Accounting for Post-Crisis Inflation and Employment: A Retro Analysis*

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December 1, 2014

*This research has been supported by the NSF grant SES-1227280.

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This research has been supported by the NSF grant SES-1227280. Harald Uhlig has an ongoing consulting relationship with a Federal Reserve Bank, the Bundesbank and the ECB.

Abstract

What accounts for inflation after 2008? We use the prominent pre-crisis Smets-Wouters (2007) model to address this question. We find that due to price markup shocks alone inflation would have been 1% higher than observed and 0.5% higher that the long-run average. Their standard deviation is similar to its pre-crisis level. Price markup shocks were also responsible for the slow recovery of employment, though not for the initial drop. Monetary policy shocks predict an inflation rate 0.5% below average. Government expenditure innovations do not contribute much either to inflation or to employment dynamics.

Technical Appendix — NOT FOR PUBLICATION

Table 1: Summary statistics

	1948Q1 - 2004Q4		1948Q1 - 2014Q2	
	mean	std dev	mean	std dev
consumption	0.535	0.846	0.480	0.834
investment	0.565	2.380	0.442	2.414
output	0.514	1.002	0.455	0.973
labor	0.825	2.900	0.000	3.650
inflation	0.8400	0.652	0.789	0.624
wage rate	0.478	0.627	0.433	0.721
interest rate	1.325	0.867	1.192	0.884

Growth rates of consumption, investment, output and real wage. Consumption, investment, output and hours worked are net of labor force growth, normalized to 1 in 2005Q1. Variables are deflated using the GDP deflator.

A Re-Estimating the Smets-Wouters model

Following Smets and Wouters, we adopt a Bayesian approach and we estimate the posterior distribution using a MH algorithm with 250,000 simulations. Priors are the same as the ones assumed in Smets-Wouters. Like them, we use 7 time series to estimate the model: output, consumption, investment, inflation, hours worked, real wages, and the (Federal Fund) interest rate. We compute consumption, investment and hours worked per-capita using a population index normalized to 1 in 1992Q4. We use the GDP deflator as a measure of inflation. Consumption, investment, output and wage are at constant prices. Variables are net of the labor force growth, normalized to 1 in 2005Q1. For the interest rate, we use the Federal Funds Rate.

We use data from U.S. Bureau of Economic Analysis and U.S. Bureau of Labor Statistics for the period 1948Q1-2014Q2. Table 1 collects some summary statistics for the the sample used by Smets and Wouter (left column) and our sample (right column). In general, the mean is smaller and unsurprisingly the standard deviation is larger when we consider the extended sample. The average of labor hours relative to the hours worked in 2005 Q2 (2005Q2=0) decreases considerably, from 1.348 to 0.663 with the inclusion of the observations from 2005Q1 to 2014Q2. Contrary to the original paper, our sample starts from 1948Q1 instead of 1947Q1 because these data points are not available for the most recent vintages of the time series.

Table 2: Posterior distributions (Metropolis Hasting 250000 simulations). Comparison between our sample and the sample used by Smets and Wouters.

		1948Q1 - 2014Q2			1948Q1 - 2004Q4		
		mean	HDP inf	HPD sup	mean	HDP inf	HPD sup
$\sigma(e_Z)$	TFP	0.507	0.468	0.551	0.522	0.467	0.579
$\sigma(e_{b^2})$	risk premium	0.121	0.096	0.146	0.112	0.069	0.153
$\sigma(e_g)$	gov't exp	0.645	0.597	0.689	0.734	0.671	0.794
$\sigma(e_\mu)$		0.477	0.412	0.536	0.435	0.333	0.529
$\sigma(e_{ms})$	monetary shock	0.224	0.205	0.244	0.236	0.212	0.258
$\sigma(e_p)$	price shock	0.204	0.176	0.233	0.216	0.184	0.247
$\sigma(e_w)$	wage shock	0.344	0.313	0.378	0.250	0.219	0.281
ρ_Z		0.985	0.977	0.991	0.974	0.958	0.991
ρ_{b^2}		0.806	0.740	0.877	0.852	0.769	0.934
ρ_g		0.977	0.967	0.988	0.978	0.964	0.991
ρ_μ		0.801	0.717	0.886	0.673	0.565	0.784
ρ_{ms}		0.160	0.071	0.247	0.137	0.049	0.220
ρ_p		0.977	0.959	0.996	0.979	0.961	0.997
ρ_w		0.964	0.939	0.989	0.965	0.944	0.988
θ_p	price MA	0.873	0.809	0.934	0.872	0.805	0.941
θ_w	wage MA	0.932	0.894	0.971	0.890	0.838	0.943

Continued on next page

Table 2 – continued from previous page

		1948Q1 - 2014Q2			1948Q1 - 2004Q4		
		mean	HDP inf	HPD sup	mean	HDP inf	HPD sup
$S''(\gamma)$	inv. adj cost	3.819	2.437	5.141	6.747	5.094	8.391
σ_c	intertemp elast	2.042	1.634	2.453	1.450	1.082	1.817
h	habits	0.348	0.265	0.427	0.506	0.421	0.585
ζ_w	wage stickiness	0.781	0.713	0.847	0.749	0.679	0.816
ν_L	labor	1.471	0.774	2.095	1.971	1.135	2.770
ζ_p	price stickiness	0.667	0.586	0.749	0.608	0.531	0.680
ι_w	wage index	0.494	0.317	0.676	0.523	0.359	0.682
ι_p	price index	0.300	0.163	0.433	0.311	0.168	0.451
$czcap$	capital utiliz.	0.7525	0.608	0.893	0.453	0.316	0.596
Φ	fixed cost	1.608	1.497	1.718	1.441	1.318	1.569
ψ_1	monetary p.	2.034	1.771	2.299	1.982	1.691	2.266
ρ_R	monetary p.	0.880	0.855	0.907	0.884	0.858	0.910
ψ_2	monetary p.	0.082	0.044	0.122	0.084	0.015	0.146
ψ_3	monetary p.	0.189	0.155	0.221	0.223	0.178	0.269
$const_\pi$	measurem eq	0.752	0.627	0.878	0.725	0.574	0.871
$constebeta$	measurem eq	0.261	0.090	0.410	0.251	0.094	0.403
$const_L$	measurem eq	-0.583	-2.747	1.491	0.558	-1.719	2.750
$ctrend$	growth rate	0.460	0.433	0.488	0.469	0.440	0.499
ρ_{gZ}	gov't exp	0.622	0.496	0.761	0.629	0.495	0.761
α	$\frac{k_*}{y_*}$	0.181	0.127	0.237	0.192	0.129	0.252

There are some changes in the estimated posteriors once we extend the time period, but they appear to be minor and not particularly remarkable. A comparison is in table **??**. There, HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval. In particular, the intertemporal elasticity of substitution σ_c falls a bit, and the habit level as well as the adjustment costs rise. Robustness checks and estimation results for different subsamples and specifications of the model are reported in a technical appendix.

Technical Appendix — Not for Publication

B The model

The model is described in detail in **?** . This is a review, for convenience. Households maximize the sum of the discounted flow of per-period utility with respect to a consumption good, labor, investment, effective capital and capital utilization. The utility function has external habits. Households can transfer resources in the future by investing in physical capital or by buying government bonds. Capital adjustments come at a cost that depends on the investment growth.

Final good producers use a continuum with mass 1 of imperfectly substitutable intermediate goods to produce a final consumption good. They solve a static problem in which they maximize profits subject to a production function and a zero-profit condition. They take the price of the final good and of the intermediate goods as given. Intermediate firms maximize the sum of the discounted flow of profits assuming a Calvo price setting with partial indexation to inflation subject to the demand of intermediate goods by the final good producers. They produce intermediate goods using capital and labor.

Households provide labor to the labor unions. Labor unions sell labor to labor packers that resell the labor to the intermediate firms. Labor packers operate in a competitive market. They buy labor from unions and repackage it according to a Dixit-Stiglitz aggregator. They maximize profits taking as given the intermediate wage and the final wage and subject to a zero profit condition. Labor unions maximize the sum of the discounted flow of profits assuming a Calvo price setting with partial indexation to inflation subject to the demand of labor by the labor packers.

Finally, a Taylor rule and a stochastic process for government expenditure close the model. Following Smets and Wouters, the government expenditure depends on its lag, an exogenous shock and the technological shock.

B.1 Household

$$\hat{c}_t = \frac{1}{1+h/\gamma}E_t\hat{c}_{t+1} + \frac{h/\gamma}{1+h/\gamma}\hat{c}_{t-1} - \frac{1-h/\gamma}{\sigma_c(1+h/\gamma)}(\hat{R}_t - E_t\hat{\pi}_{t+1}) - \frac{(\sigma_c-1)(w_*^h L_*/c_*)}{\sigma_c(1+h/\gamma)}(E_t\hat{L}_{t+1} - \hat{L}_t) + b_t^2 \quad (1)$$

$$\hat{i}_t = \frac{1}{1+\bar{\beta}\gamma}(\hat{i}_{t-1} + \bar{\beta}\gamma E_t\hat{i}_{t+1} + \frac{1}{\gamma^2 S''}\hat{Q}_t) + \hat{\mu}_t \quad (2)$$

$$\hat{Q}_t = \frac{\sigma_c(1+h/\gamma)}{1-h/\gamma}\hat{b}_t^2 - \hat{R}_t + E_t\hat{\pi}_{t+1} + \frac{r_*^k}{r_*^k+1-\delta}E_t\hat{r}_{t+1}^k + \frac{1-\delta}{r_*^k+1-\delta}E_t\hat{Q}_{t+1} \quad (3)$$

$$\hat{u}_t = \frac{r_*^k}{a''(1)}\hat{r}_t^k \quad (4)$$

$$\hat{k}_t = \hat{u}_t + \hat{\bar{k}}_{t-1} \quad (5)$$

$$\hat{\bar{k}}_t = (1 - \frac{i_*}{\bar{k}_*})\hat{\bar{k}}_{t-1} + \frac{i_*}{\bar{k}_*}\gamma^2 S''(\gamma)\mu_t + \frac{i_*}{\bar{k}_*}\hat{i}_t \quad (6)$$

B.2 Firms

$$\hat{y}_t = \Phi\hat{Z}_t + \alpha\Phi\hat{k}_t + (1-\alpha)\Phi\hat{L}_t \quad (7)$$

$$\hat{k}_t = \hat{w}_t - \hat{r}_t^k + \hat{L}_t \quad (8)$$

$$\hat{mc}_t = \alpha\hat{r}_t^k + (1-\alpha)\hat{w}_t - \hat{Z}_t \quad (9)$$

$$\hat{\pi}_t = \frac{(1-\zeta_p\bar{\beta}\gamma)(1-\zeta_p)}{(1+\bar{\beta}\gamma\iota_p)\zeta_p}\frac{1}{(\frac{y_*+\Phi}{y_*}-1)*curvp+1}\hat{mc}_t + \hat{\lambda}_{p,t} + \frac{\iota_p}{(1+\bar{\beta}\gamma\iota_p)}\hat{\pi}_{t-1} + \frac{\bar{\beta}\gamma}{(1+\bar{\beta}\gamma\iota_p)}E_t\hat{\pi}_{t+1} \quad (10)$$

