Unemployment in an Estimated New Keynesian Model

Jordi Galí [*] Frank Smets [†] Rafael Wouters [‡]

March 24, 2010

Abstract

Following Gali (2009), we introduce unemployment as an observable variable in the estimation of the Smets-Wouters (2007) model. This helps to solve the identification of wage markup and preference shocks highlighted by Chari, Kehoe and McGrattan (2008). It also allows us to better identify the wage Phillips curve and various output gaps and to analyze the sources of unemployment fluctuations in the US.

[*] CREI, Universitat Pompeu Fabra and Barcelona GSE.
[†] European Central Bank
[‡] National Bank of Belgium

1 Introduction

Over the past decade an increasing number of central banks and other policy institutions have developed and estimated medium-scale New Keynesian DSGE models.[1] The combination of a good empirical fit with a sound, micro founded structure makes these models particularly suitable for forecasting and policy analysis. However, as highlighted by Gali and Gerter (2009) and others, one of the shortcomings of these models is that there is typically no reference to unemployment. This is unfortunate because unemployment is an important indicator of resource utilisation in the macro economy. Recently, a number of papers have started to address this shortcoming by embedding various theories of unemployment in the basic New Keynesian model (e.g. Blanchard and Gali (2007, Christoffel et al (2007), Gertler, Sala and Trigari (2008), Christiano, Trabandt and Walentin (2009), de Walque et al (2008))

The present paper takes a different approach. Following Gali (2009), it reformulates the Smets and Wouters (2007; henceforth, SW) model to allow for involuntary unemployment, while preserving the convenience of the representative household paradigm. Unemployment in the model results from market power in labor markets, reflected in positive wage markups. Variations in unemployment over time are associated with changes in the wage markups, either exogenous or resulting from nominal wage rigidities.

The proposed reformulation allows us to overcome an identification problem pointed out by Chari, Kehoe and McGrattan (2008) (CKM) as an illustration of the immaturity of New Keynesian models. Their observation is

[1] See, for example, Smets et al. (2010) for a short description of the two aggregate euro area models used at the ECB.

motivated by the Smets and Wouters (2007) finding that wage markup shocks account for almost 50 percent of the variations in real GDP at horizons of more than 10 years. However, without an explicit measure of unemployment (or, alternatively, labour supply), these wage markup shocks cannot be distinguished from preference shocks that shift the marginal disutility of labour. The policy implications of these different sources of output fluctuations are, however, very different. Variations in wage markup shocks are inefficient and a welfare-maximising government should be interested in stabilising output fluctuations driven by such shocks. In contrast, if output and employment fluctuations are mostly driven by preference shocks, then the optimal policy would be to accommodate such changes. By including unemployment as an observable variable, this identification problem can be overcome, as we show below.

We estimate the reformulated Smets-Wouters model using quarterly U.S. data for the period 1965Q1 to 2008Q4. We systematically compare the performance of the model when we add unemployment as an observable variable. Furthermore, the introduction of unemployment allows us to address a number of questions of interest. What has been the role of wage markup shocks (vs. preference shocks) as a source of aggregate fluctuations? What have been the main sources of unemployment fluctuations? How do unemployment, employment and participation respond to different shocks? What is the conditional comovement of inflation and unemployment for each shock? Does including unemployment improve the fit of the other macro-economic time series? Introducing unemployment also allows us to better identify the various output and unemployment gaps in the model.

In addition to reformulating the wage Phillips curve in terms of unemployment, our model shows a number of small differences with that in SW (2007). First, and regarding the data on which the estimation is based, we use employment rather than hours worked, and redefine the wage as the wage per worker rather than the wage per hour. We do so since the model focuses on variations in labor at the extensive margin, in a way consistent with the conventional definition of unemployment. Given that most of the variation in hours worked over the business cycle is due to changes in employment rather than hours per employee, this change does not have major consequences in itself. We also combine two alternative wage measures in the estimation, compensation and earnings, and model their discrepancy explicitly. Second, we generalise the utility function in a way that allows us to parameterise the wealth effect on labour supply, as shown in Jaimovich and Rebelo (2009). This generalisation yields a better fit of the joint behavior of employment and the labor force, as we discuss in detail. Third, for simplicity, we revert to Dixit-Stiglitz preferences rather than the Kimball aggregator used in SW (2007).

