

Unemployment in an Estimated New Keynesian Model

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19 February 2010

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Introduction and motivation

- **An increasing number of central banks have developed and estimated medium-scale New Keynesian DSGE models for forecasting and policy analysis.**
- **See, for example, Smets et al (2010) for a brief description of the two aggregate euro area models used at the ECB (NAWM and CMR).**
- **Typically, the labour market is modelled using the Erceg, Henderson and Levin (2000) model of monopolistic competition and Calvo wage setting.**
 - **Plus: Fits the time series of hours worked and real wages quite well (e.g. Smets and Wouters, 2007)**
 - **Minus: no reference to unemployment**

Introduction and motivation

- **Gali (2009):**
 - proposes a reformulation of the EHL model, which implies a simple dynamic relation between wage inflation and unemployment;
 - Shows that this structural wage equation accounts reasonably well for the comovement of wage inflation and the unemployment rate in the US economy.
 - Variations in unemployment are associated with changes in wage mark-ups, either exogenous or resulting from nominal wage rigidities.
- This (forthcoming) paper embeds this reformulation in the Smets-Wouters (2007) model by adding the unemployment rate as an observable variable.

Introduction and motivation

- **This allows us to overcome the identification problem of wage mark-up and labour supply shocks mentioned in SW (2003, 2007) and emphasized by Chari et al (2009) as an illustration of the immaturity of the New Keynesian framework:**
 - **In SW (2007) wage mark-up shocks account for almost 50 percent of variations in real GDP beyond 10 years.**
 - **With only wages and employment/hours as observables those shocks can not be distinguished from labour supply/preference shocks.**
 - **The source of the shock is, however, important for welfare analysis.**
 - **Using unemployment (or labour participation) helps overcoming the identification problem**

Introduction and motivation

- **It also allows us to:**
 - **Better identify the wage Phillips curve;**
 - **Analyze the sources of unemployment variations;**
 - **Better identify the output gap in the model.**

Introduction and motivation

- **This paper is part of a growing body of work that improves the modelling of the labour market in DSGE models:**
 - **Recent examples of more complicated estimated models are Christoffel et al (2007), Gertler, Sala and Trigari (2008) and Christiano, Trabandt and Walentin (2009)**
- **We only look at the extensive margin:**
 - **See de Walque et al (2009) for a model that has both margins.**

Outline

- **Modifications to the Smets-Wouters (2007) model for the US economy**
- **Estimation results**
- **Conclusions**

The modified Smets-Wouters model

- **Benchmark model without unemployment differs slightly from Smets-Wouters (2007):**
 - **Somewhat different data and sample: Employment (rather than hours); Wage per worker**
 - **Jaimovich-Rebelo preferences;**
 - **Priors on standard deviation of shocks are uniform distributions instead of inverse-gamma;**
 - **Dixit-Stiglitz rather than Kimball aggregator.**

The modified Smets-Wouters model

- **Large representative household with a continuum of members:**

$$E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, \{N_t(i)\}, X_t)$$

where

$$\begin{aligned} U(C_t, \{N_t(i)\}, X_t) &\equiv \frac{1}{1-\sigma} \left((C_t - h\bar{C}_{t-1}) - \chi_t Z_t \int_0^1 \int_0^{N_t(i)} j^\varphi dj di \right)^{1-\sigma} \\ &= \frac{1}{1-\sigma} \left((C_t - h\bar{C}_{t-1}) - \chi_t Z_t \int_0^1 \frac{N_t(i)^{1+\varphi}}{1+\varphi} di \right)^{1-\sigma} \end{aligned}$$

and

$$Z_t = Z_{t-1}^{1-v} (\bar{C}_t - h\bar{C}_{t-1})^v$$

- **Extends Jaimovich-Rebelo (JR, 2009) preferences to allow for external habit formation**

The modified Smets-Wouters model

- **The marginal rate of substitution between consumption and employment is:**

$$-\frac{U_{n(i),t}}{U_{c,t}} = \chi_t Z_t N_t(i)^\varphi$$

or in natural logs:

$$mrs_t(i) = z_t + \varphi n_t(i) + \xi_t$$

The modified Smets-Wouters model

- As in EHL, workers supplying a labor service of a given type get to reset their nominal wage with probability $1 - \theta_w$ each period.
- The nominal wage in period $t+k$ for workers who last re-optimised their wage in period t :

$$W_{t+k|t} = W_{t+k-1|t} \Pi^x (\Pi_{t-1}^p)^{\gamma_w} (\Pi^p)^{1-\gamma_w}$$

- The first-order condition is:

$$\sum_{k=0}^{\infty} (\beta\theta_w)^k E_t \left\{ \frac{N_{t+k|t}}{C_{t+k}} \left(\frac{W_{t+k|t}^*}{P_{t+k}} - \mathcal{M}_{w,t}^n MRS_{t+k|t} \right) \right\} = 0$$

- The aggregate wage index can be written as:

$$W_t \equiv \left[\theta_w (W_{t-1} (\Pi_{t-1}^p)^{\gamma_w})^{1-\epsilon_{w,t}} + (1 - \theta_w) (W_t^*)^{1-\epsilon_{w,t}} \right]^{\frac{1}{1-\epsilon_{w,t}}}$$

The modified Smets-Wouters model

- **Log-linearisation leads to the following equation for nominal wage inflation:**

$$\pi_t^w = \gamma_w \pi_{t-1}^p + \beta E_t \{ \pi_{t+1}^w - \gamma_w \pi_t^p \} - \lambda_w (\mu_{w,t} - \mu_{w,t}^n)$$

where $\lambda_w \equiv \frac{(1-\beta\theta_w)(1-\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$, $\mu_{w,t}^n \equiv \log \mathcal{M}_{w,t}^n$

and $\mu_{w,t} \equiv (w_t - p_t) - mrs_t$

Introducing unemployment

- An individual will find it optimal to participate in the labour market in period t if:

$$\frac{W_t(i)}{P_t} \geq \chi_t Z_t j^\varphi$$

- The marginal supplier of type i labor is given

$$\frac{W_t(i)}{P_t} = \chi_t Z_t L_t(i)^\varphi$$

$$w_t - p_t = z_t + \varphi l_t + \xi_t$$

Introducing unemployment

- **Following Gali (2009), the unemployment rate is defined as:**

$$u_t \equiv l_t - n_t$$

- **Combining the definition of the average mark-up with the above and the labour supply**

$$\mu_{w,t} = \varphi u_t$$

- $$\pi_t^w = \gamma_w \pi_{t-1}^p + \beta E_t \{ \pi_{t+1}^w - \gamma_w \pi_t^p \} - \lambda_w \varphi u_t + \lambda_w \mu_{w,t}^n$$

Introducing unemployment

- **Wage equation:**

$$\pi_t^w = \gamma_w \pi_{t-1}^p + \beta E_t \{ \pi_{t+1}^w - \gamma_w \pi_t^p \} - \lambda_w \varphi u_t + \lambda_w \mu_{w,t}^n$$

In contrast to SW, the error term only captures shocks to the wage mark-up, no preference shocks

- **Labor supply equation:**

$$w_t - p_t = z_t + \varphi l_t + \xi_t$$

$$u_t \equiv l_t - n_t$$

- **The Phillips curve will only include wage mark-up shocks, whereas the labour supply equation will only include preference shocks**

Modified Smets-Wouters model

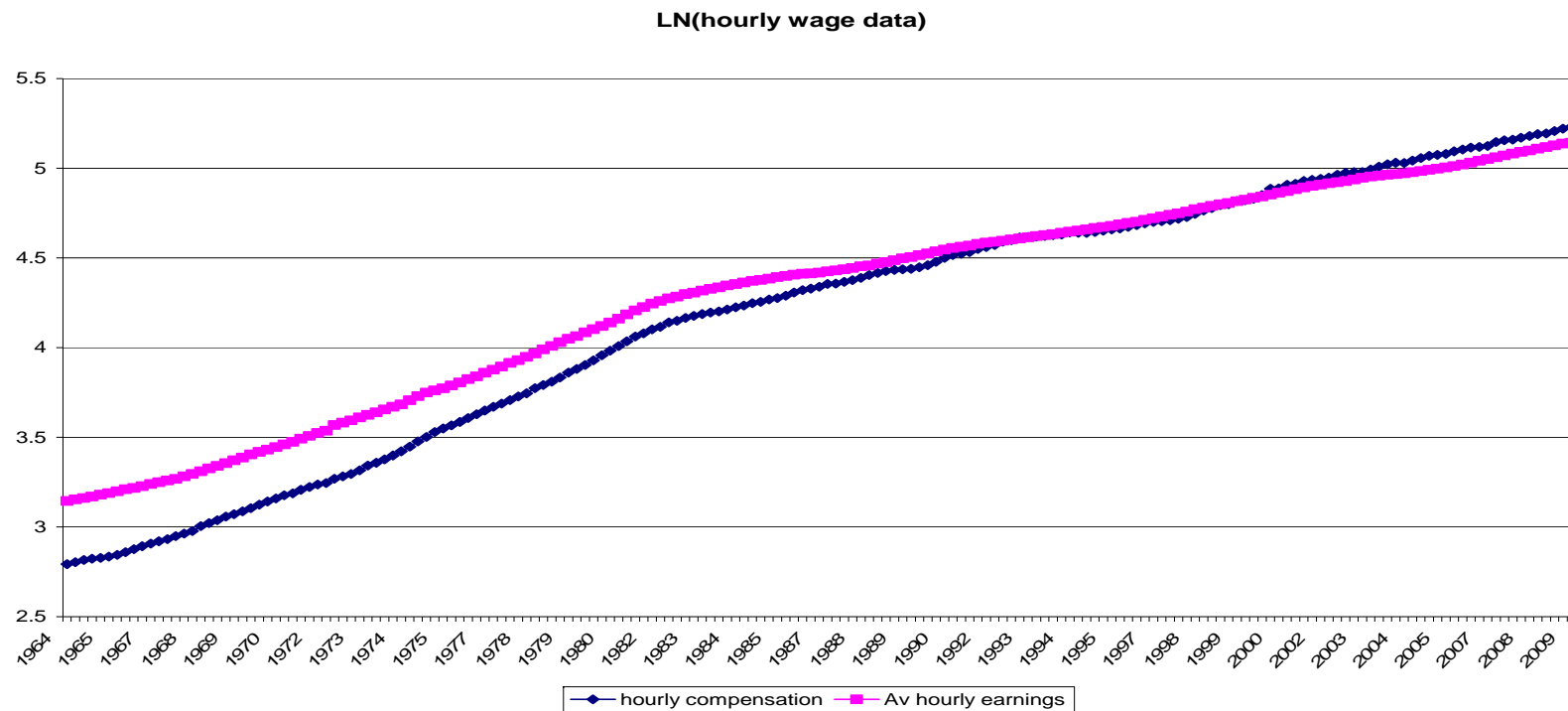
- **With the exception of the consumption Euler equation which reflects the change to JR preferences, all the other equations are as in SW (2007):**
 - **New Keynesian Phillips curve;**
 - **Capital accumulation equations;**
 - **Investment equation based on q-theory;**