B.3 Labor unions

$$(1+\bar{\beta}\gamma)\hat{w}_t - \hat{w}_{t-1} - \bar{\beta}\gamma E_t \hat{w}_{t+1} =$$
$$= \frac{(1-\zeta_w\bar{\beta}\gamma)(1-\zeta_w)}{\zeta_w} \frac{1}{(\lambda_w - 1) * curvw + 1} \left[\frac{1}{1-h/\gamma}\hat{c}_t - \frac{h/\gamma}{1-h/\gamma}\hat{c}_{t-1} + \nu_L \hat{L}_t - \hat{w}_t \right]$$
$$-(1+\bar{\beta}\gamma\iota_w)\hat{\pi}_t + \iota_w\hat{\pi}_{t-1} + \bar{\beta}\gamma E_t\hat{\pi}_{t+1} + \hat{\lambda}_{w,t}$$

B.4 Government and Monetary Policy

$$\hat{R}_t = \rho_R \hat{R}_{t-1} + (1-\rho_R)(\psi_1\hat{\pi}_t + \psi_2(\hat{y}_t - \hat{y}_t^{flex})) + \psi_3(\hat{y}_t - \hat{y}_{t-1} - (\hat{y}_t^{flex} - \hat{y}_{t-1}^{flex})) + ms_t \tag{11}$$

B.5 Aggregate resource constraints

$$\frac{c_*}{y_*}\hat{c}_t + \frac{i_*}{y_*}\hat{i}_t + \hat{g}_t + \frac{r_*^k k_*}{y_*}\hat{u}_t = \hat{y}_t \tag{12}$$

B.6 Natural output level

B.6.1 Household

$$\hat{c}_t = \frac{1}{1+h/\gamma}E_t\hat{c}_{t+1} + \frac{h/\gamma}{1+h/\gamma}\hat{c}_{t-1} - \frac{1-h/\gamma}{\sigma_c(1+h/\gamma)}\hat{R}_t - \frac{(\sigma_c-1)(w_*^h L_*/c_*)}{\sigma_c(1+h/\gamma)}(E_t\hat{L}_{t+1} - \hat{L}_t) + b_t^2 \tag{13}$$

$$\hat{i}_t = \frac{1}{1+\bar{\beta}\gamma}(\hat{i}_{t-1} + \hat{\beta}\gamma E_t\hat{i}_{t+1} + \frac{1}{\gamma^2 S''}\hat{Q}_t) + \hat{\mu}_t \tag{14}$$

$$\hat{Q}_t = \frac{\sigma_c(1+h/\gamma)}{1-h/\gamma}\hat{b}_t^2 - \hat{R}_t + \frac{r_*^k}{r_*^k + 1 - \delta}E_t\hat{r}_{t+1}^k + \frac{1-\delta}{r_*^k+1-\delta}E_t\hat{Q}_{t+1} \tag{15}$$

$$\hat{u}_t = \frac{r_*^k}{a''(1)}\hat{r}_t^k \tag{16}$$

$$\hat{k}_t = \hat{u}_t + \hat{\bar{k}}_{t-1} \tag{17}$$

$$\hat{\bar{k}}_t = (1 - \frac{i_*}{\bar{k}_*})\hat{\bar{k}}_{t-1} + \frac{i_*}{\bar{k}_*}\gamma^2 S''(\gamma)\mu_t + \frac{i_*}{\bar{k}_*}\hat{i}_t \tag{18}$$

B.6.2 Firms

$$\hat{y}_t = \Phi\hat{Z}_t + \alpha\Phi\hat{k}_t + (1-\alpha)\Phi\hat{L}_t \tag{19}$$

$$\hat{k}_t = \hat{w}_t - \hat{r}_t^k + \hat{L}_t \tag{20}$$

$$0 = \alpha\hat{r}_t^k + (1-\alpha)\hat{w}_t - \hat{Z}_t \tag{21}$$

B.6.3 Labor unions

$$\hat{w}_t = \frac{1}{1-h/\gamma}\hat{c}_t - \frac{h/\gamma}{1-h/\gamma}\hat{c}_{t-1} + \nu_L\hat{L}_t \tag{22}$$

B.6.4 Aggregate resource constraints

$$\frac{c_*}{y_*}\hat{c}_t + \frac{i_*}{y_*}\hat{i}_t + \hat{g}_t + \frac{r_*^k k_*}{y_*}\hat{u}_t = \hat{y}_t \tag{23}$$

B.7 Exogenous processes

$$Z_t = \rho_Z Z_{t-1} + e_Z \tag{24}$$

$$b_t^2 = \rho_{b^2} b_{t-1}^2 + e_{b^2} \tag{25}$$

$$g_t = \rho_g g_{t-1} + e_g + \rho_{gZ} e_Z \tag{26}$$

$$\mu_t = \rho_\mu \mu_{t-1} + e_\mu \tag{27}$$

$$\lambda_{p,t} = \rho_p \lambda_{p,t-1} + e_p - \theta_p e_{p,t-1} \tag{28}$$

$$\lambda_{w,t} = \rho_w \lambda_{w,t-1} + e_w - \theta_w e_{w,t-1} \tag{29}$$

$$ms_t = \rho_{ms} ms_{t-1} + e_{ms} \tag{30}$$

B.8 Measurement equations

$$dy_t = y_t - y_{t-1} + ctrend \tag{31}$$

$$dc_t = c_t - c_{t-1} + ctrend \tag{32}$$

$$dinve_t = i_t - i_{t-1} + ctrend \tag{33}$$

$$dw_t = w_t - w_{t-1} + ctrend \tag{34}$$

$$pinfobs_t = \pi_t + const_\pi \tag{35}$$

$$robs_t = R_t + const_R \tag{36}$$

$$labobs_t = L_t + const_L \tag{37}$$

C The data

We list the data used in our estimation:

- **GDPC96**: Real Gross Domestic Product, 3 decimal - Billions of Chained 2009 Dollars, Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce, Bureau of Economic Analysis

- **GDPDEF**: Gross Domestic Product - Implicit Price Deflator - 2009=100, Seasonally Adjusted. Source: U.S. Department of Commerce, Bureau of Economic Analysis

- **PCEC**: Personal Consumption Expenditures - Billions of Dollars, Seasonally Adjusted Annual Rate. Source: U.S. Department of Commerce, Bureau of Economic Analysis

- **FPI** : Fixed Private Investment - Billions of Dollars, Seasonally Adjusted Annual Rate Source: U.S. Department of Commerce, Bureau of Economic Analysis. We are using the latest vintage date, $FPI\_20130731$ (Source for alternative vintage dates: ALFRED).

- **CE16OV** : Civilian Employment: Sixteen Years & Over, Thousands, Seasonally Adjusted. Source: U.S. Department of Labor: Bureau of Labor Statistics. Start date: 1948Q1.

- **CE16OV index** : CE16OV (2009:1)=1

- **Effective Federal Funds Rate** : Percentage, Averages of Daily Figures Percent, Quarterly. Not Seasonally Adjusted. Source: Board of Governors of the Federal Reserve System. (Before 1954: 3-Month Treasury Bill Rate, Secondary Market Averages of Business Days, Discount Basis. For this time series, we used the data from FRED, TB3MS, 3-Month Treasury Bill: Secondary Market Rate (TB3MS), Percent, Quarterly, Not Seasonally Adjusted.)

- **LNS10000000** : Labor Force Status : Civilian noninstitutional population - Age : 16 years and over - Seasonally Adjusted - Number in thousands. Source: U.S. Bureau of Labor Statistics. (Before 1976: CNP16OV : Civilian Noninstitutional Population level - 16 Years and Older)
- **LNSindex** : LNS10000000(2005:1)=1
- **PRS85006023** - Nonfarm Business, All Persons, Average Weekly Hours Duration : index, 2005 = 100, Seasonally Adjusted. Source : U.S. Department of Labor.
- **COMPNFB** :Nonfarm Business Sector: Compensation Per Hour, Index 2005=100, Quarterly, Seasonally Adjusted. Source : U.S. Department of Labor

Definition of data variables in the measurement equations:

$$consumption = dc = \Delta LN((PCEC/GDPDEF)/LNSindex) * 100 \quad (38)$$

$$investment = dinve = \Delta LN((FPI/GDPDEF)/LNSindex) * 100 \quad (39)$$

$$output = dy = \Delta LN(GDPC96/LNSindex) * 100 \quad (40)$$

$$hours = labobs = LN((PRS85006023 * CE16OV/100)/LNSindex) * 100 \quad (41)$$

$$inflation = pinfobs = LN(GDPDEF/GDPDEF(-1)) * 100 \quad (42)$$

$$realwage = dw = \Delta LN(COMPNFB/GDPDEF) * 100 \quad (43)$$

$$interestrate = robs = FederalFundsRate/4 \quad (44)$$

D Estimation procedure

We use a Metropolis-Hasting algorithm with 250,000 iterations to compute the posterior distributions. We used the same priors as Smets-Wouters 2006.

D.1 List of estimated parameters

The following are the parameters estimated in the model.

Parameters for the stochastic processes:
$std\ err\ e_Z, std\ err\ e_{b^2}, std\ err\ e_g, std\ err\ e_\mu, std\ err\ e_{ms}, std\ err\ e_p, std\ err\ e_w,$
$\rho_Z, \rho_{b^2}, \rho_g, \rho_{gZ}, \rho_\mu, \rho_{ms}, \rho_p, \rho_w, \theta_p, \theta_w$
Investment adjustment cost: $S''(\gamma)$
Utility function: $\sigma_c, h, \nu_L,$
Capital utilization parameter: $czcap$
Inflation indexation parameters: ι_w, ι_p
Calvo probability of price resetting: ζ_w, ζ_p
Fixed production cost: Φ
Capital share: α
Taylor rule: $\psi_1, \rho_R, \psi_2, \psi_3$
Measurement equations: $const_\pi, constebeta, const_L, ctrend$

D.2 List of calibrated parameters

The following parameters have been calibrated.
Capital depreciation: $\delta = .025$
Steady state labor markup: $\lambda_{w,*} = 0.5$
Steady state government expenditure: $g_* = 0.18$
Generalization of the Dixit-Stigler aggregators for the intermediate good firms and the labor unions: $curvp = curvw = 10$

D.3 List of derived parameters

The following are function of other parameters:

$$\bar{\beta} = \beta\gamma^{-\sigma_c} \tag{45}$$

$$ctrend = 100(\gamma - 1) \tag{46}$$

$$\lambda_{p,*} = \Phi - 1 \tag{47}$$

$$cr = \frac{cpie}{\beta\gamma^{-\sigma_c}} \tag{48}$$

$$r_{k,*} = \beta^{-1}\gamma^{\sigma_c} - (1 - \delta) \tag{49}$$

$$w_* = \left(\frac{\alpha^\alpha(1-\alpha)^{1-\alpha}}{\Phi r_{k,*}^\alpha}\right)^{\frac{1}{1-\alpha}} \tag{50}$$

$$\frac{i_*}{\bar{k}_*} = 1 - \frac{1-\delta}{\gamma} \tag{51}$$

$$\frac{k_*}{L_*} = \frac{\alpha}{1-\alpha}\frac{w_*}{r_{k,*}} \tag{52}$$

$$\frac{k_*}{y_*} = \Phi(\frac{k_*}{L_*})^{1-\alpha} \tag{53}$$

$$\frac{i_*}{y_*} = (1 - \frac{1-\delta}{\gamma})\gamma\frac{k_*}{y_*} \tag{54}$$

$$\frac{c_*}{y_*} = 1 - g_* - \frac{i_*}{y_*} \tag{55}$$

$$\frac{w_*^h L_*}{c_*} = \frac{1}{1+\lambda_{w,*}}\frac{1-\alpha}{\alpha}r_{k,*}\frac{k_*}{c_*} \tag{56}$$

$$const_R = (cr - 1) * 100 \tag{57}$$

$$const_\pi = (cpie - 1) * 100 \tag{58}$$

$$a'(1) = \frac{1 - czcap}{czcap}r_{k,*} \tag{59}$$

E Robustness checks

In this section we summarize the results from our robustness checks.