The rest of the paper is structured as follows. Section 2 describes the modified Smets-Wouters model. Next, Section 3 presents the estimation. Section 4 contains the discussion of the main findings. Finally, in Section 5 we conclude.

2 Introducing Unemployment in the Smets-Wouters Model

2.1 Staggered Wage Setting and Wage Inflation Dynamics

This section introduces a variant of the wage setting block of the SW model, which is itself an extension of that in Erceg, Henderson and Levin (2000; henceforth, EHL). The variant presented here, based on Galí (2009), assumes that labor is indivisible, with all variations in hired labor input taking place at the extensive margin. That feature gives rise to a notion of unemployment consistent with its empirical counterpart.

The model assumes a (large) representative household with a continuum of members represented by the unit square and indexed by a pair $(i, j) \in [0,1] \times [0,1]$. The first dimension, indexed by $i \in [0,1]$, represents the type of labor service in which a given household member is specialized. The second dimension, indexed by $j \in [0,1]$, determines his disutility from work. The latter is given by $\chi_t j^{\varphi}$ if he is employed, and zero otherwise, where $\varphi \geq 0$ and $\chi_t > 0$ is an exogenous preference shifter. Household utility is assumed to take the form

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

where C_t denotes household consumption, and $N_t(i) \in [0,1]$ is the fraction of members specialized in type i labor who are employed in period t. Variable X_t includes several factors (the preference shifter χ_t among them) that influence utility but which are taken as exogenous by each individual household. As in Merz (1995), full risk sharing of consumption among household members is assumed.

Period utility is given by

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

where $\overline{C}_t$ is aggregate consumption (which is taken as given by each household), and where Z_t evolves over time according to

$$
Z_t = Z_{t-1}^{1-\upsilon} \; (\overline{C}_t - h\overline{C}_{t-1})^{\upsilon}
$$

The previous specification extends the preferences assumed in Jaimovich-Rebelo (2009; JR, henceforth) to allow for (external) habit formation, indexed by $h \in [0,1]$. As is well known, the JR preferences reconcile the existence of a balanced growth path with an arbitrarily small *short-term* wealth effect. The latter's importance is determined by the size of parameter $\upsilon \in [0,1]$. As discussed below, that feature is needed in order to match the cyclical behavior of the labor force.

Note that under the previous preferences, the relevant marginal rate of substitution between consumption and employment for type i workers in period t is given by

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

Equivalently, letting $\xi_t \equiv \log \chi_t$ and using lower case letters denote the natural logarithms of the original variables, we can write:

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

As in EHL, and following the formalism of Calvo (1983), workers supplying a labor service of a given type (or a union representing them) get to reset their (nominal) wage with probability $1-\theta_w$ each period. That probability is independent of the time elapsed since they last reset their wage, in addition to being independent across labor types. Thus, a fraction of workers θ_w keep their wage unchanged in any given period, making that parameter a natural index of nominal wage rigidities. All those who adjust their wage choose an identical wage, denoted by W_t^*, since they face an identical problem. Following SW, we allow for partial wage indexation: between re-optimization periods the nominal wage is adjusted mechanically in proportion to past price inflation. Formally, and letting $W_{t+k|t}$ denote the nominal wage in period $t+k$ for workers who last reoptimized their wage in period t, we assume

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

for $k = 1, 2, 3, ...$and $W_{t,t} = W_t^*$, and where $\Pi_t^p \equiv P_t/P_{t-1}$ denotes the gross rate of price inflation, Π^x is the steady state growth rate of productivity, and $\gamma_w \in [0, 1]$ measures the degree of wage indexation to past inflation.

When reoptimizing their wage in period t, workers choose a wage W_t^* in order to maximize household utility (as opposed to their individual utility), subject to the usual sequence of household flow budget constraints, as well as a sequence of isoelastic demand schedules of the form $N_{t+k|t} = (W_{t+k|t}/W_{t+k})^{-\epsilon_{w,t}} N_{t+k}$, where $N_{t+k|t}$ denotes period $t+k$ employment among workers whose wage was last reoptimized in period t, and where $\epsilon_{w,t}$ is the period t wage elasticity of the relevant labor demand schedule.[2] The first

[2]Details of the derivation of the optimal wage setting condition can be found in EHL (2000).

order condition associated with that problem can be written as:

$$\sum_{k=0}^{\infty} (\beta\theta_w)^k \; E_t \left\{ \frac{N_{t+k|t}}{C_{t+k}} \; \left(\frac{W^*_{t+k|t}}{P_{t+k}} - \mathcal{M}^n_{w,t} \; MRS_{t+k|t} \right) \right\} = 0 \tag{1}$$

where $MRS_{t+k|t} \equiv \chi_t Z_t N^{\varphi}_{t+k|t}$ is the relevant marginal rate of substitution between consumption and employment in period $t+k$, and $\mathcal{M}^n_{w,t} \equiv \frac{\epsilon_{w,t}}{\epsilon_{w,t}-1}$ is the natural or desired wage markup, i.e. the one that would obtain under flexible wages.