Data

- **US data (1965:1-2008:4);**
- **Use employment (extensive margin) rather than hours worked;**
- **Add unemployment.**
- **Use two wage concepts:**
 - **Compensation per employee, from the BLS Productivity and Costs Statistics**
 - **Average Weekly Earnings from the Current Employment Statistics**
- **Compare model without unemployment with the model with unemployment as observable.**

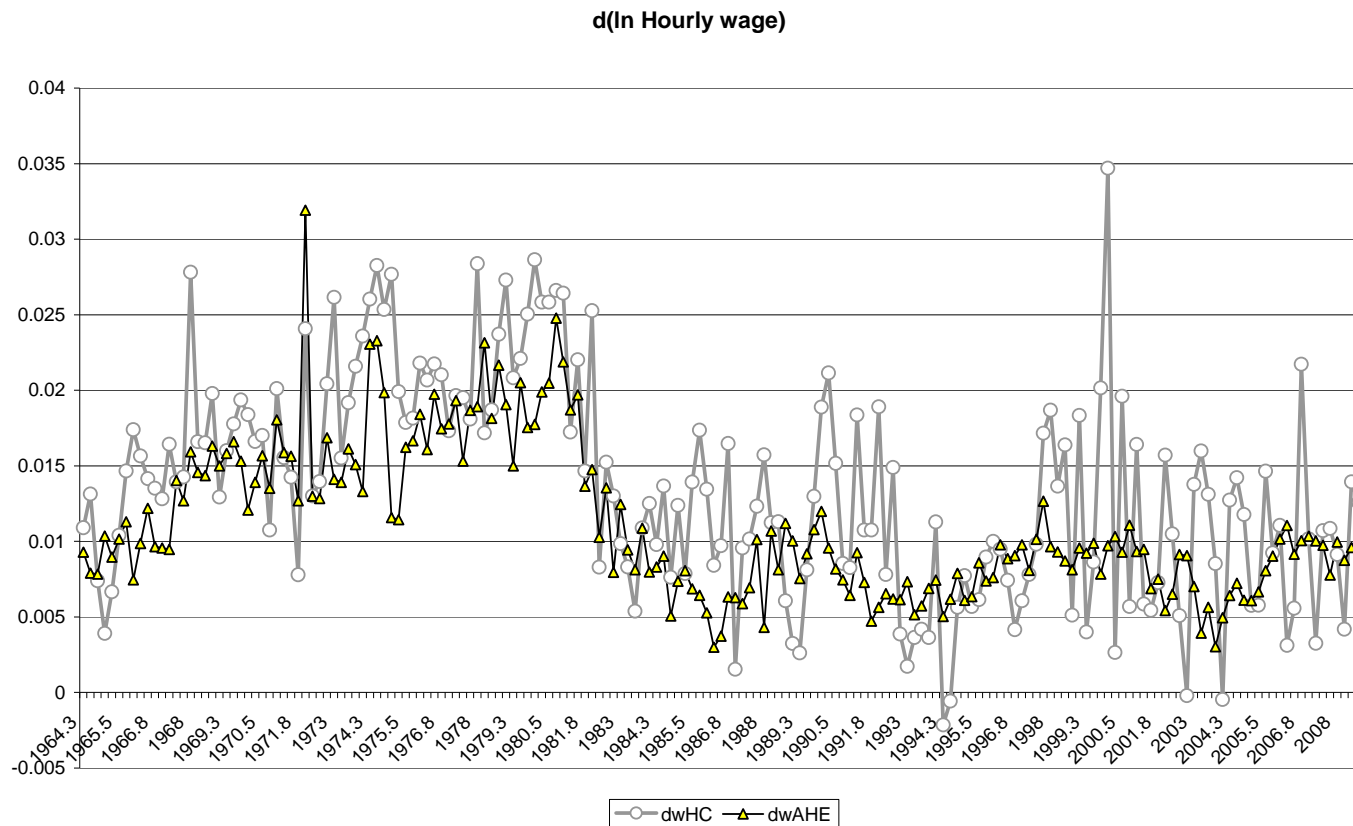
Data

- Quite large discrepancies between the two wage data series:



Data

- **Quite large discrepancies between the two wage data series:**



Data

- **In the baseline model, we use both series and add measurement error to account for the differences;**
- **Results also available for each series used separately:**
 - **The higher volatility of the compensation series does affect estimates of the labour supply elasticity and some of the other parameters.**

Estimation results

Most parameter estimates are very similar.

Focus on wage Phillips curve and labour supply equation:

Without UR:

$$w_t - p_t = z_t + 3.02l_t$$
$$z_t = 0.19z_t + 0.81(\bar{C}_t - 0.64\bar{C}_{t-1})$$
$$\pi_t^w = 0.17\pi_{t-1}^p + 0.99E_t \{ \pi_{t+1}^w - 0.17\pi_t^p \} - 0.048u_t + 0.016\mu_{w,t}^n$$

With UR:

$$w_t - p_t = z_t + 3.63l_t + \xi_t$$
$$z_t = 0.91z_t + 0.01(\bar{C}_t - 0.63\bar{C}_{t-1})$$
$$\pi_t^w = 0.15\pi_{t-1}^p + 0.99E_t \{ \pi_{t+1}^w - 0.15\pi_t^p \} - 0.065u_t + 0.018\mu_{w,t}^n$$

Estimation results

- **The standard deviation of the wage mark-up shock drops from 17% to 8.2%:**
- **This implies that the standard deviation of the natural unemployment rate is of the order of 2.25%.**
- **The standard deviation of the change in the labour supply shock is 0.96.**