Firstly, we want to evaluate if introducing the years of the recession for the estimation significantly modifies the estimates for the posterior distributions. We compared the posterior distribution for two samples: 1948Q1-2004Q1, the sample used by the authors (except for the first 4 data points that we dropped as discussed in the paper) and 1948Q1-2014Q2, the extended sample. We do not estimate the posterior distributions separately for the last part of the sample because 2007-2014 would be too short of a sample period relative to the full sample to guarantee comparability of the results.

Parameters with the largest deviations are: $std\,err\,e_g$, ρ_{b^2}, ρ_μ, $S''(\gamma)$ (investment adjustment cost), σ_c, h, czcap (function of the capital utilization adjustment cost), Φ, α. However, due to the large number of data points in common, the difference is small relative to the confidence intervals of the corresponding parameters.

We estimated the parameters for smaller subsamples, to investigate whether there are major changes in the posterior distributions.

When we consider the periods 1988-1996, 1996-2004 and 2005-2014, the estimate of the coefficient of autocorrelation of the real interest rate becomes progressively larger as we move forward in time. The AR and the MA coefficients for the price markup and the wage markup decrease as we estimate them using subsamples towards the end of the considered period.

Moreover there is some variation in the estimates of the elasticity of intertemporal substitution and the habit formation parameter across subsamples. For the elasticity of intertemporal substitution the lowest value for the mean (0.860 compared to the whole sample estimate of 1.984) is attained in the sample 1988-1996, while in the sample 2005-2014 the mean for the habit formation parameter is twice as large as the corresponding value estimated with the whole sample.

Following Smets and Wouters, we used a generalization of the Dixit-Stiglitz index for the general specification of the model. However, we tested the implications for the posterior distributions of changing this assumption and we conclude that there are no main changes in the posterior distributions of the parameters if we use the Dixit-Stiglitz aggregator.

Table 3: Posterior distributions (Metropolis Hasting 250000 simulations). Comparison between our sample and the sample used by Smets and Wouters.

		1948Q1 - 2014Q2			1948Q1 - 2004Q4		
		mean	HDP inf	HPD sup	mean	HDP inf	HPD sup
$\sigma(e_Z)$	TFP	0.503	0.458	0.547	0.522	0.467	0.579
$\sigma(e_{b^2})$	risk premium	0.136	0.099	0.172	0.112	0.069	0.153
$\sigma(e_g)$	gov't exp	0.647	0.602	0.695	0.734	0.671	0.794
$\sigma(e_\mu)$		0.488	0.421	0.554	0.435	0.333	0.529
$\sigma(e_{ms})$	monetary shock	0.226	0.206	0.247	0.236	0.212	0.258
$\sigma(e_p)$	price shock	0.208	0.180	0.235	0.216	0.184	0.247
$\sigma(e_w)$	wage shock	0.278	0.249	0.307	0.250	0.219	0.281
ρ_Z		0.985	0.978	0.992	0.974	0.958	0.991
ρ_{b^2}		0.765	0.658	0.871	0.852	0.769	0.934
ρ_g		0.977	0.965	0.988	0.978	0.964	0.991
ρ_μ		0.780	0.694	0.873	0.673	0.565	0.784
ρ_{ms}		0.167	0.076	0.256	0.137	0.049	0.220
ρ_p		0.975	0.957	0.996	0.979	0.961	0.997
ρ_w		0.960	0.936	0.986	0.965	0.944	0.988
θ_p	price MA	0.882	0.823	0.944	0.872	0.805	0.941

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Table 3 – continued from previous page

		1948Q1 - 2014Q2			1948Q1 - 2004Q4		
		mean	HDP inf	HPD sup	mean	HDP inf	HPD sup
θ_w	wage MA	0.922	0.880	0.965	0.890	0.838	0.943
$S''(\gamma)$	inv. adj cost	4.063	2.572	5.514	6.747	5.094	8.391
σ_c	intertemp elast	1.984	1.528	2.443	1.450	1.082	1.817
h	habits	0.384	0.287	0.483	0.506	0.421	0.585
ζ_w	wage stickiness	0.803	0.739	0.866	0.749	0.679	0.816
ν_L	labor	1.638	0.862	2.391	1.971	1.135	2.770
ζ_p	price stickiness	0.675	0.584	0.761	0.608	0.531	0.680
ι_w	wage index	0.489	0.319	0.656	0.523	0.359	0.682
ι_p	price index	0.290	0.162	0.415	0.311	0.168	0.451
$czcap$	capital utiliz.	0.690	0.528	0.854	0.453	0.316	0.596
Φ	fixed cost	1.609	1.495	1.721	1.441	1.318	1.569
ψ_1	monetary p.	1.969	1.705	2.226	1.982	1.691	2.266
ρ_R	monetary p.	0.881	0.853	0.909	0.884	0.858	0.910
ψ_2	monetary p.	0.084	0.043	0.123	0.084	0.015	0.146
ψ_3	monetary p.	0.187	0.152	0.221	0.223	0.178	0.269
$const_\pi$	measurem eq	0.740	0.612	0.868	0.725	0.574	0.871
$constebeta$	measurem eq	0.248	0.091	0.398	0.251	0.094	0.403
$const_L$	measurem eq	-0.021	-2.097	2.128	0.558	-1.719	2.750
$ctrend$	growth rate	0.469	0.440	0.499	0.469	0.440	0.499
ρ_{gZ}	gov't exp	0.629	0.495	0.761	0.629	0.495	0.761
α	$\frac{k_*}{y_*}$	0.192	0.129	0.252	0.192	0.129	0.252

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

Table 4: **Posterior distributions in subsamples (Metropolis Hasting 25000 simulations)**

	1964Q3 2004Q4		
	mean	HPD inf	HPD sup
$\sigma(e_Z)$	0.4291	0.387	0.4763
$\sigma(e_{b^2})$	0.2315	0.1885	0.2725
$\sigma(e_g)$	0.5148	0.4663	0.5631
$\sigma(e_\mu)$	0.4	0.3349	0.4581
$\sigma(e_{ms})$	0.2407	0.2167	0.2626
$\sigma(e_p)$	0.1255	0.1018	0.1489
$\sigma(e_w)$	0.2615	0.2225	0.3019
ρ_Z	0.9551	0.9358	0.972
ρ_{b^2}	0.2503	0.0985	0.387
ρ_g	0.9622	0.9473	0.9783
ρ_μ	0.8022	0.7075	0.8962
ρ_{ms}	0.1588	0.0541	0.2667
ρ_p	0.8913	0.8181	0.9628
ρ_w	0.945	0.912	0.9774
θ_p	0.7311	0.5947	0.8682
θ_w	0.798	0.6775	0.9217
$S''(\gamma)$	5.1598	3.423	6.9416
σ_c	1.559	1.2911	1.8157
h	0.656	0.5741	0.7373
ζ_w	0.6916	0.5841	0.805
ν_L	1.6361	0.613	2.6136
ζ_p	0.7103	0.6449	0.7788

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Table 4 – continued from previous page

	1964Q3 2004Q4			
	mean	mode	HPD inf	HPD sup
ι_w	0.6333	0.4523	0.8503	
ι_p	0.3351	0.1581	0.512	
czcap	0.4927	0.341	0.6416	
Φ	1.6933	1.5646	1.826	
ψ_1	2.0242	1.7617	2.3184	
ρ_R	0.8107	0.7726	0.8538	
ψ_2	0.0826	0.047	0.1218	
ψ_3	0.2203	0.1752	0.2636	
$const_\pi$	0.7029	0.5892	0.8139	
constebeta	0.2492	0.0954	0.3969	
$const_L$	0.4429	-1.2289	2.0248	
ctrend	0.4388	0.407	0.4737	
ρ_{gZ}	0.6125	0.4584	0.7703	
α	0.3058	0.2376	0.3662	

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

Table 5: **Posterior distributions in subsamples (Metropolis Hasting 25000 simulations)**

	1964Q3 2014Q2		
	mean	HPD inf	HPD sup
$\sigma(e_Z)$	0.4503	0.4058	0.4917
$\sigma(e_{b^2})$	0.1695	0.1187	0.2141
$\sigma(e_g)$	0.5016	0.4628	0.541
$\sigma(e_\mu)$	0.3922	0.3191	0.4585
$\sigma(e_{ms})$	0.2307	0.2063	0.2518
$\sigma(e_p)$	0.1244	0.1054	0.1459
$\sigma(e_w)$	0.3707	0.3304	0.4085
ρ_Z	0.9683	0.9538	0.9826
ρ_{b^2}	0.5116	0.3251	0.7038
ρ_g	0.9687	0.957	0.9811
ρ_μ	0.8581	0.7915	0.9304
ρ_{ms}	0.1936	0.0922	0.3074
ρ_p	0.9166	0.8642	0.9723
ρ_w	0.9563	0.9251	0.986
θ_p	0.7819	0.6806	0.8804
θ_w	0.9239	0.8741	0.9712
$S''(\gamma)$	4.156	2.5194	5.7709
σ_c	1.6607	1.3621	1.9754
h	0.5599	0.4544	0.6695
ζ_w	0.7859	0.7022	0.8657
ν_L	1.3969	0.5682	2.2562
ζ_p	0.766	0.7085	0.8258

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Table 5 – continued from previous page

1964Q3 2014Q2	mean	HPD inf	HPD sup
ι_w	0.6317	0.4331	0.8272
ι_p	0.2461	0.1189	0.3704
czcap	0.8195	0.7152	0.9267
Φ	1.6489	1.5227	1.7826
ψ_1	1.8612	1.5969	2.1239
ρ_R	0.805	0.766	0.8486
ψ_2	0.0589	0.0334	0.0879
ψ_3	0.2311	0.1872	0.2747
$const_\pi$	0.735	0.6263	0.8319
constebeta	0.2659	0.0865	0.4361
$const_L$	-1.3316	-3.0709	0.442
ctrend 0.4224	0.3942	0.4508	
ρ_{gZ} 0.5644	0.4437	0.7014	
α	0.2043	0.1498	0.2613

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

Table 6: **Posterior distributions in subsamples (Metropolis Hasting 25000 simulations)**