Under the above assumptions, we can rewrite the aggregate wage index $W_t \equiv \left(\int_0^1 W_t(i)^{1-\epsilon_{w,t}} di \right)^{\frac{1}{1-\epsilon_{w,t}}}$ as follows:

$$W_t \equiv \left[\theta_w (W_{t-1} \Pi^x (\Pi^p_{t-1})^{\gamma_w} (\Pi^p)^{1-\gamma_w})^{1-\epsilon_{w,t}} + (1-\theta_w)(W^*_t)^{1-\epsilon_{w,t}} \right]^{\frac{1}{1-\epsilon_{w,t}}} \tag{2}$$

Log-linearizing (1) and (2) around a perfect foresight zero inflation steady state and combining the resulting expressions, allows us to derive (after some algebra) the following equation for wage inflation $\pi^w_t \equiv w_t - w_{t-1}$:

$$\pi^w_t = \alpha_w + \gamma_w \pi^p_{t-1} + \beta E_t\{\pi^w_{t+1} - \gamma_w \pi^p_t\} - \lambda_w \; (\mu_{w,t} - \mu^n_{w,t}) \tag{3}$$

where $\alpha_w \equiv (1-\beta)((1-\gamma)\pi^p + \pi^x)$, $\lambda_w \equiv \frac{(1-\beta\theta_w)(1-\theta_w)}{\theta_w(1+\epsilon_w\varphi)}$, $\mu^n_{w,t} \equiv \log \mathcal{M}^n_{w,t}$ is the (log) natural wage markup, and $\mu_{w,t} \equiv (w_t - p_t) - mrs_t$ is the (log) average wage markup, with $mrs_t \equiv z_t + \varphi n_t + \xi_t$ denoting the (log) average marginal rate of substitution. As equation (3) makes clear, variations in wage inflation above and beyond those resulting from indexation to past price inflation are driven by deviations of average wage markups from their desired levels, for those deviations generate pressure on workers currently setting wages to adjust those wages one way or another.

2.2 Introducing Unemployment

Consider an individual specialized in type i labor and with disutility of work $\chi_t j^{\varphi}$. Using household welfare as a criterion, and *taking as given* current labor market conditions (as summarized by the prevailing wage for his labor type), that individual will find it optimal to participate in the labor market in period t if and only if

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

Thus, the marginal supplier of type i labor, which I denote by $L_t(i)$, is implicitly given by

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

Taking logs and integrating over i we obtain

$$w_t - p_t = z_t + \varphi \, l_t + \xi_t \tag{4}$$

where $l_t \equiv \int_0^1 l_t(i) \, di$ can be interpreted as the model's implied (log) aggregate labor force or participation rate.

Following Galí (2009), the unemployment rate u_t is defined as

$$u_t \equiv l_t - n_t \tag{5}$$

Combining the definition $\mu_{w,t} \equiv (w_t - p_t) - (z_t + \varphi n_t + \xi_t)$ with (4) and (5), the following simple linear relation between the average wage markup and the unemployment rate can be derived

$$\mu_{w,t} = \varphi \, u_t \tag{6}$$

Finally, combining (3), (6), and (8) we obtain an equation relating wage inflation to price inflation and unemployment

$$\pi_t^w = \alpha_w + \gamma_w \pi_{t-1}^p + \beta E_t\{\pi_{t+1}^w - \gamma_w \pi_t^p\} - \lambda_w \varphi \, u_t + \lambda_w \, \mu_{w,t}^n \tag{7}$$

Note that in contrast with the representation of the wage equation found in Smets and Wouters (2003, 2007) and related papers, the error term in (7) captures exclusively shocks to the wage markup, and *not* preference shocks (even though the latter have been allowed for in the model above). That feature, made possible by reformulating the wage equation in terms of the (observable) unemployment rate, allows us to overcome the identification problem raised by Chari, Kehoe and McGrattan (2008) in their critique of New Keynesian models.