Variance decomposition

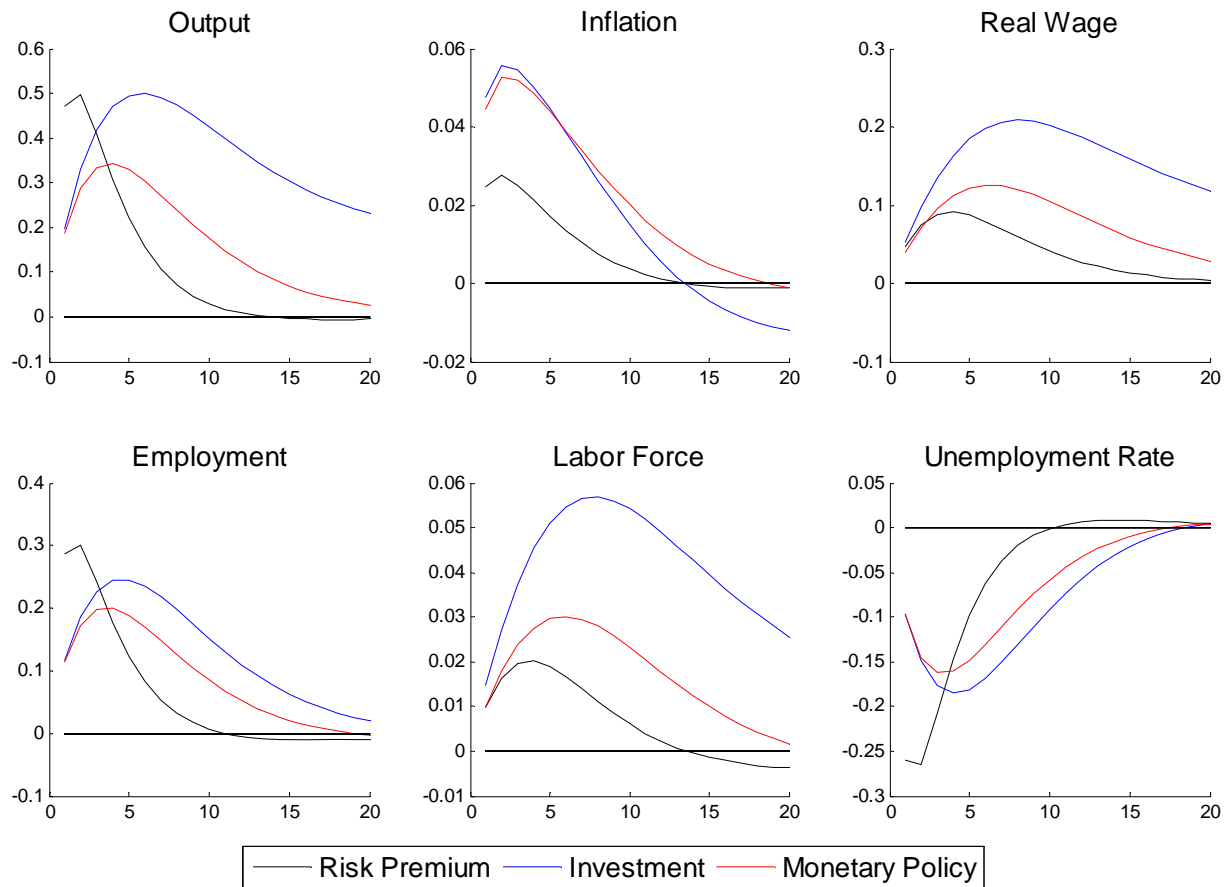
	y	π	w	n	u	l	R
10 Quarter horizon							
Prod	41/56	4/5	25/35	4/7	-/4	-/6	9/12
Cpref	7/6	3/2	2/2	12/14	-/19	-/0	17/16
Govt	6/2	1/1	0/0	13/5	-/7	-/0	4/6
Fin	18/15	9/9	9/13	22/21	-/20	-/3	37/38
Monp	7/5	9/8	4/5	11/12	-/14	-/1	16/12
Pmup	6/2	33/34	47/32	6/4	-/0	-/7	4/2
Wmup	14/4	41/41	13/13	33/12	-/32	-/3	13/11
Lpref	-/9	-/0	-/1	-/24	-/4	-/80	-/3
40 Quarter horizon							
Prod	42/64	4/5	53/70	2/7	-/2	-/8	8/11
Cpref	2/2	2/1	1/1	4/6	-/10	-/0	14/14
Govt	3/1	1/2	1/1	7/2	-/3	-/0	4/7
Fin	8/8	8/8	8/9	9/10	-/10	-/2	33/36
Monp	3/2	8/7	3/2	4/5	-/7	-/0	13/10
Pmup	3/1	27/28	28/12	3/2	-/0	-/2	4/2
Wmup	40/9	50/48	7/5	72/25	-/65	-/2	24/19
Lpref	-/15	-/0	-/0	-/44	-/2	-/86	-/2

Variance decomposition

- **The introduction of unemployment reduces substantially the role of wage mark-up shocks**
- **At business cycle frequencies, unemployment is largely driven by demand shocks and the wage mark-up shock**
- **Labour preference shocks have a significant role for employment and labour supply, but not for unemployment**