	1988Q3 1996Q3		
	mean	HPD inf	HPD sup
$\sigma(e_Z)$	0.2882	0.219	0.3528
$\sigma(e_{b^2})$	0.1246	0.067	0.1865
$\sigma(e_g)$	0.3155	0.25	0.3739
$\sigma(e_\mu)$	0.4558	0.3271	0.5832
$\sigma(e_{ms})$	0.0925	0.0708	0.1124
$\sigma(e_p)$	0.083	0.0516	0.1129
$\sigma(e_w)$	0.2204	0.1461	0.2872
ρ_Z	0.7458	0.5487	0.9732
ρ_{b^2}	0.5977	0.2279	0.8847
ρ_g	0.9267	0.8719	0.9817
ρ_μ	0.3911	0.1262	0.6495
ρ_{ms}	0.4781	0.2682	0.6737
ρ_p	0.5854	0.3498	0.8421
ρ_w	0.7952	0.6795	0.9101
θ_p	0.4058	0.1308	0.6579
θ_w	0.301	0.0822	0.5021
$S''(\gamma)$	4.7921	2.7207	6.6622
σ_c	1.072	0.7006	1.4933
h	0.656	0.5142	0.79
ζ_w	0.5462	0.422	0.6718
ν_L	1.8372	0.7643	2.9239
ζ_p	0.7658	0.6753	0.8646

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Table 6 – continued from previous page

	1988Q3 1996Q3		
	mean	HPD inf	HPD sup
ι_w	0.5012	0.2545	0.7297
ι_p	0.4688	0.2266	0.7011
czcap	0.4872	0.2836	0.6949
Φ	1.3721	1.2155	1.5335
ψ_1	1.671	1.3066	2.0548
ρ_R	0.8119	0.7427	0.8883
ψ_2	0.1129	0.0242	0.1984
ψ_3	0.1085	0.0511	0.1635
$const_\pi$	0.5856	0.4756	0.6945
constebeta	0.2589	0.1059	0.4173
$const_L$	0.9035	-0.4823	2.2403
ctrend	0.4496	0.3738	0.517
ρ_{gZ}	0.3218	0.0555	0.5523
α	0.2974	0.2228	0.3678

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

Table 7: **Posterior distributions in subsamples (Metropolis Hasting 25000 simulations)**

	1996Q4 2004Q4		
	mean	HPD inf	HPD sup
$\sigma(e_Z)$	0.4079	0.3126	0.4967
$\sigma(e_{b^2})$	0.1256	0.0638	0.1938
$\sigma(e_g)$	0.41	0.3038	0.5113
$\sigma(e_\mu)$	0.3707	0.234	0.5004
$\sigma(e_{ms})$	0.1022	0.0781	0.1256
$\sigma(e_p)$	0.0804	0.0485	0.1073
$\sigma(e_w)$	0.5068	0.3536	0.6731
ρ_Z	0.6237	0.3747	0.8924
ρ_{b^2}	0.5997	0.2702	0.8714
ρ_g	0.8407	0.742	0.9358
ρ_μ	0.6198	0.4028	0.8204
ρ_{ms}	0.3761	0.136	0.6149
ρ_p	0.7787	0.5951	0.9646
ρ_w	0.4959	0.2056	0.7961
θ_p	0.4963	0.1895	0.7981
θ_w	0.5532	0.2601	0.8866
$S''(\gamma)$	5.5894	3.4611	7.4793
σ_c	1.3417	0.907	1.7607
h	0.6367	0.5228	0.7628
ζ_w	0.6473	0.5315	0.7749
ν_L	1.3849	0.3243	2.2253
ζ_p	0.688	0.5803	0.798

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Table 7 – continued from previous page

	1996Q4 2004Q4		
	mean	HPD inf	HPD sup
ι_w	0.4919	0.2539	0.7359
ι_p	0.4385	0.2116	0.6862
czcap	0.6921	0.5116	0.879
Φ	1.3714	1.2141	1.5314
ψ_1	1.5669	1.1107	1.9673
ρ_R	0.8162	0.7387	0.8881
ψ_2	0.1493	0.0795	0.2259
ψ_3	0.1259	0.0677	0.185
$const_\pi$	0.6719	0.5296	0.8102
constebeta	0.2519	0.0841	0.4186
$const_L$	1.2548	-0.2489	2.6742
ctrend	0.6078	0.5391	0.678
ρ_{gZ}	0.7038	0.4368	0.9379
α	0.2529	0.1685	0.3335

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

Table 8: **Posterior distributions in subsamples (Metropolis Hasting 25000 simulations)**

	2005Q1 2014Q2		
	mean	HPD inf	HPD sup
$\sigma(e_Z)$	0.5226	0.4086	0.6298
$\sigma(e_{b^2})$	0.0869	0.055	0.12
$\sigma(e_g)$	0.4499	0.3565	0.5381
$\sigma(e_\mu)$	0.344	0.1989	0.4766
$\sigma(e_{ms})$	0.0851	0.0649	0.1051
$\sigma(e_p)$	0.1483	0.0926	0.1979
$\sigma(e_w)$	0.7066	0.5553	0.8587
ρ_Z	0.9266	0.8847	0.9734
ρ_{b^2}	0.8576	0.7896	0.9289
ρ_g	0.8718	0.8052	0.9391
ρ_μ	0.7338	0.5287	0.9479
ρ_{ms}	0.6126	0.4404	0.786
ρ_p	0.5598	0.248	0.8725
ρ_w	0.3815	0.0676	0.6421
θ_p	0.5462	0.2787	0.8617
θ_w	0.5465	0.3404	0.7756
$S''(\gamma)$	4.9614	2.8923	6.8457
σ_c	1.0194	0.7983	1.2607
h	0.7195	0.6236	0.8228
ζ_w	0.7329	0.6073	0.8664
ν_L	1.14	0.2503	2.1553
ζ_p	0.7789	0.6841	0.8626

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Table 8 – continued from previous page

	2005Q1 2014Q2		
	mean	HPD inf	HPD sup
ι_w	0.4249	0.1939	0.6651
ι_p	0.321	0.1365	0.4771
czcap	0.8369	0.7358	0.94
Φ	1.347	1.1744	1.5085
ψ_1	1.4027	1	1.7051
ρ_R	0.8623	0.8036	0.91
ψ_2	0.1086	0.0493	0.1657
ψ_3	0.1135	0.0693	0.1569
$const_\pi$	0.641	0.5075	0.7785
constebeta	0.2469	0.0897	0.386
$const_L$	-0.35	-2.2096	1.6797
ctrend	0.3863	0.2745	0.4882
ρ_{gZ}	0.5888	0.3347	0.8105
α	0.2469	0.1732	0.3271

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

Table 9: **Posterior distributions with Dixit-Stiglitz aggregator (Metropolis Hasting 25000 simulations)**

DixitStiglitz aggregator 1948Q1 2014Q2	mean	HPD inf	HPD sup
$\sigma(e_Z)$	0.5107	0.467	0.5557
$\sigma(e_{b^2})$	0.1196	0.0947	0.1455
$\sigma(e_g)$	0.6458	0.6007	0.6904
$\sigma(e_\mu)$	0.4915	0.4281	0.5615
$\sigma(e_{ms})$	0.2254	0.2034	0.2467
$\sigma(e_p)$	0.21	0.1826	0.2371
$\sigma(e_w)$	0.3495	0.3141	0.381
ρ_Z	0.985	0.9772	0.9922
ρ_{b^2}	0.8084	0.7436	0.878
ρ_g	0.9779	0.968	0.9884
ρ_μ	0.8168	0.7266	0.9193
ρ_{ms}	0.1602	0.0753	0.2439
ρ_p	0.9802	0.9651	0.9955
ρ_w	0.966	0.9439	0.9885
θ_p	0.8474	0.7787	0.917
θ_w	0.925	0.8811	0.9671
$S''(\gamma)$	3.4535	2.001	4.668
σ_c	2.0222	1.5757	2.4105
h	0.3417	0.2519	0.4256
ζ_w	0.8866	0.8488	0.9211
ν_L	1.3977	0.6634	2.1122

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Table 9 – continued from previous page

DixitStiglitz aggregator 1948Q1 2014Q2			
	mean	HPD inf	HPD sup
ζ_p	0.8143	0.7659	0.8614
ι_w	0.4954	0.3109	0.6757
ι_p	0.3426	0.1936	0.4948
czcap	0.7796	0.6425	0.9161
Φ	1.591	1.4855	1.7084
ψ_1	2.0434	1.7827	2.2888
ρ_R	0.8698	0.8422	0.898
ψ_2	0.0732	0.0392	0.1112
ψ_3	0.1852	0.1533	0.2216
$const_\pi$	0.7639	0.6401	0.8935
constebeta	0.2482	0.0836	0.4018
$const_L$	-0.8031	-2.9312	1.4902
ctrend	0.458	0.4288	0.487
ρ_{gZ}	0.627	0.4899	0.7577
α	0.1774	0.1166	0.2373

Note: HPD inf and HPD low are respectively the lower bound and the upper bound of a 90% HPD interval.

We report in Figure 8 the time series of the estimated shocks. The price and markup shocks do not appear particularly large, whereas it seems that during the financial crisis exceptionally large realizations of the shocks to the risk premium, TFP and monetary policy occurred.

F Figures

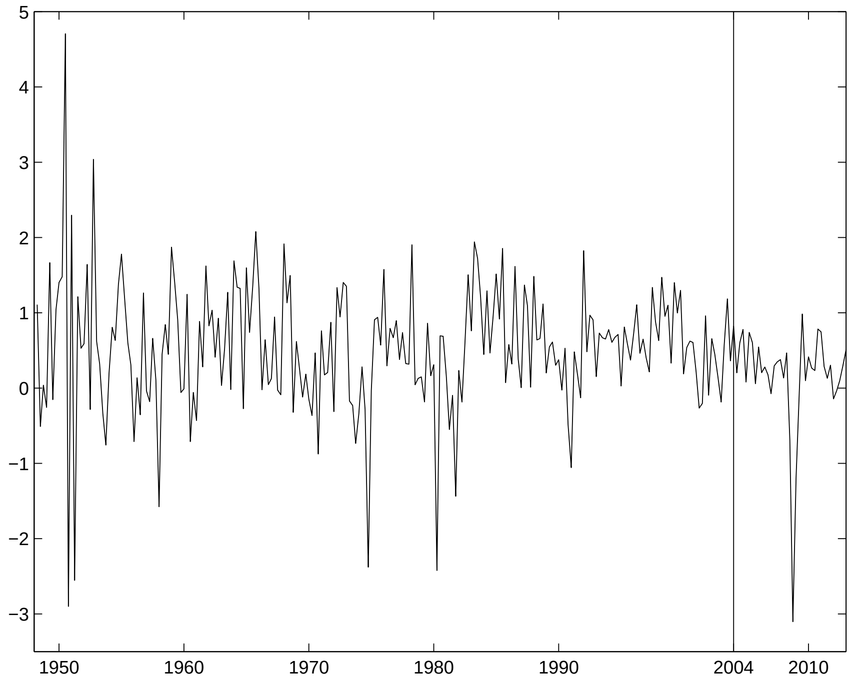

Figure 1: Consumption (percentage change). The line highlights the data points in addition to Smets, Wouters (2006)