Finally, note that we can define the *natural* rate of unemployment, u_t^n, as the unemployment rate that would prevail in the absence of nominal wage rigidities. Under our assumptions, the natural rate will vary exogenously in proportion to the natural wage markup, and can be determined using the relation:

$$\mu_{w,t}^n = \varphi \; u_t^n \tag{8}$$

The complete model of linearised equations is presented in the appendix. With the exception of the consumption Euler equation (which is adjusted to accommodate JR preferences), the equations are identical to those in SW (2007).

3 Estimation

We estimate the reformulated SW model on US data for the period from 1965Q1 to 2008Q4 using Bayesian full-system estimation techniques. Five of the seven data series used by SW (2007) are the same: the log difference of real GDP, real consumption, real investment, the GDP deflator and the level of the federal funds rate. As we are interested in explaining unemployment, we use employment rather than hours worked. The main results are not affected if we use hours instead. In addition, we experiment with two wage concepts. The first one is the same as in SW (2007), namely, compensation per employee derived from the BLS Productivity and Costs Statistics. The other one is Average Weekly Earnings from the Current Employment Statistics. Finally, we add unemployment as an additional observable variable. The idea is to compare the model estimated with and without unemployment as an observable variable.

As is clear from Figure 1, the properties of both wage series are quite different. First, the average growth rate of compensation per employee is significantly larger than the average growth rate of earnings per employee (1.27 versus 1.04). The average growth rate of the first is more compatible with a balanced growth path in which real wages grow at the same rate as real output, consumption and investment. Second, the compensation series is much more volatile than the earnings series, especially over the past two decades. The standard deviation of the nominal growth rate of compensation per employee is 0.66 versus 0.56 for the earnings series. Finally, the correlation between the quarter-to-quarter growth rates of both wage measures is surprisingly low at 0.60.

For our benchmark estimation, we will use both wage series as imperfect measures of the wage concept found in the model. This is done by adding measurement error to both measurement equations and allowing for a smaller trend in the earnings series.[3] In the appendix we also report the estimation results when using each of the wage concepts separately. The main impact

[3] Justiniano and Primiceri (2007) have argued that the price and wage mark-up shocks can be better captured as measurement error.

of the higher volatility in the compensation series is to increase the estimate of the inverse Frisch elasticity of the labour supply when unemployment is added. With higher observed volatility of wages, the response of labour supply to real wages is estimated to be less. This has then some additional impact on some of the other parameters. In the rest of the paper, we focus on the model with both wage concepts and measurement error.

Table A1 in the appendix systematically compares the estimated parameters in the model with and without unemployment as an unobservable variable. As discussed above, adding unemployment allows us to distinguish between the wage markup and preference shocks. In addition, according to the model steady-state unemployment is proportional to the steady-state wage markup. The average unemployment rate in the sample therefore allows us to estimate the elasticity of substitution between different types of labour, which determines the steady-state wage markup. In the model without unemployment this parameter is not identified.

Overall, most of the estimated parameters are very similar in the two models. [4] In Table 1 we compare the estimates of the labour market block, i.e. the wage Phillips curve and the labour supply decision.

A number of findings are worth emphasizing. First, in the model with the two wage concepts the estimated labour supply elasticity is quite similar whether one includes unemployment or not. The inverse of the Frisch elasticity increases slightly from 3 to 3.6 as one includes unemployment. Second, in contrast the parameter, ν, governing the short-run wealth effects on labour

[4] A robust feature of the model with unemployment is that the labour preference shock and the productivity shock are positively correlated. Allowing for such a correlation further improves the fit of the model, but does not affect the estimation results discussed below.

supply, changes quite dramatically from 0.81 to 0.09. Roughly speaking this amounts to a change from King, Plosser, Rebelo (KPR) preferences, where there are large wealth effects, to a specification closer to the Greenwood, Hercowitz, Huffman (GHH) preferences. In the latter case, wealth effects are zero in the short run. Jaimovich and Rebelo (2009) have argued that small short-run wealth effects on labour supply are necessary to generate comovement between employment and output in response to actual and expected productivity shocks. In this paper, we add an explicit measure of labour supply through the unemployment variable and find that indeed the estimated short-run wealth effect is small. As discussed below, this will help in ensuring that not only employment, but also labour supply moves procyclically in response to most shocks. This helps overcome the criticism of the Galí (2009) framework by Christiano, Trabandt and Walentin (2009). To see this note that under standard KPR preferences the labor supply equation (4) can be written as

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

where habit formation is omitted to simplify the argument.

