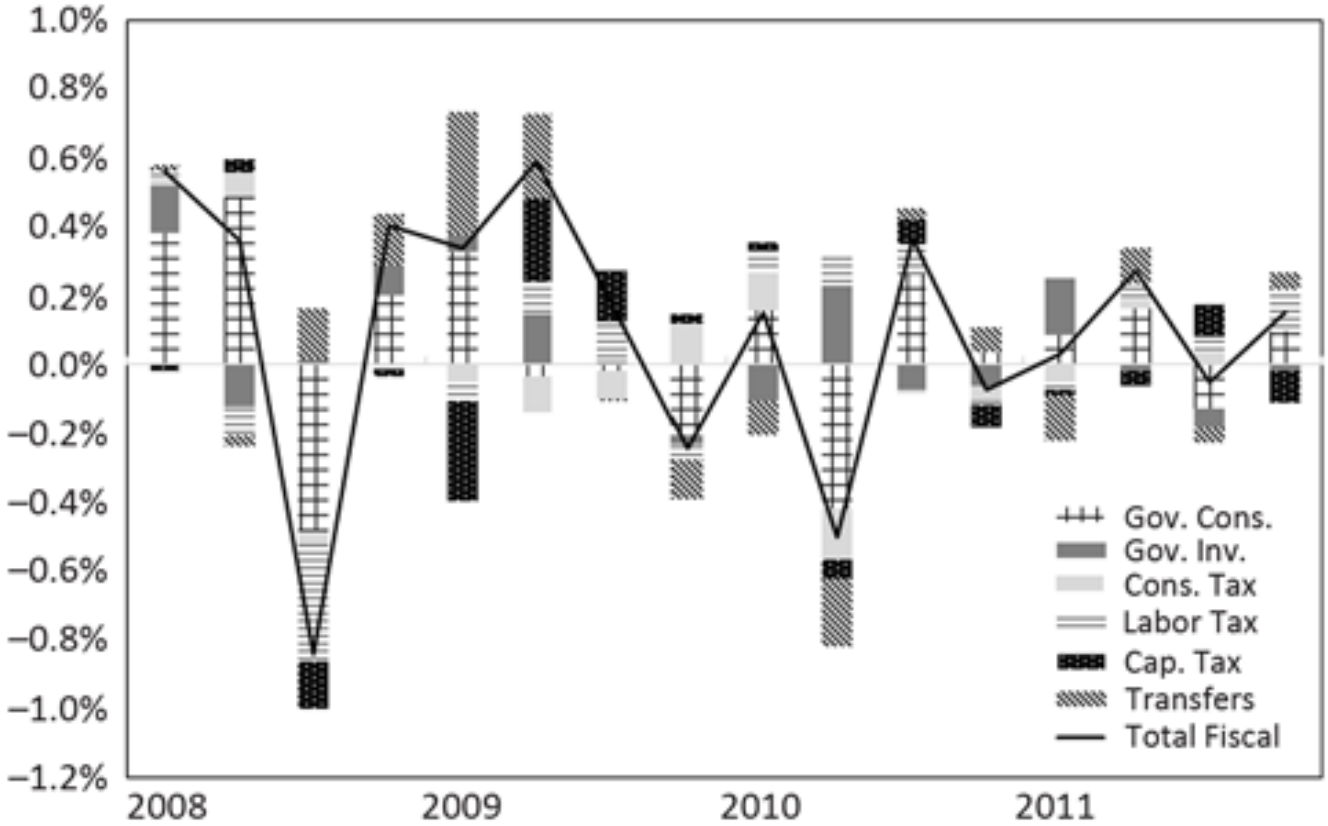
Historical Decomposition of GDP Growth



Fiscal Stimulus



Effectiveness of Fiscal Policy

- Effectiveness measured as cumulative present value of government spending/revenue multipliers

$$CPVM^k = \frac{E_t \sum_{j=0}^{k} (1+R)^{-j} \Delta y_{t+j}}{E_t \sum_{j=0}^{k} (1+R)^{-j} \Delta f_{t+j}},$$

with the respective fiscal variable f_t

Shock	Impact	1 year	2 years	3 years	4 years	5 years
Government consumption	1.64	1.49	1.28	1.16	1.10	1.06
Government investment	0.39	1.33	1.40	1.60	1.83	2.06
Government transfers	0.55	0.83	0.76	0.72	0.69	0.67
Labor tax rate	0.65	1.03	0.98	0.92	0.86	0.81
Consumption tax rate	0.31	0.82	0.84	0.83	0.83	0.82
Capital tax rate	0.60	0.67	0.60	0.52	0.45	0.41

The Effects of Fiscal Policy

Conclusion

- Estimated DSGE model for Germany with a detailed fiscal sector
- Downturn and subsequent upturn primarily driven by foreign shocks, to a smaller extents by domestic preference and risk premium shocks
- Positive impact of fiscal shocks on GDP growth at the end of 2008 and the beginning of 2009
- Fiscal policy measures have prevented a larger downturn and stabilized economic activity at the beginning of the recession, however no contribution to its acceleration throughout 2010