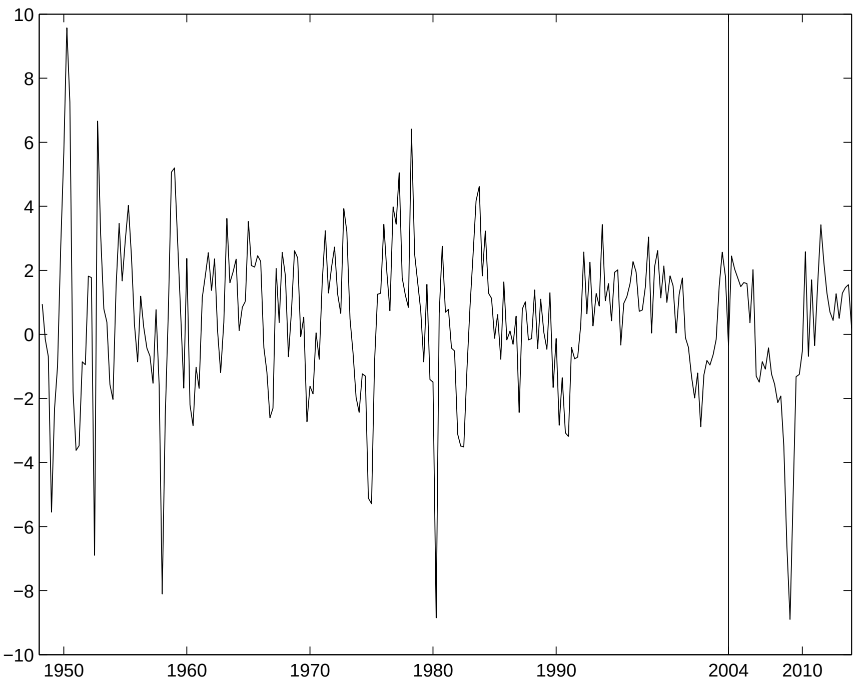

Figure 2: Investment (percentage change). The line highlights the data points in addition to Smets, Wouters (2006)

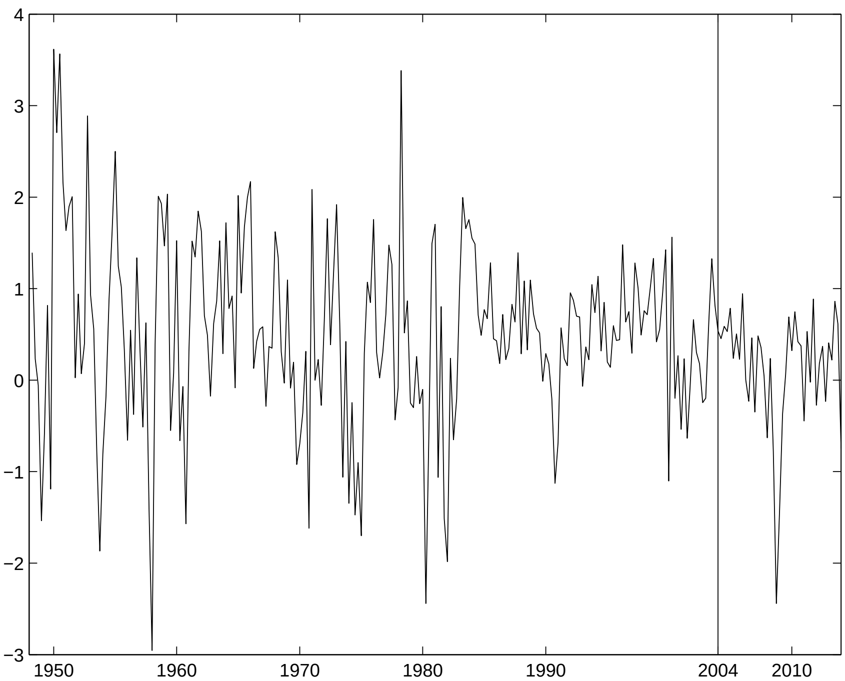

Figure 3: Output (percentage change). The line highlights the data points in addition to Smets, Wouters (2006)

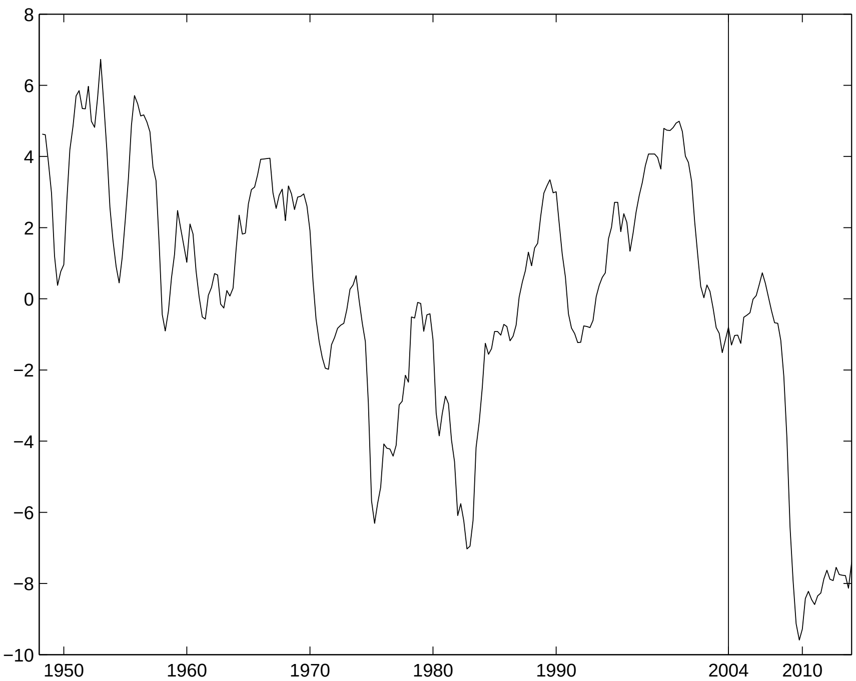

Figure 4: Labor (index). The line highlights the data points in addition to Smets, Wouters (2006)

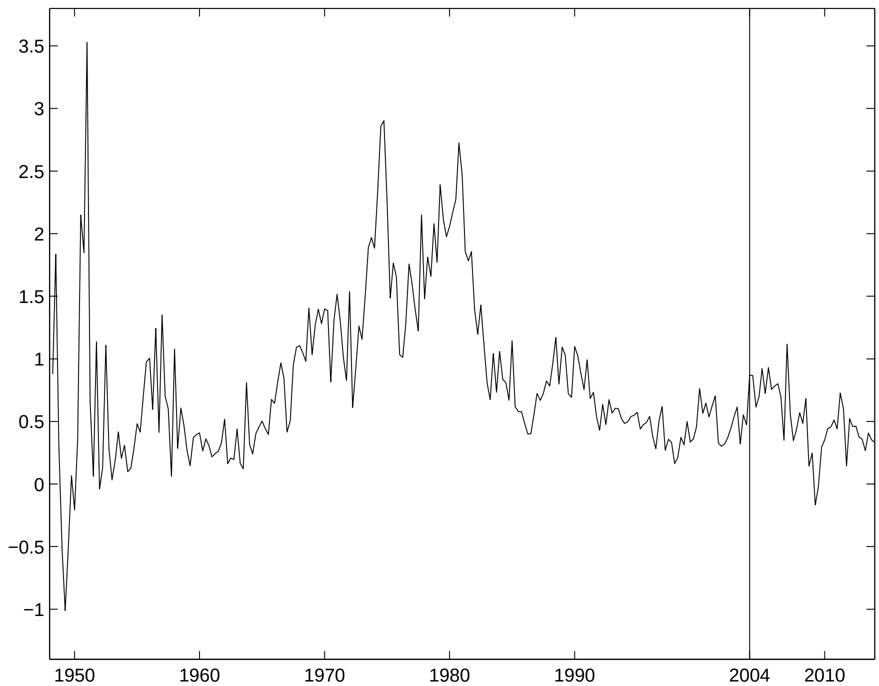

Figure 5: Inflation. The line highlights the data points in addition to Smets, Wouters (2006)

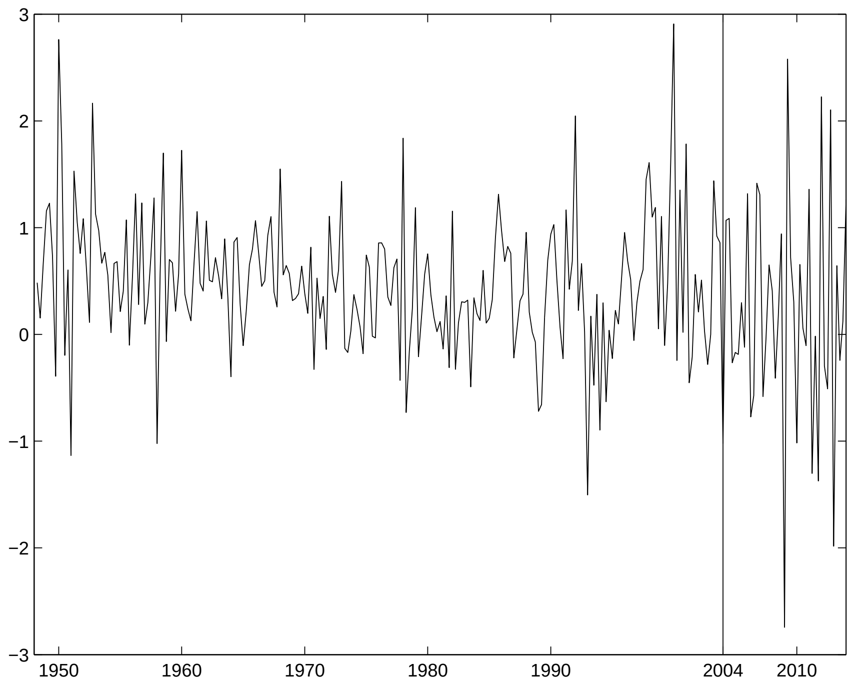

Figure 6: Wage rate (percentage change). The line highlights the data points in addition to Smets, Wouters (2006)

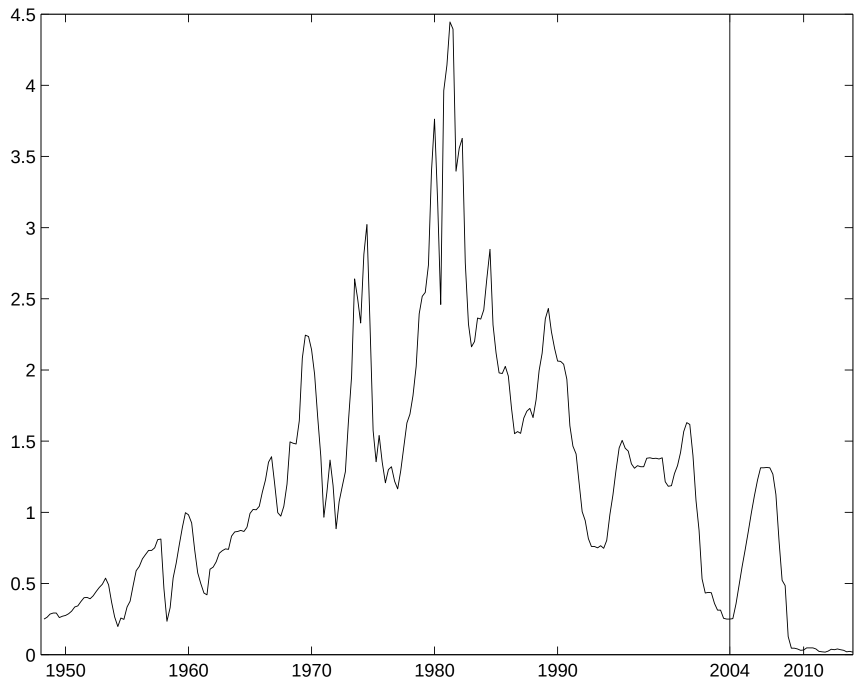

Figure 7: Interest rate. The line highlights the data points in addition to Smets, Wouters (2006)