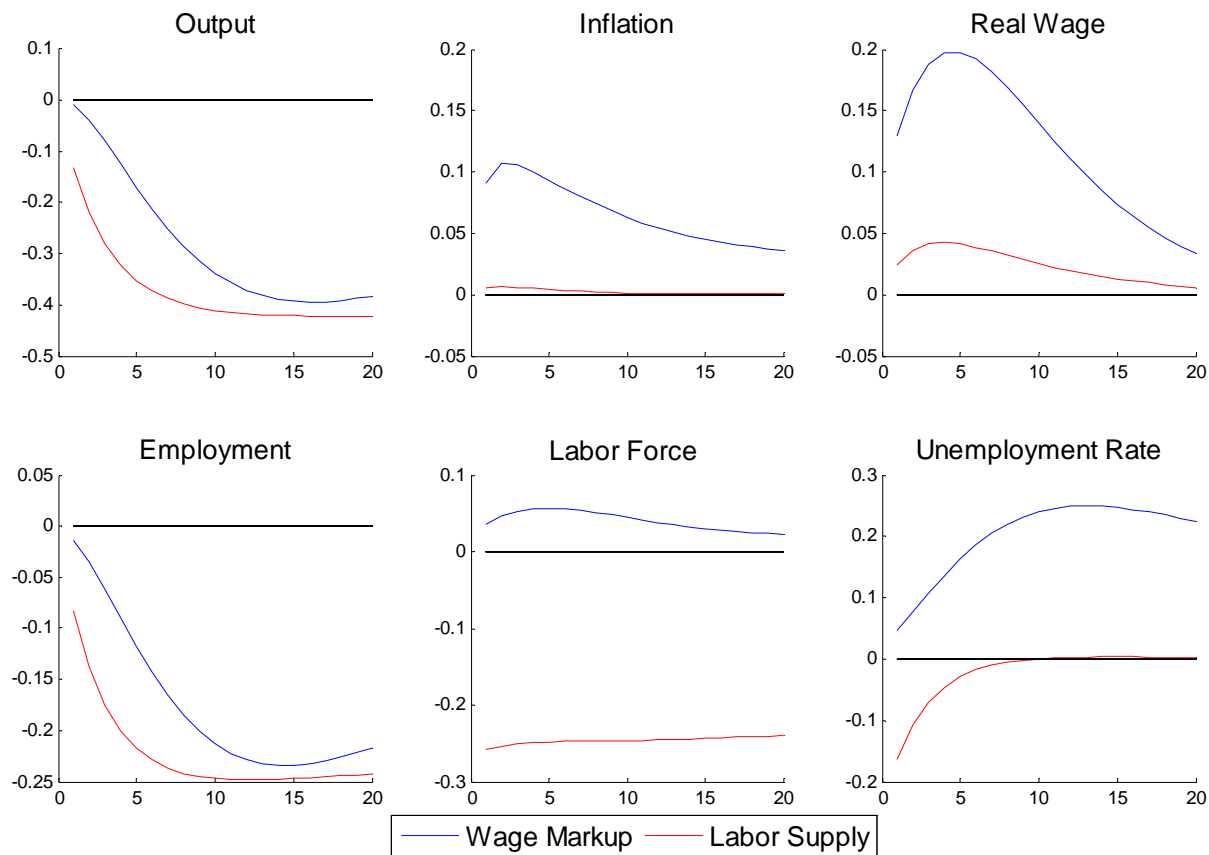
Impulse responses

- “Demand” shocks



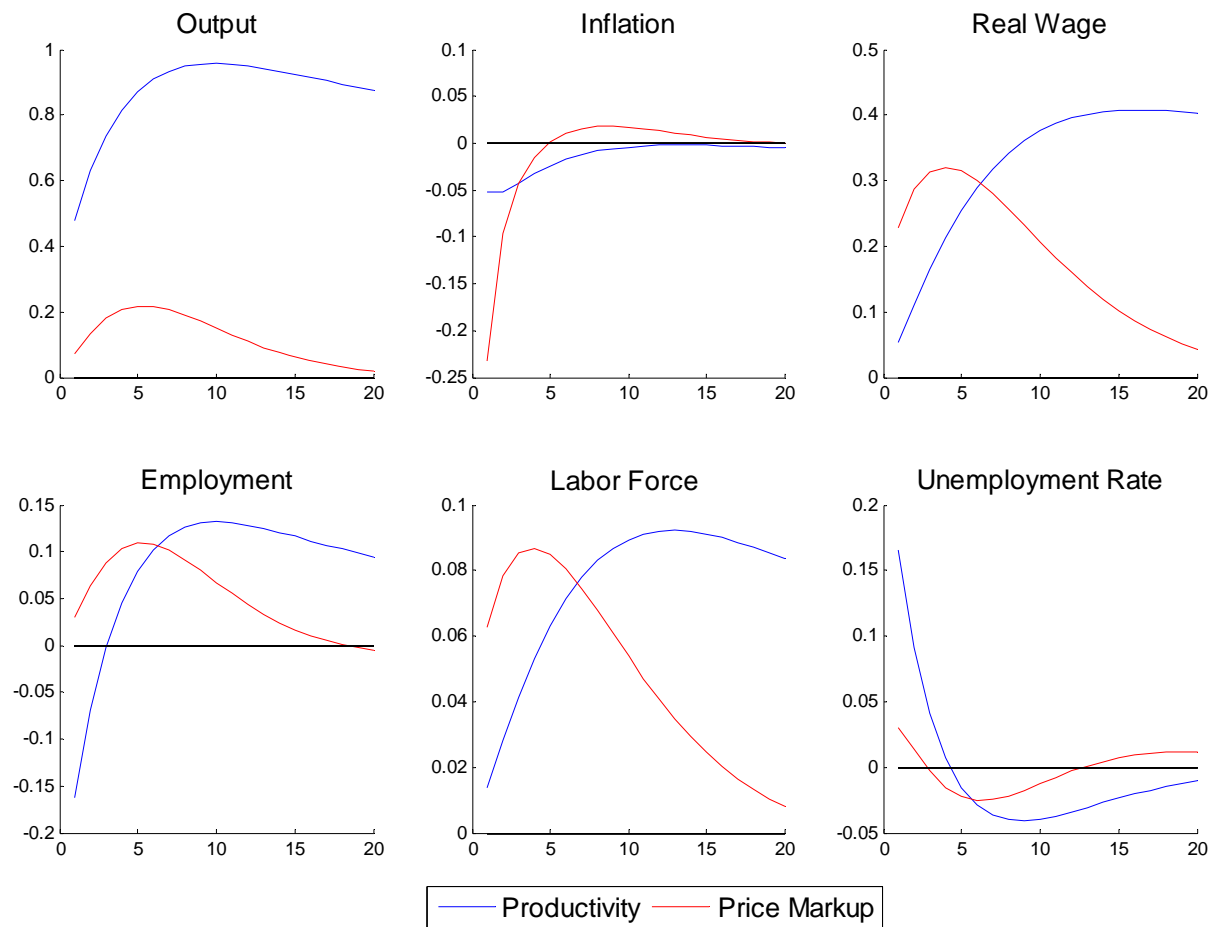
Impulse responses

- Labour supply and mark-up shocks

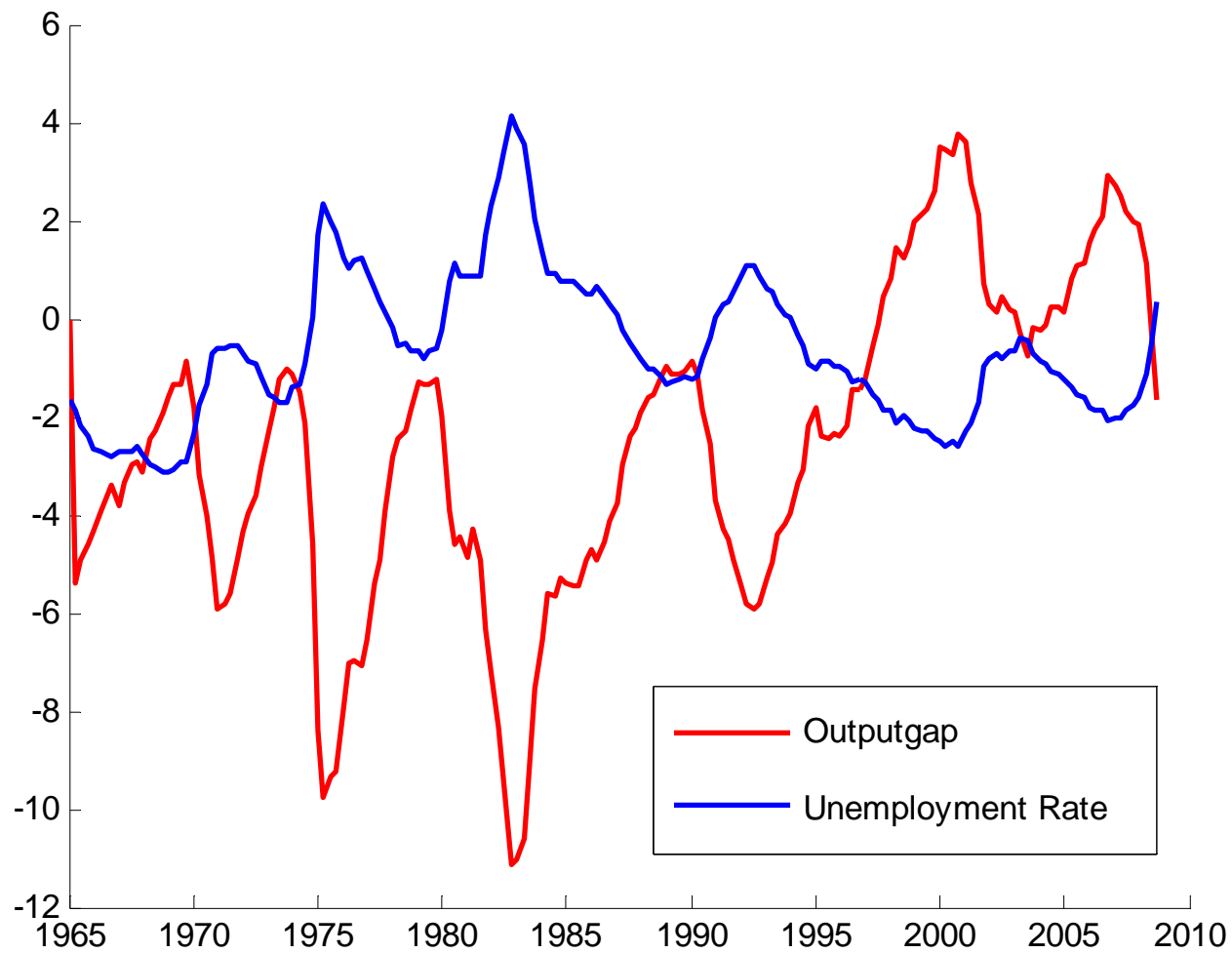


Impulse responses

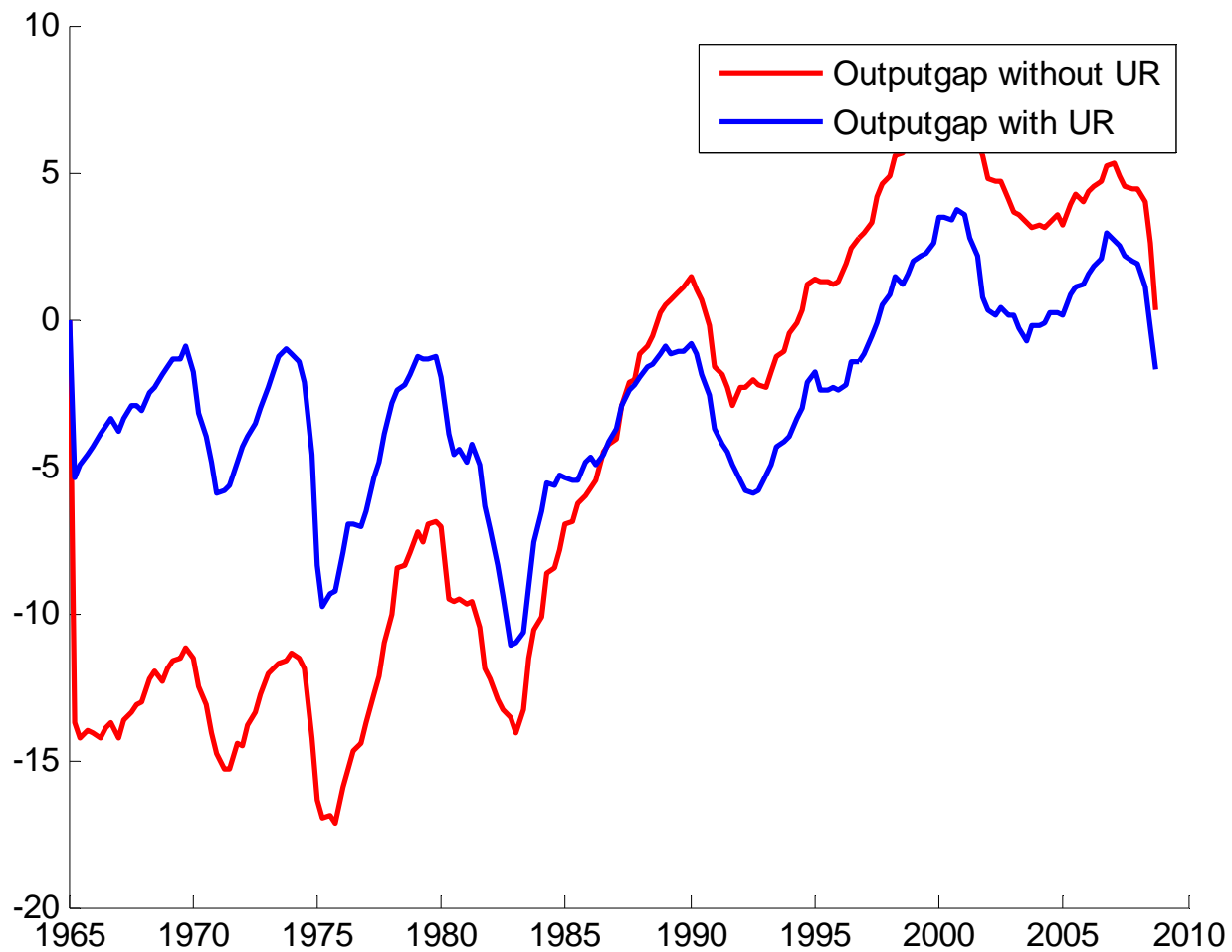
- Productivity and price mark-up shocks



Output gap and unemployment

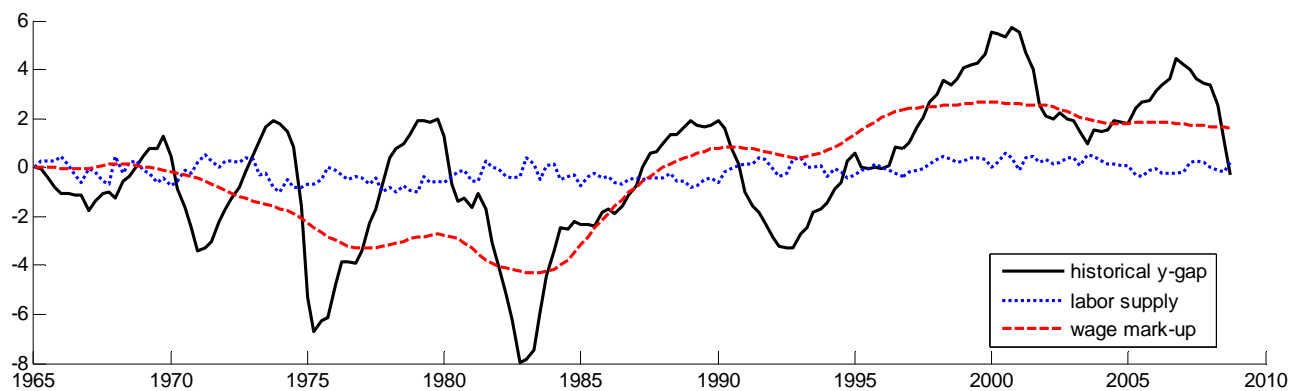
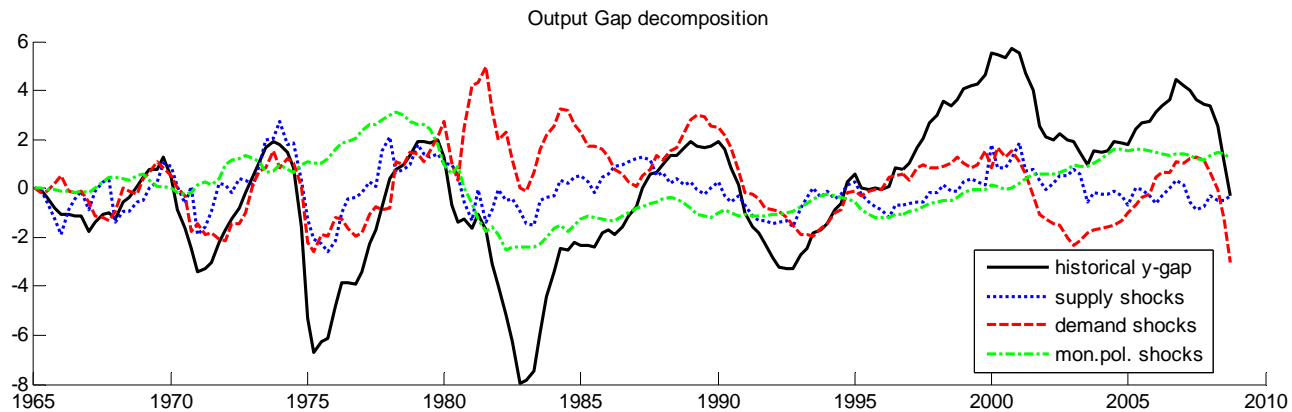


Output gap and unemployment



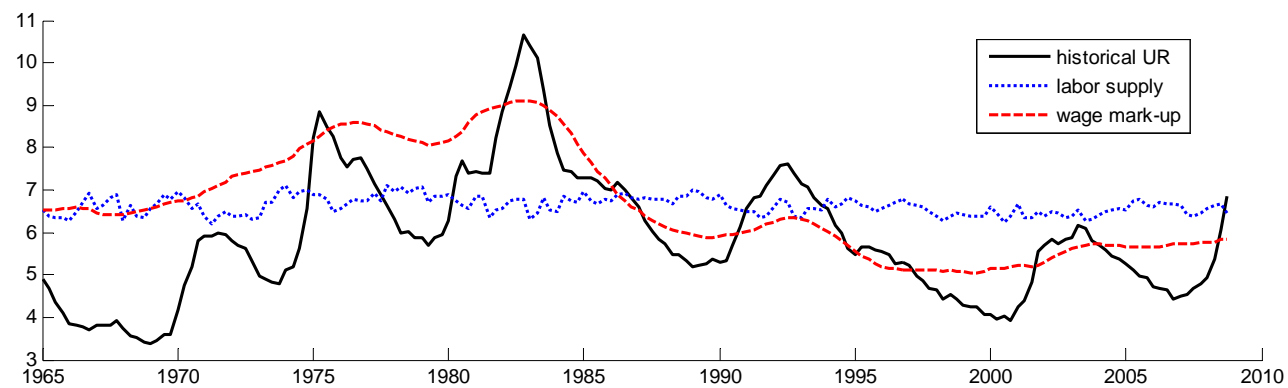
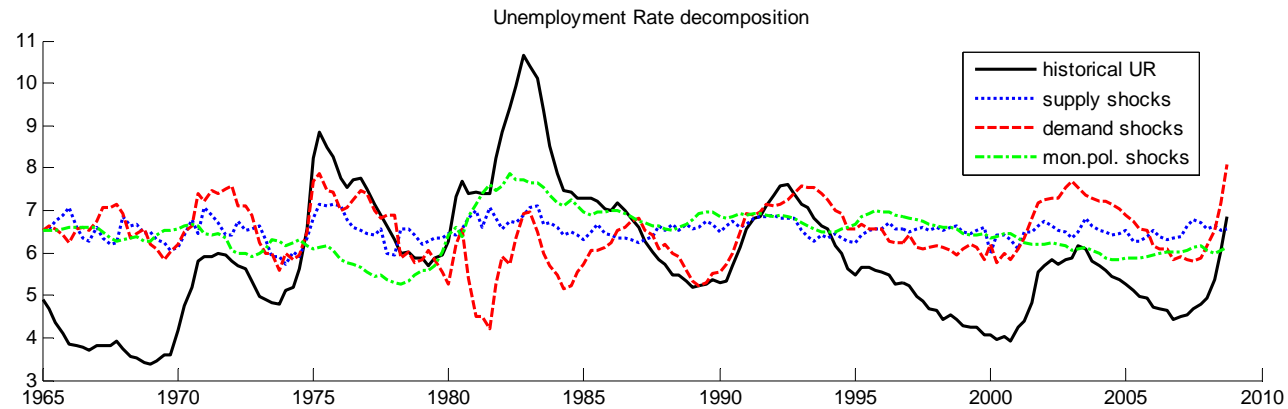
Historical decomposition

Output gap