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Optimizers

- Budget constraint

$$
\begin{aligned}
P_t C_t^o \left(1+\tau_t^c\right) \quad &+ \quad P_t I_t^o + \frac{B_t^o}{\epsilon_t^{rp}} + e_t B_{F,t}^o = \left(1-\tau_t^w\right) W_t^o L_t^o \\
&+ \quad R_{t-1}\left(B_{t-1}^o + e_t B_{F,t-1}^o \phi_t\left(NFA_t\right)\right) \\
&+ \quad \left(1-\tau_t^k\right)\left[R_{k,t} u_t - a(u_t) P_t\right] K_{t-1}^o \\
&+ \quad \tau_t^k \delta P_t K_{t-1}^o + \Pi_t + TR_t^o - LS_t^o .
\end{aligned}
$$

Back

Capital Accumulation

- Capital stock evolves according to

$$K_t^o = (1-\delta) K_{t-1}^o + \epsilon_t^i \left(1 - S\left(\frac{I_t^o}{I_{t-1}^o}\right)\right) I_t^o$$

with investment adjustment cost function $S(\cdot)$ and investment specific shock ϵ^i

Back

Capital Utilization

- Utilization adjustment costs

$$a(u_t) = \gamma_{u,1}(u_t - 1) + \frac{\gamma_{u,2}}{2}(u_t - 1)^2$$

Back

First Order Conditions I

- Consumption

$$\epsilon_t^b \left(C_t^o - hC_{t-1}^o\right)^{-\sigma} = \left(1 + \tau_t^c\right) \lambda_t^o$$

- Investment

$$\begin{aligned} & Q_t^o \epsilon_t^i \left(1 - S\left(\frac{I_t^o}{I_{t-1}^o}\right) - \frac{I_t^o}{I_{t-1}^o} S'\left(\frac{I_t^o}{I_{t-1}^o}\right)\right) \\ + \quad & \beta E_t Q_{t+1}^o \frac{\lambda_{t+1}^o}{\lambda_t^o} \epsilon_{t+1}^i \left(\frac{I_{t+1}^o}{I_t^o}\right)^2 S'\left(\frac{I_{t+1}^o}{I_t^o}\right) = 1 \end{aligned}$$

- Labor

$$\left(L^o\right)_t^{\varphi} = -(1 - \tau_t^w)\lambda_t^o \frac{W_t}{P_t}$$

Back

First Order Conditions II

- Capital stock

$$Q_t^o = \beta \frac{\lambda_{t+1}^o}{\lambda_t^o} \left(\left(1 - \tau_t^k\right) \left[r_t^k u_t - a\left(E_t u_t + 1\right) \right] + \tau_t^k \delta + \left(1 - \delta\right) E_t Q_{t+1}^o \right)$$

- Capital utilization rate

$$a'\left(u_t\right) = r_t^k$$

- Domestic Bond holdings

$$\lambda_t^o P_t = \beta E_t \left(\lambda_{t+1}^o P_{t+1} \right) \epsilon_t^{rp} R_t$$

- Foreign Bond holdings

$$\lambda_t^o P_t = \beta E_t \left(\lambda_{t+1}^o P_{t+1} \right) e_t R_t \phi\left(NFA_t\right)$$

Back

Estimated Parameters

		Prior			Posterior	
Parameter		Distr.	Mean	S.d.	Mean	90%	HPD
Gov. Cons. Output Reac.	$\rho_{gc,y}$	norm	0.00	0.5000	-0.0683	-0.6493	0.5050
Gov. Cons. Debt Reac.	$\rho_{gc,b}$	norm	0.00	0.5000	0.3106	-0.1229	0.7361
Gov. Inv. Output Reac.	$\rho_{gi,y}$	norm	0.00	0.5000	0.0199	-0.7532	0.7843
Gov. Inv. Debt Reac.	$\rho_{gi,b}$	norm	0.00	0.5000	0.0865	-0.5786	0.7526
Gov. Tran. Labor Reac.	$\rho_{tr,l}$	norm	0.00	0.5000	-0.6800	-1.0173	-0.3296
Gov. Tran. Debt Reac.	$\rho_{tr,b}$	norm	0.00	0.5000	-0.0528	-0.2454	0.1391
Cons. Tax Output Reac.	$\rho_{\tau c,y}$	norm	0.00	0.5000	0.1775	0.0269	0.3297
Cons. Tax Debt Reac.	$\rho_{\tau c,b}$	norm	0.00	0.5000	-0.0178	-0.1022	0.0723
Labor Tax Labor Reac.	$\rho_{\tau w,y}$	norm	0.00	0.5000	0.0574	-0.1170	0.2388
Labor Tax Debt Reac.	$\rho_{\tau w,b}$	norm	0.00	0.5000	-0.0831	-0.1928	0.0245
Capital Tax Investm. Reac.	$\rho_{\tau k,y}$	norm	0.00	0.5000	0.1886	-0.1404	0.5139
Capital Tax Debt Reac.	$\rho_{\tau k,b}$	norm	0.00	0.5000	-0.1216	-0.5487	0.2997