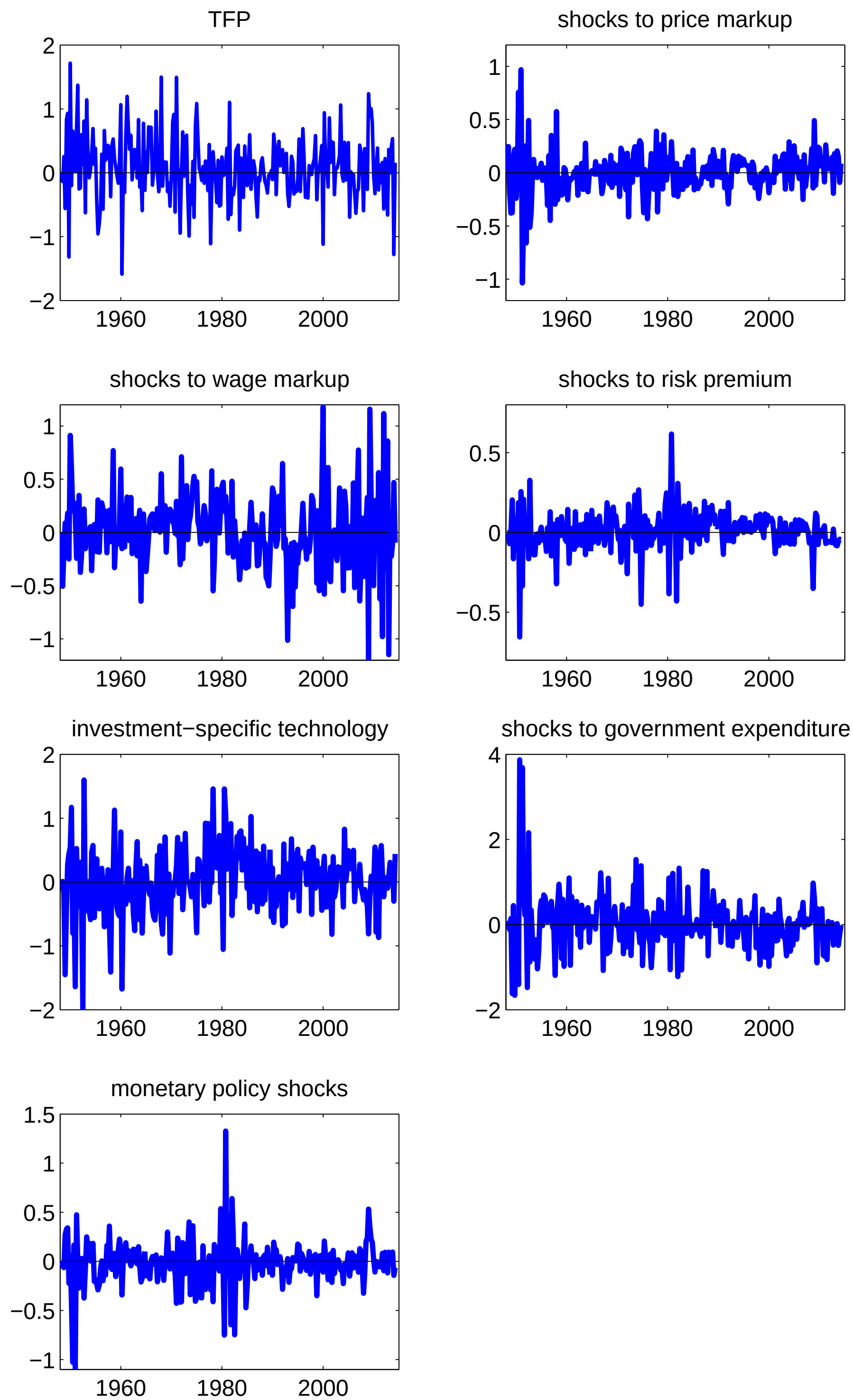

Figure 8: Time series of the estimated shocks

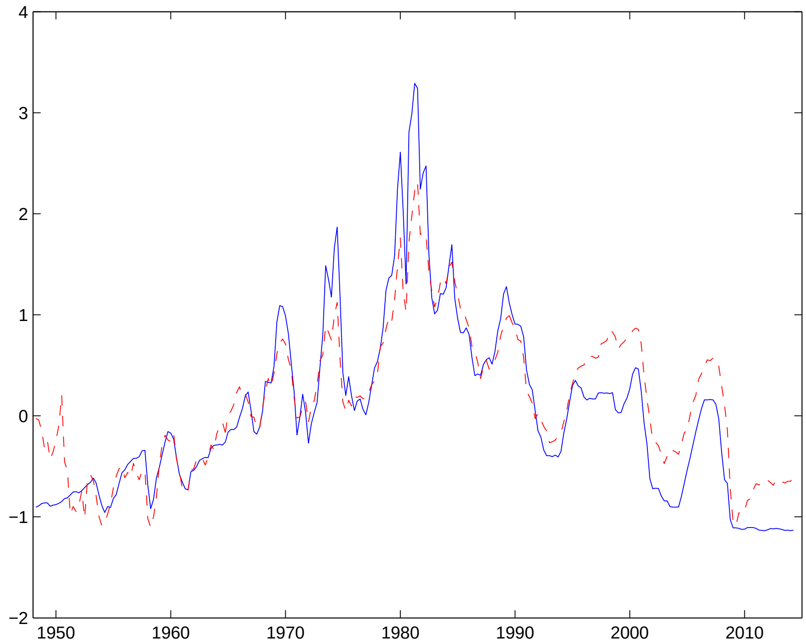

Figure 9: Historical shock decomposition of the interest rate (relative to long-run constant). The solid line is actual interest rate. The dashed line is interest rate generated by a combination of the estimated shocks to the risk premium and to investment adjustment cost.

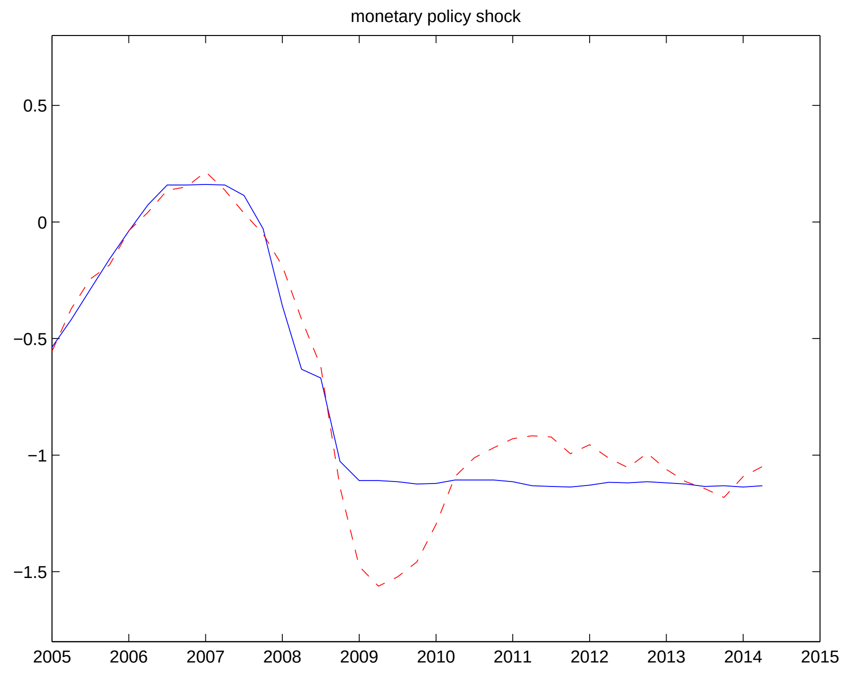

Figure 10: Historical shock decomposition of the interest rate (relative to long-run constant). The solid line is actual interest rate. The dashed line is the predicted interest rate if there were no monetary policy shocks.