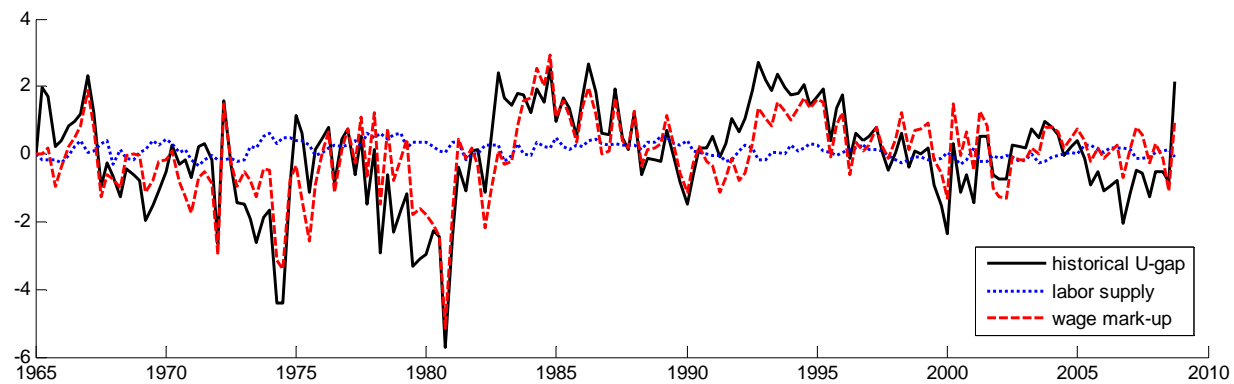
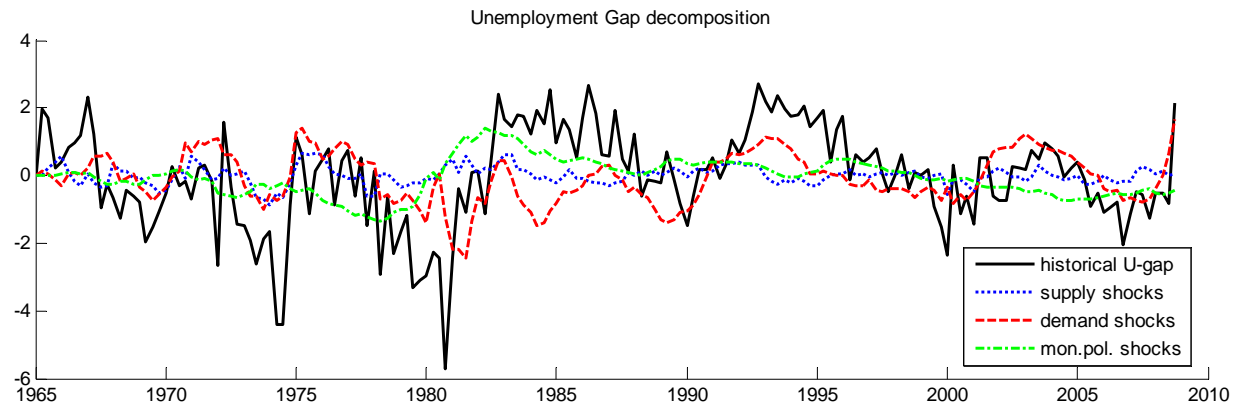
Historical decomposition

Unemployment rate



Historical decomposition

Unemployment gap



Conclusions

- **Adding unemployment (labour supply) in the standard CEE/SW model helps identifying labour supply from labour mark-up shocks; mark-up shocks do not explain a lot of output and the variance of the mark-up shocks is reasonable.**
- **Unemployment helps estimating the wage Phillips curve and generally improves the marginal likelihood of the original system by about 20; unemployment has relevant information.**