As shown in Christiano et al. (2009) the previous equation is at odds with their empirical estimates of the effects of monetary policy shocks, which show a countercyclical response of $w_t - p_t - c_t$ coexisting with a procyclical response of the labor force l_t. Instead, under the assumed preferences, a procyclical response of the labor force is consistent with the model as long as the short run wealth effect is sufficiently weak, implying a small adjustment of z_t and hence a procyclical response of $w_t - p_t - z_t$.

Turning to the estimates of the wage Phillips curve, it is clear that the estimated degree of wage indexation is relatively small and robust across the two models. The slope of the wage Phillips curve increases significantly from 0.048 to 0.065 in absolute value. This is partly due to the small increase in the inverse labour supply elasticity discussed above. However, it also reflects a fall in the estimated Calvo probability of unchanged wages from 0.67 to 0.57. In sum, the introduction of unemployment as an observable variable leads to a somewhat steeper wage Phillips curve.

Finally, it is useful to address the CKM criticism that the variance of the wage markup shocks is too large to be plausible. The estimated parameters of the ARMA(1,1) process for the exogenous wage markup imply that the standard deviation drops from 17 to 8.2 percent once unemployment is included. Based on equation x and the estimated inverse labour supply elasticity this implies that the standard deviation of the natural unemployment rate is of the order of 2.25% in the model with unemployment. This is relatively high, but not unreasonable. The standard deviation of the innovations in the preference shock is 0.96. In the next section, we will discuss the contribution of those two shocks to the variance decomposition of output, employment and unemployment.

4 Sources of unemployment fluctuations

4.1 The variance decomposition

Table 2 presents the variance decomposition of the forecast errors of the eight observable variables at the 10 quarter and 10 year horizon. The first entry in the table gives the shares in the model without unemployment as an observable variables, whereas the second entry given the shares in the model with unemployment. A number of observations are worth making. First, the importance of wage markup shocks for medium and long-term output fluctuations is very much reduced. At the ten year horizon, the share drops from 40 to 9 percent for real GDP and from 72 to 25 percent for employment. Wage markup shocks continue to be the most important source of unemployment and inflation fluctuations.

Secondly, the preference shocks that shift the supply of labour are by far the most important source of fluctuations in labour supply both in the short and long run. They also explain an important part of fluctuations in employment, particularly in the longer run, but are less important for output. Thirdly, in the short run unemployment is mostly driven by "demand" shocks. The risk premium, government spending, investment-specific technology and monetary policy shocks together account for 60 percent of unemployment fluctuations at the 10 quarter horizon, and still for about one third at the 10 year horizon. The rest of unemployment fluctuations is mostly due to wage markup shocks. Finally, productivity shocks are the most important determinant of output and wages, in particular in the longer run.

4.2 Impulse responses

Figure 2 shows the impulse responses of output, inflation, the real wage, employment, the labour force and the unemployment rate to the four "demand" shocks, including the monetary policy shock. We call those shocks "demand" shocks because with the exception of unemployment all variables comove positively. It is particularly noteworthy that employment and the labour force comove positively in response to all those shocks. This is consistent with the empirical VAR evidence as, for example, in Christiano et al (2010). However, as discussed before it is difficult to achieve such comovement without Jaimovich-Rebelo preferences. Indeed, when output and consumption go up, typically leisure will also go up and thus the labour force will fall. With smallshort-run wealth effects on labour supply this counterfactual implication can be avoided. Note, however, that the size of the labour force response is much smaller than that of employment, so that unemployment will be mostly driven by employment.

Figure 3 shows the impulse response to the labour preference and markup shocks. A positive wage markup shock has a sizeable positive impact on inflation and unemployment and a negative impact on output and employment. The effects of a reduction in the labour force has similar effects on output and employment, but leads to a temporary drop in unemployment and has little effect on inflation.

Finally, figure 4 illustrates the effects of a positive productivity shock and a negative price markup shock. In line with the empirical VAR results of Blanchard and Quah (1989) and Barnichon (2008), unemployment increases for about a year following the positive productivity shock.