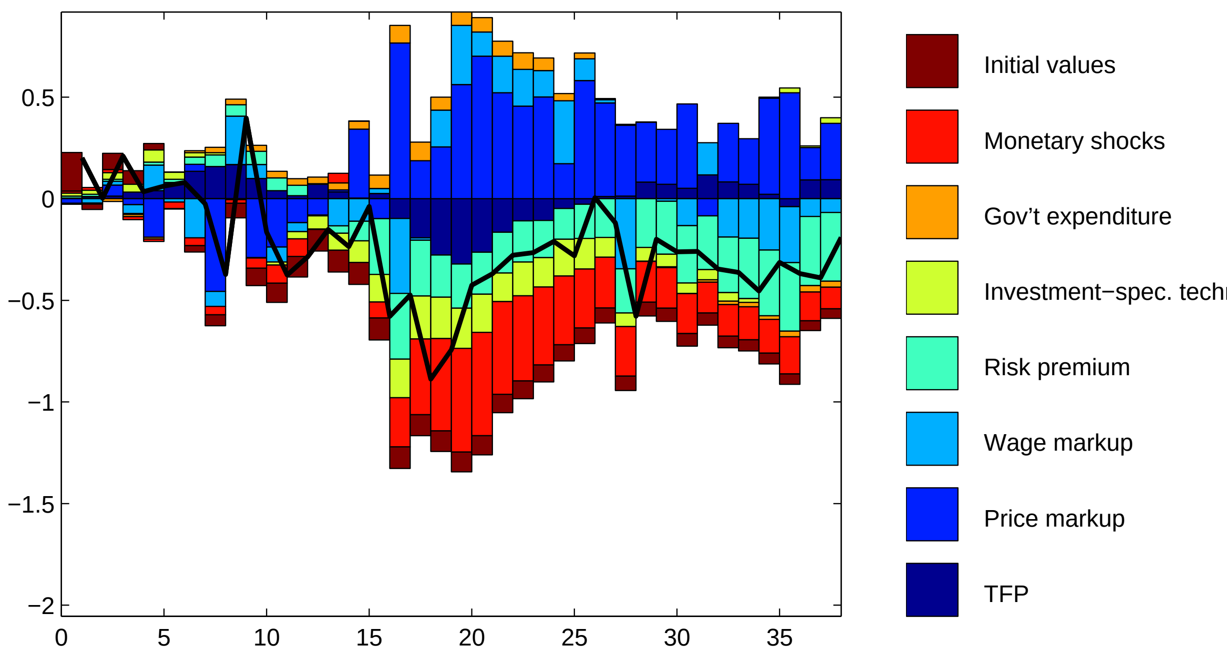

Figure 11: Historical shock decomposition of inflation

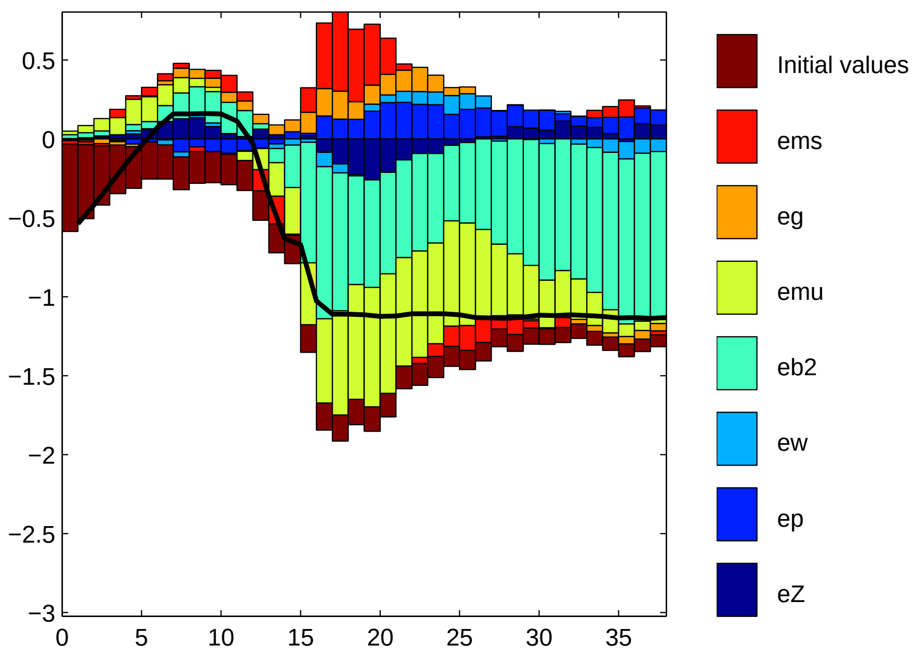

Figure 12: Historical shock decomposition of the interest rate

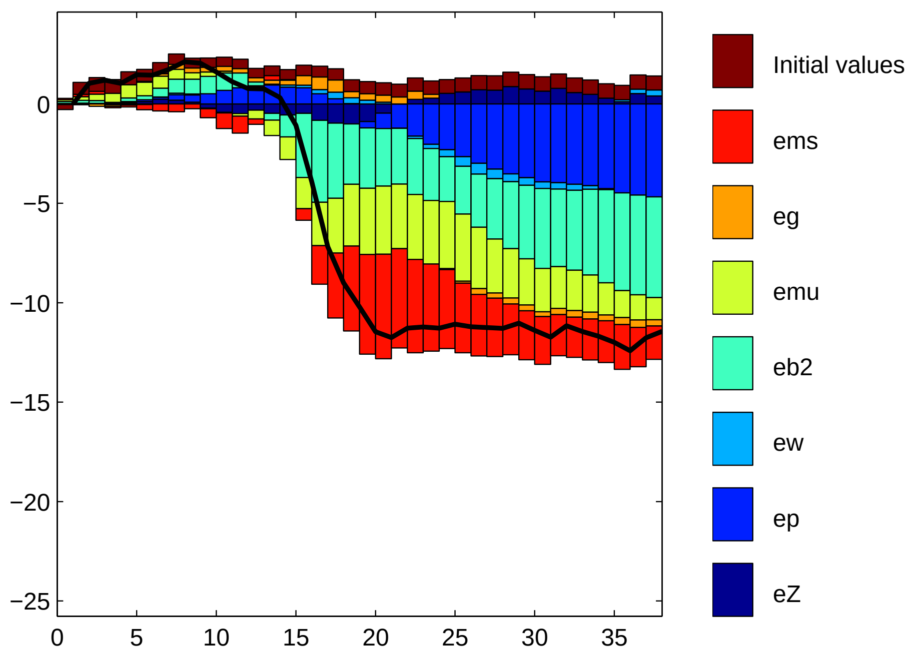

Figure 13: Historical shock decomposition of the output gap

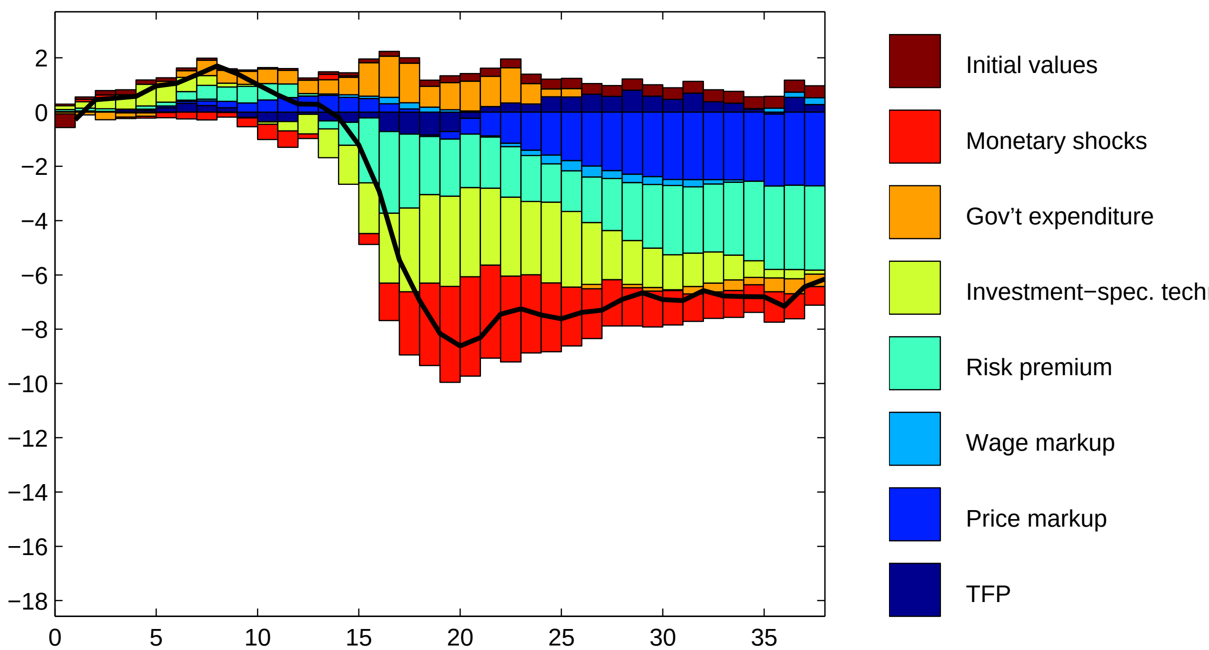

Figure 14: Historical shock decomposition of the labor

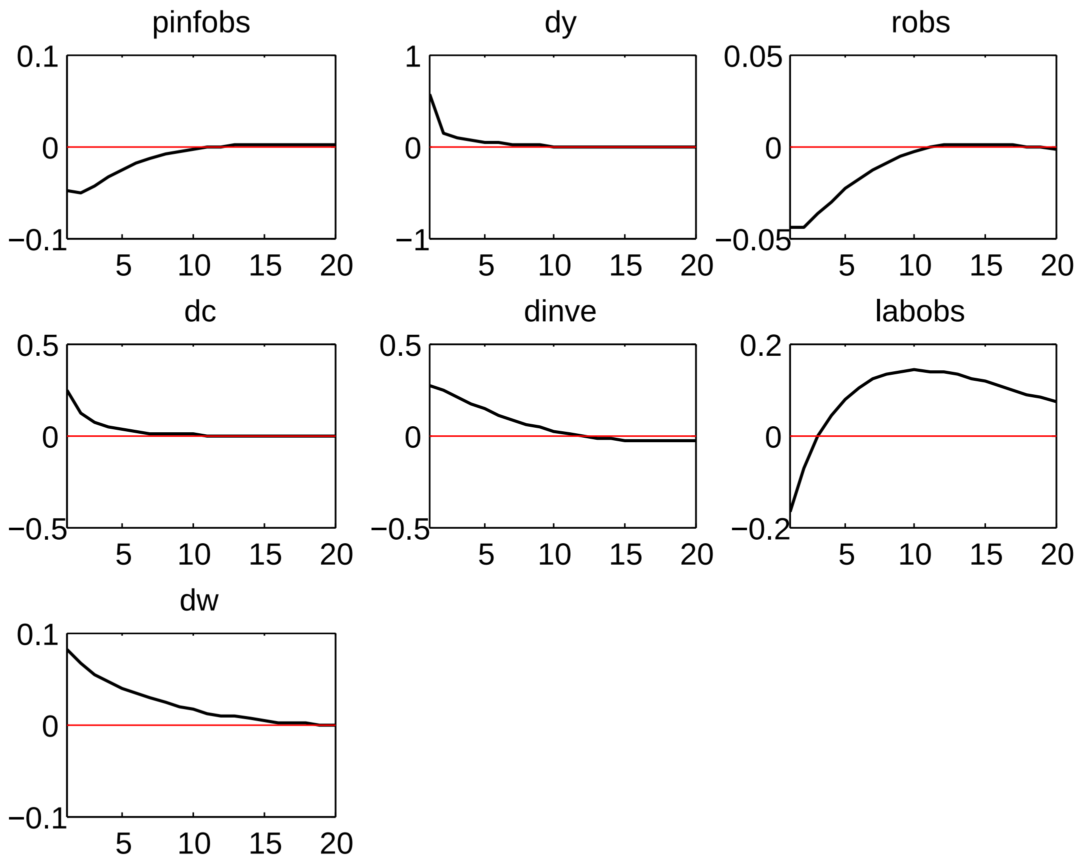

Figure 15: Impulse Response Functions to a shock to TFP

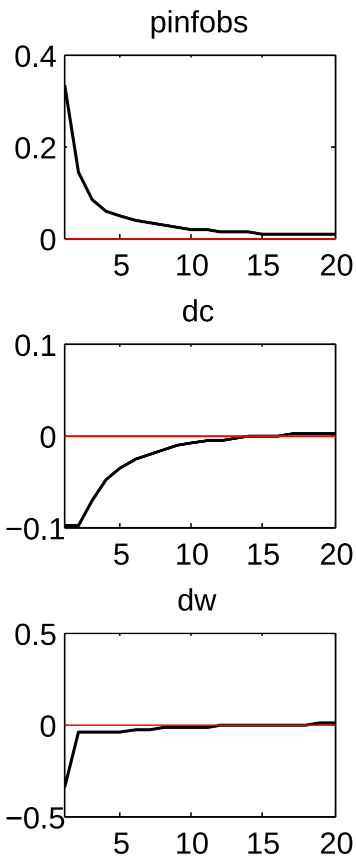

Figure 16: Impulse Response Functions to a shock to price markup