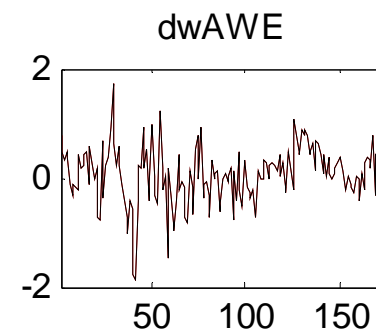
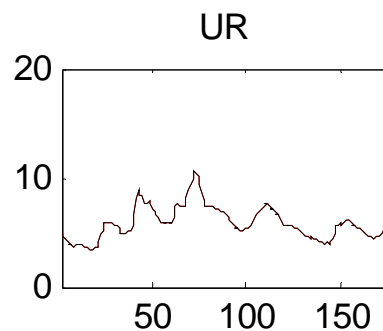
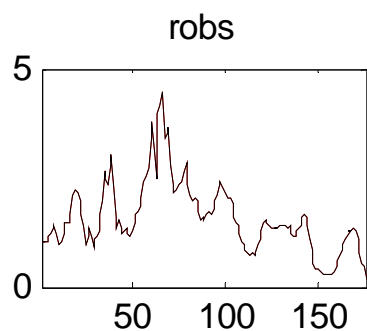
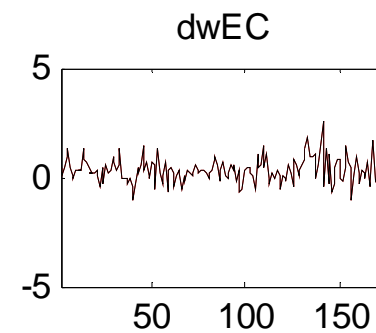
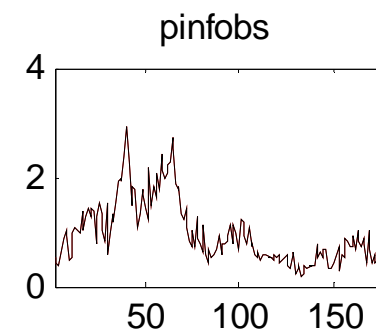
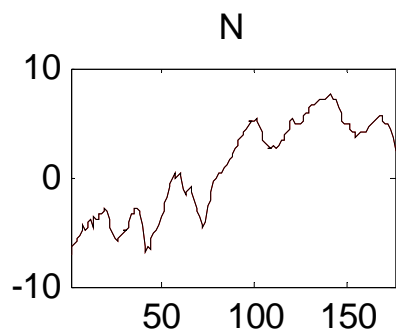
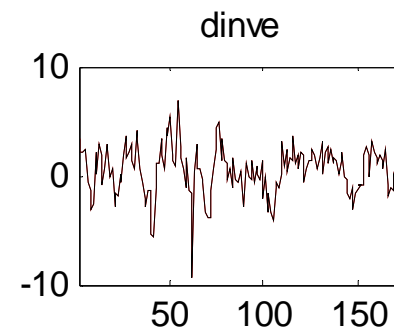
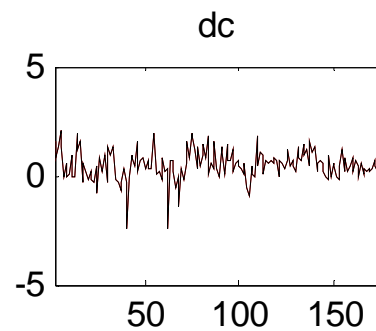
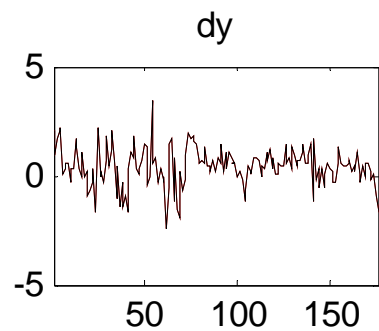
Conclusions

- **Labour supply comoves positively with employment; low wealth effects on labour supply**
- **Unemployment most driven by demand and labour mark-up shocks.**

Extensions

- **Estimate a model for the euro area**
- **May improve the forecast for wages.**

Appendix: Data series used



Appendix: Estimation results

				GJRWs		GJRWsc_UR		GJRWs		GJRWsc_UR		GJRWs_dwAWE		GJRWsc_UR_dwAWE			
				based on dwEC		based on dwEC		based on dwAWE		based on dwAWE		dwEC + dwAWE		dwEC + dwAWE			
								free cwtrend		free cwtrend		free cwtrend		free cwtrend			
												measurement error		measurement error			
Parameters		Prior Assumptions															
		prior	mean	stdev	mode	s.d.	mode	s.d.	mode	s.d.	mode	s.d.	mode	s.d.	mode	s.d.	
AR and MA coefficients																	
crhoa	prodty	beta	0.5	0.2	0.972	0.005	0.988	0.004	0.982	0.003	0.994	0.003	0.976	0.004	0.988	0.005	
crhob	risk prem.	beta	0.5	0.2	0.288	0.101	0.570	0.122	0.245	0.102	0.385	0.116	0.261	0.110	0.362	0.149	
crhog	gov spending	beta	0.5	0.2	0.977	0.010	0.990	0.005	0.973	0.009	0.986	0.006	0.974	0.009	0.986	0.007	
crhoqs	inv.spec.tech	beta	0.5	0.2	0.760	0.051	0.946	0.033	0.755	0.048	0.828	0.064	0.767	0.049	0.817	0.070	
crhoms	monetary pol	beta	0.5	0.2	0.129	0.060	0.069	0.045	0.128	0.064	0.112	0.059	0.127	0.061	0.081	0.050	
crhopinf	p markup	beta	0.5	0.2	0.870	0.047	0.852	0.052	0.993	0.006	0.888	0.045	0.855	0.062	0.780	0.093	
crhow	w markup	beta	0.5	0.2	0.983	0.005	0.848	0.095	0.989	0.004	0.958	0.034	0.989	0.004	0.974	0.024	
cmap	p parkup	beta	0.5	0.2	0.731	0.083	0.706	0.091	0.813	0.065	0.687	0.092	0.674	0.101	0.608	0.137	
cmaw	w markup	beta	0.5	0.2	0.897	0.062	0.792	0.119	0.752	0.083	0.787	0.085	0.634	0.191	0.698	0.190	
crhols	labor supply	beta	0.5	0.2			0.999	-	0.999	-	0.999	-			0.999	-	
crhotax	Ar(2) tax	beta	0.5	0.2													
Structural parameters																	
csadjcost	inv adj cost	norm	4	1.5	4.779	1.005	2.141	0.802	4.465	0.967	4.039	1.188	4.293	0.986	4.109	1.326	
csigma	IES	norm	1.5	0.38	1.666	0.182	1.832	0.267	1.949	0.191	1.659	0.215	1.748	0.177	1.556	0.227	
chabb	habit	beta	0.7	0.1	0.644	0.050	0.467	0.104	0.641	0.048	0.628	0.073	0.640	0.053	0.633	0.083	
cprowb	calvo w	beta	0.5	0.1	0.673	0.079	0.688	0.060	0.600	0.047	0.520	0.065	0.670	0.044	0.574	0.057	
csigl	labor elast.	norm	2	0.75	2.973	0.608	5.029	0.448	2.962	0.541	4.455	0.449	3.020	0.565	3.632	0.448	
cprowp	calvo p	beta	0.5	0.1	0.642	0.049	0.616	0.041	0.609	0.052	0.650	0.050	0.572	0.052	0.588	0.048	
cindw	index w	beta	0.5	0.15	0.408	0.128	0.419	0.133	0.252	0.094	0.213	0.080	0.175	0.073	0.153	0.065	
cindp	index p	beta	0.5	0.15	0.280	0.110	0.282	0.106	0.212	0.087	0.217	0.084	0.215	0.087	0.215	0.089	
czcap	capacity utiliz	beta	0.5	0.15	0.479	0.109	0.670	0.114	0.388	0.091	0.547	0.115	0.483	0.108	0.632	0.116	
cfc	fixed cost	norm	1.25	0.13	1.854	0.076	1.706	0.071	1.863	0.076	1.763	0.076	1.837	0.077	1.802	0.080	
crpi	monopol inflation	norm	1.5	0.25	2.012	0.176	1.955	0.175	2.044	0.167	2.009	0.176	1.970	0.171	2.017	0.170	
crr	monopol inertia	beta	0.75	0.1	0.826	0.022	0.859	0.018	0.826	0.022	0.862	0.018	0.821	0.022	0.863	0.018	
cry	monopol y-gap	norm	0.125	0.05	0.060	0.014	0.152	0.034	0.078	0.016	0.120	0.032	0.070	0.014	0.133	0.031	
crdy	monopol d(y-gap)	norm	0.125	0.05	0.240	0.027	0.269	0.032	0.218	0.025	0.215	0.027	0.238	0.027	0.228	0.029	
constepinf		gamm	0.625	0.1	0.900	0.114	0.696	0.104	0.673	0.107	0.755	0.103	0.792	0.116	0.705	0.118	
constebeta		gamm	0.25	0.1	0.147	0.057	0.151	0.062	0.133	0.054	0.139	0.057	0.125	0.050	0.192	0.076	
constelab		norm	0	2	3.002	1.181	-3.981	1.030	3.677	1.136	-3.929	1.261	3.986	1.080	-2.242	1.457	
ctrend		norm	0.4	0.1	0.350	0.016	0.283	0.017	0.391	0.021	0.364	0.036	0.376	0.018	0.318	0.030	
cgy	(gov - prodty)	norm	0.5	0.25	0.709	0.086	0.695	0.080	0.693	0.087	0.695	0.082	0.709	0.086	0.699	0.084	
calfa	prod function	norm	0.3	0.05	0.170	0.016	0.146	0.016	0.162	0.042	0.166	0.016	0.180	0.016	0.162	0.017	
cwterm		norm	0.25	0.1					0.192	0.016	0.100	0.025	0.099	0.027	0.062	0.030	
clandaw		norm	1.500	0.25			1.379	0.045			1.320	0.050			1.278	0.052	
cchi	JR-stock	beta	0.5	0.2	0.852	0.117	0.009	0.004	0.747	0.152	0.015	0.007	0.807	0.148	0.008	0.005	
cal	els/ Δ labstar=>a	norm	0.5	0.25													
ctax		norm	0.000	1													
st errors shocks																	
ea	prodty	unif	2.5	1.44	0.401	0.024	0.425	0.026	0.398	0.024	0.4159	0.0256	0.401	0.024	0.409	0.025	
eb	risk prem.	unif	2.5	1.44	1.796	0.468	0.882	0.349	2.176	0.589	1.7465	0.5784	1.896	0.552	1.774	0.745	
eg	gov spending	unif	2.5	1.44	0.475	0.026	0.468	0.026	0.476	0.026	0.4696	0.0258	0.474	0.026	0.471	0.026	
eqs	inv.spec.tech	unif	2.5	1.44	0.413	0.040	0.583	0.172	0.427	0.039	0.4116	0.0406	0.422	0.039	0.423	0.041	
em	monetary pol	unif	2.5	1.44	0.227	0.013	0.220	0.013	0.225	0.013	0.2169	0.0125	0.228	0.013	0.212	0.012	
epinf	p markup	unif	2.5	1.44	0.094	0.034	0.068	0.020	0.059	0.022	0.0769	0.0295	0.055	0.019	0.060	0.021	
ew	w markup	unif	2.5	1.44	0.280	0.198	0.619	0.304	0.104	0.039	0.1162	0.052	0.066	0.036	0.052	0.035	
eAWE	Measurement	unif	2.5	1.44									0.319	0.028	0.336	0.027	
eEC	Measurement	unif	2.5	1.44									0.445	0.029	0.449	0.029	
els	labor supply	unif	2.5	1.44			1.397	0.132			1.2473	0.1293			0.964	0.125	
etax	tax	unif	2.5	1.44													
log density (laplace approx)							-962.5		-978.8		-921.5		-941.8		-1043.0		-1045.0
mode log posterior							-879.9		-889.1		-832.2		-849.9		-952.4		-949.7

Appendix:

				GJRWsc_UR_dwAWE	GJRWsc_UR_dwAWE	GJRWsc_UR_dwAWE	GJRWsc_UR_dwAWE						
Parameters				Prior Assumptions		with correlation (ea,els)		with ea = cal*els		with wc = w+tax			
				prior	mean	stdev	mode	s.d.	mode	s.d.	mode	s.d.	
AR and MA coefficients													
crhoa	prodty	beta	0.5	0.2	0.988	0.005	0.9855	0.0044	0.9856	0.0044	0.9864	0.0054	
crhob	risk prem.	beta	0.5	0.2	0.362	0.149	0.3937	0.1419	0.4333	0.1683	0.6169	0.2174	
crhog	gov spending	beta	0.5	0.2	0.986	0.007	0.983	0.0071	0.9831	0.0084	0.989	0.0065	
crhoqs	inv.spec.tech	beta	0.5	0.2	0.817	0.070	0.8077	0.070	0.8297	0.068	0.8943	0.0838	
crhoms	monetary pol	beta	0.5	0.2	0.081	0.050	0.0791	0.049	0.078	0.0489	0.0597	0.043	
crhopinf	p markup	beta	0.5	0.2	0.780	0.093	0.7656	0.0975	0.7756	0.0923	0.7015	0.2605	
crhow	w markup	beta	0.5	0.2	0.974	0.024	0.9783	0.0254	0.9691	0.0228	0.9569	0.0259	
cmaw	p parkup	beta	0.5	0.2	0.608	0.137	0.5921	0.1408	0.6064	0.1348	0.5728	0.2425	
cmaw	w markup	beta	0.5	0.2	0.698	0.190	0.719	0.1747	0.6898	0.1931	0.7371	0.1316	
crhols	labor supply	beta	0.5	0.2	0.999	-	0.999	-	0.999	-	0.999	-	
crhotax	Ar(2) tax	beta	0.5	0.2							0.91	0.0451	
Structural parameters													
csadjcost	inv adj cost	norm	4	1.5	4.109	1.326	3.9968	1.2018	3.7605	1.3262	2.469	1.7721	
csigma	IES	norm	1.5	0.38	1.556	0.227	1.5183	0.207	1.4629	0.2045	1.581	0.2471	
chabb	habit	beta	0.7	0.1	0.633	0.083	0.6153	0.0799	0.6043	0.0985	0.4758	0.1827	
cprobw	calvo w	beta	0.5	0.1	0.574	0.057	0.5552	0.0599	0.5747	0.0563	0.5725	0.0592	
csigl	labor elast.	norm	2	0.75	3.632	0.448	3.6449	0.4442	3.6224	0.4191	3.6029	0.4489	
cprobp	calvo p	beta	0.5	0.1	0.588	0.048	0.5686	0.0486	0.5709	0.0493	0.554	0.0534	
cindw	index w	beta	0.5	0.15	0.153	0.065	0.1651	0.0691	0.1562	0.0661	0.1604	0.0661	
cindp	index p	beta	0.5	0.15	0.215	0.089	0.2174	0.0904	0.2235	0.0915	0.2577	0.1214	
czcap	capacity utiliz	beta	0.5	0.15	0.632	0.116	0.5885	0.1152	0.6232	0.1179	0.583	0.1235	
cfc	fixed cost	norm	1.25	0.13	1.802	0.080	1.9084	0.0842	1.8903	0.0802	1.8878	0.0923	
crpi	monpol inflation	norm	1.5	0.25	2.017	0.170	2.0038	0.1674	1.9833	0.1697	2.0288	0.1778	
crr	monpol inertia	beta	0.75	0.1	0.863	0.018	0.8614	0.0176	0.8617	0.0178	0.8666	0.0169	
cry	monpol y-gap	norm	0.125	0.05	0.133	0.031	0.1384	0.0317	0.1363	0.0324	0.1561	0.0412	
crdy	monpol d(y-gap)	norm	0.125	0.05	0.228	0.029	0.2156	0.026	0.2226	0.0271	0.238	0.0385	
constepinf		gamm	0.625	0.1	0.705	0.118	0.7198	0.1063	0.6933	0.1017	0.6796	0.1009	
constebeta		gamm	0.25	0.1	0.192	0.076	0.1556	0.0622	0.1428	0.0582	0.1462	0.0619	
constelab		norm	0	2	-2.242	1.457	-1.6511	1.3285	-2.08	1.3513	-1.784	1.5471	
ctrend		norm	0.4	0.1	0.318	0.030	0.347	0.0225	0.343	0.0234	0.3323	0.0244	
cgy	(gov - prodty)	norm	0.5	0.25	0.699	0.084	0.7123	0.0871	0.9403	0.1033	0.9594	0.1071	
calfa	prod function	norm	0.3	0.05	0.162	0.017	0.1663	0.017	0.1596	0.0165	0.1496	0.0175	
cwterm		norm	0.25	0.1	0.062	0.030	0.0797	0.0284	0.0768	0.0288			
clandaw		norm	1.500	0.25	1.278	0.052	1.2575	0.0497	1.2717	0.0447	1.2521	0.0429	
cchi	JR-stock	beta	0.5	0.2	0.008	0.005	0.0135	0.0071	0.0112	0.0052	0.012	0.0059	
cal	els=>a	norm	0.5	0.25					0.2319	0.0344	0.2475	0.0399	
ctax		norm	0.000	1							-1.3428	0.1866	
st errors shocks													
ea	prodty	unif	2.5	1.44	0.409	0.025	0.3918	0.0235	0.3158	0.0206	0.3103	0.022	
eb	risk prem.	unif	2.5	1.44	1.774	0.745	1.6192	0.6275	1.4392	0.6761	0.8162	0.6289	
eg	gov spending	unif	2.5	1.44	0.471	0.026	0.4766	0.0261	0.454	0.0254	0.4526	0.0257	
eqs	inv.spec.tech	unif	2.5	1.44	0.423	0.041	0.4237	0.0411	0.4212	0.0453	0.4762	0.1535	
em	monetary pol	unif	2.5	1.44	0.212	0.012	0.2113	0.0121	0.2121	0.0122	0.2115	0.0129	
epinf	p markup	unif	2.5	1.44	0.060	0.021	0.0592	0.0202	0.0597	0.0205	0.0583	0.0195	
ew	w markup	unif	2.5	1.44	0.052	0.035	0.0537	0.0336	0.0529	0.0346	0.0735	0.041	
eAWE	Measurement	unif	2.5	1.44	0.336	0.027	0.3347	0.0262	0.3382	0.0259	0.2739	0.0295	
eEC	Measurement	unif	2.5	1.44	0.449	0.029	0.4467	0.0282	0.4451	0.0282	0.4317	0.029	
els	labor supply	unif	2.5	1.44	0.964	0.125	0.9534	0.1241	0.9589	0.119	0.9277	0.1268	
etax	tax	unif	2.5	1.44							0.1742	0.0357	
(ea,els)	correlation	norm	0	0.25			0.5931	0.0529					
log density (laplace approx)													
mode log posterior													
								-1045.0			-1012.7		
								-949.7			-914.84		
											-1006.8		
											-907.96		