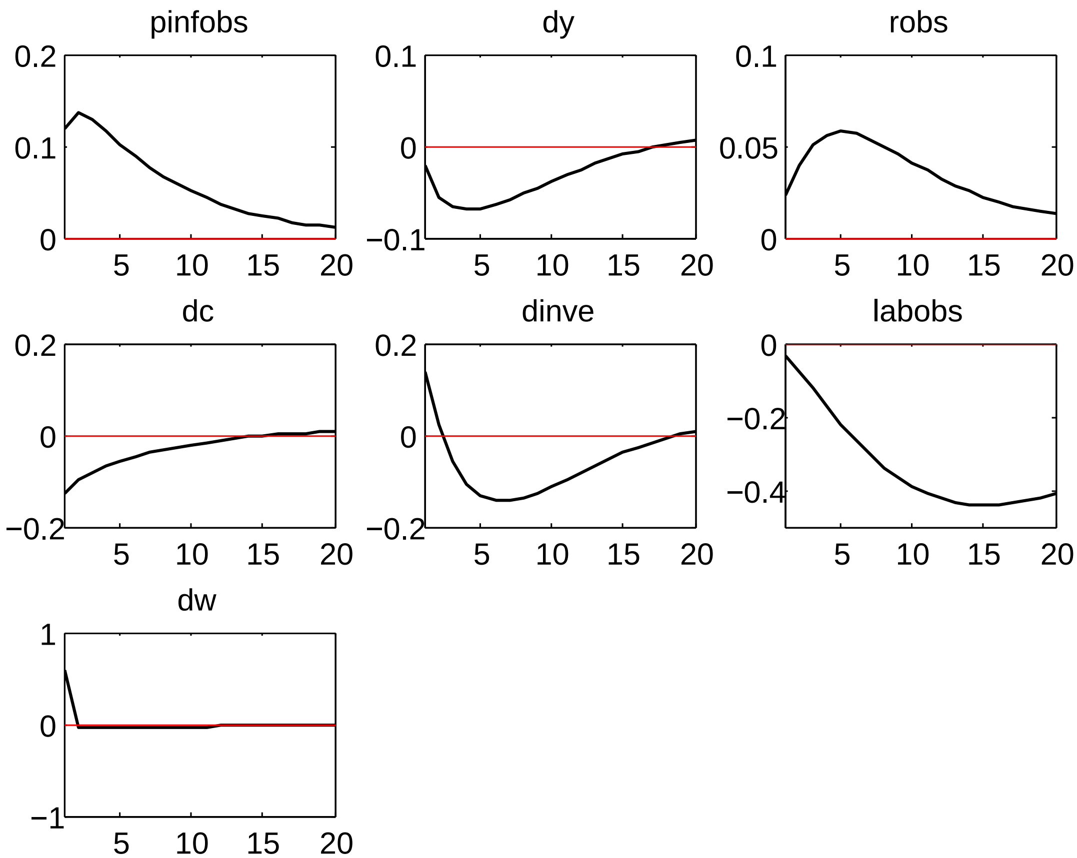

Figure 17: Impulse Response Functions to a shock to wage markup

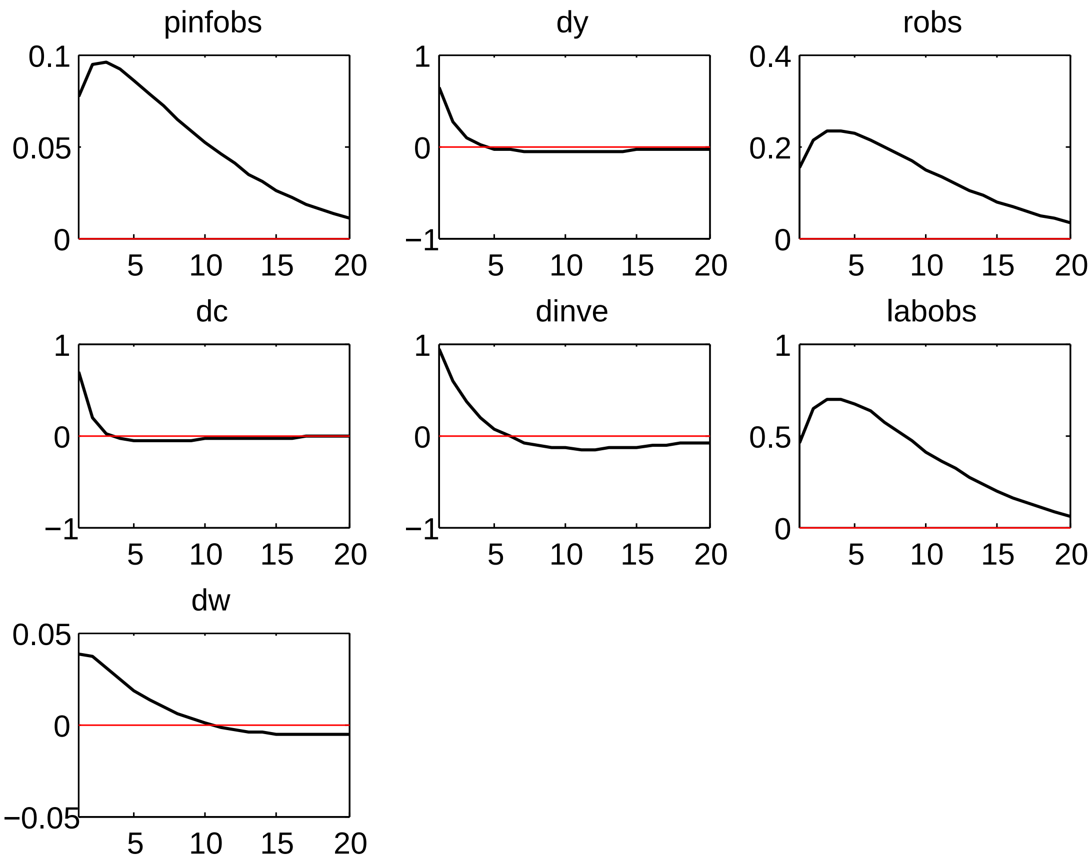

Figure 18: Impulse Response Functions to a shock to the risk premium

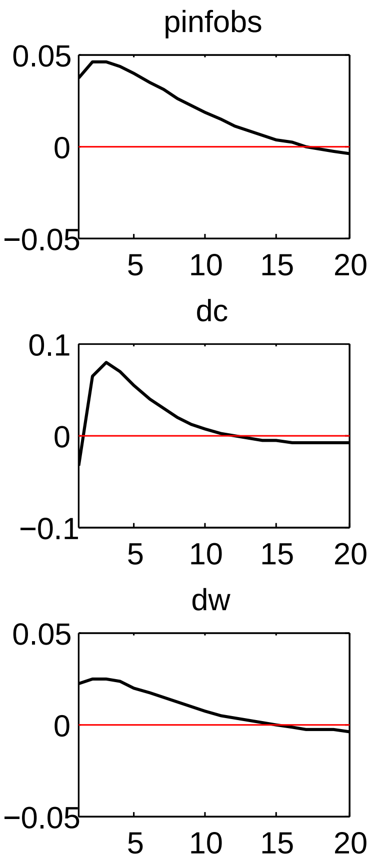

Figure 19: Impulse Response Functions to a shock to investment-specific technology

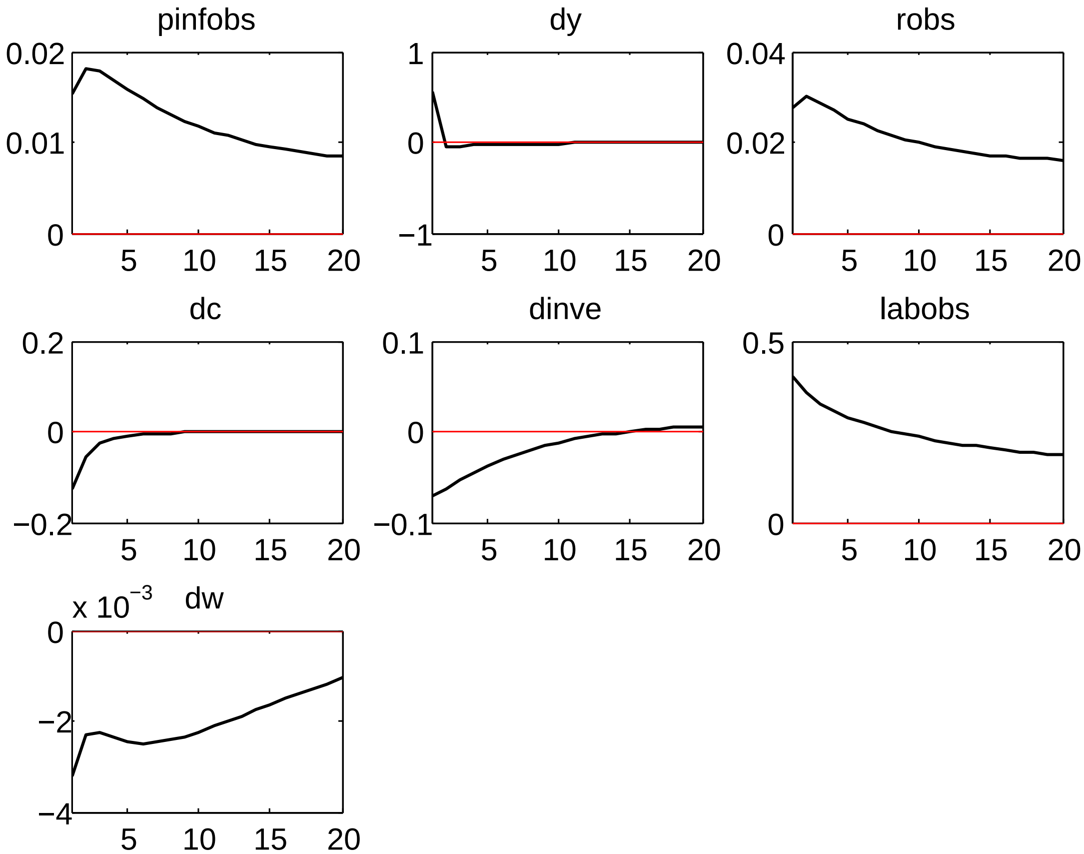

Figure 20: Impulse Response Functions to a shock to government expenditure

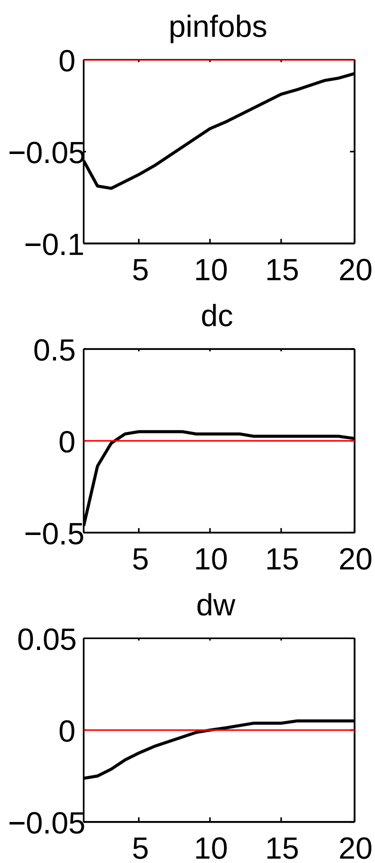

Figure 21: Impulse Response Functions to a monetary policy shock