Appendix

usmodel_jan2010_SW_N_dwEC_GJRWs_dwAWE										
0q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N
ea	23.23	23.23	3.72	3.07	4.00	0.02	0.04	3.92	10.89	20.27
eb	31.88	31.88	81.80	8.16	3.60	2.63	3.99	1.08	28.01	33.16
eg	28.47	28.47	0.89	0.88	0.37	0.48	0.72	0.44	3.78	30.48
eqs	9.18	9.18	0.29	82.32	2.12	3.14	4.76	3.40	3.52	9.37
em	5.48	5.48	9.95	3.80	2.47	3.35	5.07	3.31	47.03	5.46
epinf	1.49	1.49	0.94	1.67	65.65	0.09	0.14	74.98	5.80	0.54
ew	0.27	0.27	2.41	0.10	21.78	20.36	30.80	12.87	0.98	0.72
eEC	0.00	0.00	0.00	0.00	0.00	69.92	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	54.49	0.00	0.00	0.00
4q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N
ea	22.29	33.73	16.28	6.30	13.48	0.13	0.17	5.35	11.33	7.29
eb	29.45	14.31	37.52	1.81	3.16	3.24	4.22	2.19	23.04	21.14
eg	25.15	11.54	3.99	1.81	0.32	0.78	1.02	1.02	4.45	18.44
eqs	11.58	20.83	0.20	83.39	5.99	9.25	12.07	8.72	25.46	25.68
em	6.27	9.72	17.89	3.47	4.76	8.04	10.49	8.43	22.46	13.52
epinf	2.80	5.70	5.70	3.16	55.24	0.22	0.28	41.13	6.08	4.83
ew	2.47	4.15	18.42	0.06	17.04	30.18	39.37	33.16	7.17	9.10
eEC	0.00	0.00	0.00	0.00	0.00	48.17	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	32.37	0.00	0.00	0.00
10q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N
ea	21.39	41.62	21.70	11.94	25.47	0.24	0.31	4.39	8.83	3.88
eb	28.87	6.50	14.16	0.94	1.87	3.01	3.83	2.03	16.77	11.59
eg	24.31	6.23	5.85	3.62	0.15	0.77	0.98	1.14	4.02	12.70
eqs	11.96	18.24	1.55	75.44	8.50	10.18	12.98	9.45	36.65	22.14
em	6.75	6.64	10.08	2.86	4.46	8.32	10.60	9.15	16.01	10.59
epinf	2.90	6.37	5.79	4.11	46.99	0.23	0.29	32.60	4.39	6.46
ew	3.82	14.40	40.87	1.09	12.55	32.84	41.86	41.23	13.32	32.63
eEC	0.00	0.00	0.00	0.00	0.00	44.41	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	29.15	0.00	0.00	0.00
40q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N
ea	21.44	41.51	18.71	23.76	52.81	0.76	0.95	3.85	8.03	1.63
eb	28.30	2.39	3.27	0.60	0.94	2.77	3.45	1.67	13.77	4.20
eg	23.86	2.57	6.21	8.17	0.54	0.84	1.05	1.30	4.41	6.54
eqs	12.41	7.96	3.19	52.49	7.93	9.87	12.30	8.23	32.99	8.67
em	6.82	2.54	2.48	1.92	2.56	7.65	9.53	7.67	13.28	3.91
epinf	3.24	2.80	1.76	3.18	28.32	0.63	0.78	27.05	3.86	2.61
ew	3.93	40.22	64.38	9.88	6.90	36.83	45.88	50.23	23.65	72.44
eEC	0.00	0.00	0.00	0.00	0.00	40.65	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	26.07	0.00	0.00	0.00
100q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N
ea	21.54	35.85	16.30	24.95	59.14	1.43	1.74	3.86	8.54	1.61
eb	28.22	1.70	1.92	0.53	0.79	2.53	3.09	1.43	11.55	2.92
eg	23.80	1.84	5.42	8.50	1.08	0.97	1.18	1.41	4.71	5.29
eqs	12.37	5.73	2.37	45.95	7.08	9.18	11.20	7.23	28.32	6.20
em	6.80	1.81	1.46	1.68	2.16	7.00	8.54	6.59	11.16	2.73
epinf	3.23	2.00	1.05	2.78	23.76	0.58	0.71	23.23	3.28	1.82
ew	4.03	51.08	71.47	15.60	5.99	41.12	50.17	56.24	32.45	79.43
eEC	0.00	0.00	0.00	0.00	0.00	37.18	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	23.36	0.00	0.00	0.00

Appendix

usmodel_jan2010_SW_N_dwEC_GJRWsc_UR_dwAWE												
0q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N	UR	labstar
ea	34.08	34.08	11.35	4.02	3.68	0.00	0.00	3.96	23.49	13.89	14.98	0.26
eb	32.74	32.74	68.22	11.33	2.69	1.82	2.69	0.86	19.63	43.05	36.90	0.13
eg	19.02	19.02	5.15	1.21	0.78	0.67	1.00	0.47	11.07	25.17	21.52	0.08
eqs	5.66	5.66	0.81	77.12	3.43	3.60	5.33	3.19	4.82	7.18	5.04	0.30
em	5.17	5.17	7.82	4.51	2.00	2.59	3.83	2.83	31.06	6.63	5.06	0.14
epinf	0.80	0.80	0.47	1.17	65.67	0.01	0.01	76.93	2.78	0.47	0.50	5.40
ew	0.01	0.01	0.24	0.06	21.04	17.55	25.98	11.71	0.69	0.10	1.17	1.76
els	2.52	2.52	5.93	0.58	0.71	0.31	0.46	0.04	6.47	3.51	14.83	91.94
eEC	0.00	0.00	0.00	0.00	0.00	0.00	73.45	0.00	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	60.71	0.00	0.00	0.00	0.00	0.00
4q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N	UR	labstar
ea	32.81	47.72	30.08	7.01	16.43	0.18	0.23	5.82	15.83	4.00	5.61	2.41
eb	29.66	14.28	26.40	2.64	3.43	2.66	3.44	1.79	21.44	27.96	31.73	0.39
eg	17.73	4.71	12.89	1.96	0.67	0.97	1.26	1.11	7.53	9.72	10.88	0.20
eqs	8.09	14.47	0.32	81.53	9.82	9.94	12.87	8.39	26.47	22.00	19.37	1.79
em	5.72	8.38	10.97	4.10	4.72	6.94	8.98	7.69	16.61	15.69	15.53	0.67
epinf	1.44	2.68	2.18	1.89	47.08	0.46	0.60	42.77	3.13	3.54	0.28	8.17
ew	0.80	0.95	2.70	0.07	17.08	27.00	34.95	32.34	5.51	2.73	9.61	3.18
els	3.75	6.81	14.46	0.80	0.77	0.35	0.45	0.10	3.48	14.36	6.99	80.88
eEC	0.00	0.00	0.00	0.00	0.00	51.49	0.00	0.00	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	37.22	0.00	0.00	0.00	0.00	0.00
10q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N	UR	labstar
ea	31.93	56.37	38.45	12.23	34.72	0.45	0.57	4.82	11.85	6.52	4.07	6.02
eb	29.66	5.83	9.80	1.24	2.05	2.47	3.13	1.59	16.19	14.37	19.33	0.26
eg	17.37	1.86	16.38	3.46	0.31	0.93	1.18	1.25	6.05	4.99	6.57	0.18
eqs	8.08	14.50	1.16	75.56	13.39	10.49	13.27	8.56	38.26	21.41	19.87	2.95
em	6.17	5.49	6.47	3.26	4.85	7.32	9.26	8.41	11.94	12.21	13.53	0.80
epinf	1.58	2.42	1.96	1.94	31.68	0.48	0.61	34.09	2.31	3.94	0.36	6.74
ew	1.50	4.13	7.56	1.05	12.51	30.10	38.07	41.18	10.90	12.13	32.08	3.16
els	3.72	9.40	18.22	1.27	0.51	0.33	0.41	0.09	2.50	24.43	4.19	79.90
eEC	0.00	0.00	0.00	0.00	0.00	47.42	0.00	0.00	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	33.49	0.00	0.00	0.00	0.00	0.00
40q	dy	y	c	inve	w	winfEC	winfAWE	pinfobs	robs	N	UR	labstar
ea	31.76	63.51	39.93	27.00	70.30	0.98	1.22	4.58	10.87	6.83	2.24	7.74
eb	29.28	1.84	2.32	0.73	0.72	2.31	2.86	1.32	13.56	5.90	9.65	0.10
eg	17.16	0.74	17.12	8.44	0.67	1.13	1.40	1.79	6.60	2.13	3.28	0.25
eqs	8.42	7.68	4.94	51.37	9.22	10.94	13.55	8.32	36.02	9.50	10.24	1.53
em	6.32	1.85	1.68	2.03	2.07	6.82	8.45	7.11	10.11	5.12	6.84	0.30
epinf	1.74	0.85	0.55	1.25	11.96	0.72	0.89	28.31	2.03	1.71	0.25	2.35
ew	1.65	8.86	11.17	5.75	4.87	33.10	41.01	48.47	18.71	25.27	65.40	1.66
els	3.67	14.68	22.29	3.43	0.19	0.31	0.38	0.10	2.11	43.54	2.09	86.07
eEC	0.00	0.00	0.00	0.00	0.00	43.69	0.00	0.00	0.00	0.00	0.00	0.00
eAWE	0.00	0.00	0.00	0.00	0.00	0.00	30.23	0.00	0.00	0.00	0.00	0.00