5 Output and unemployment gaps and the Phillips curve

5.1 Output and unemployment gaps

As argued above, the inclusion of unemployment in the estimation of the model allows us to distinguish between markup and labour preference shocks.

It also allows us to better identify the output gap. The latter is defined as the (log) difference between actual output and the constant-markup, flexible-price-and-wage output. Note that, under the assumptions of the model, the output gap thus defined will differ from the gap from the efficient level of output by an additive constant.

Figure 5 shows the unemployment rate and the output gap. The correlation between the two is minus 80 percent. Arguably this output gap is the most welfare-relevant output gap concept as it leads to a stabilisation of the time-varying markup shocks. Figure 5 shows that the inclusion of unemployment in the estimation process allows us to derive a more stationary output gap. Figures 6, 7, 8 and 9 show the historical decomposition of unemployment, the output gap, and annual wage and price inflation. Clearly, the wage markup shock captures the secular movements in the unemployment rate, the output gap and inflation and wage inflation. In particular, the rise of unemployment and inflation in the seventies is mostly captured by persistent positive wage markup shocks. Monetary policy also contributed to the rise in the seventies, but led to a reduction in the unemployment rate. The Volcker disinflation starting in 1979 led to a gradual fall in inflation and a strong rise in the unemployment rate by almost three percentage points from 1979 till 1982.

Most of the business cycle fluctuations in unemployment are driven by demand shocks. This is particularly the case since the 1990s. Both the 2001 and 2007-2008 recessions are driven by negative demand shocks, further contributing to a fall in inflation.

Figure 10 shows the actual and the natural unemployment rate. As is clear from equation (), the natural unemployment rate is proportional to the wage markup. According to Figure 10, the natural unemployment rate rose above actual unemployment in the 1970s reflecting positive wage markup shocks. The positive unemployment gap put upward pressure on wage inflation.

Finally, Figure 11 shows that most of the trend in employment is due to labour supply developments.

5.2 Conditional Phillips curves

To be completed. In this section we draw "conditional" Phillips curves using historical decomposition (distinguishing between demand shocks and wage markup shocks).

5.3 The information content of unemployment

To be completed. In this section, we analyse to what extent adding observed unemployment to the estimation of the New Keynesian model helps fitting the original SW data series.

6 Conclusion

As shown by Gali (2009), the standard New Keynesian model incorporates a theory of unemployment based on time-varying wage markups and staggered nominal wage setting. In this paper we add unemployment as an observable variable in the estimation of the Smets-Wouters (2007) model. This, first, helps to identify labour supply from labour markup shocks and to address one of the criticisms of Chari, Kehoe and McGrattan (2009). One of the main findings is that labour markup shocks only play a limited role in driving output fluctuations. However, they do explain most of the secular movements in the unemployment rate and inflation. Second, adding unemployment allows us to investigate the main sources of unemployment fluctuations. In the short to medium run, most unemployment fluctuations are driven by demand shocks.

Table 1
Estimates of the labour market block

Baseline without unemployment

Labour supply	$w_t - p_t = z_t + 3.02 l_t$
JR	$z_t = 0.19 z_t + 0.81 (C_t - 0.64 C_{t-1})$
Wage Phillips curve	$\pi_t^w = 0.17 \pi_{t-1}^p + 0.99 \mathrm{E}_t \{\pi_{t+1}^w - 0.17 \pi_t^p\} - 0.048 u_t + 0.016 \mu_{w,t}^n$

Baseline with unemployment

Labour supply	$w_t - p_t = z_t + 3.63 l_t + \xi_t$
JR	$z_t = 0.91 z_t + 0.01 (C_t - 0.63 C_{t-1})$
Wage Phillips curve	$\pi_t^w = 0.15 \pi_{t-1}^p + 0.99 \mathrm{E}_t \{\pi_{t+1}^w - 0.15 \pi_t^p\} - 0.065 u_t + 0.018 \mu_{w,t}^n$

Table 2
Variance decomposition

	y	π	w	n	u	l	R
	10 quarter horizon						
Productivity	41/56	4/5	25/35	4/7	-/4	-/6	9/12
Risk premium	7/6	3/2	2/2	12/14	-/19	-/0	17/16
Govt spending	6/2	1/1	0/0	13/5	-/7	-/0	4/6
Investment	18/15	9/9	9/13	22/21	-/20	-/3	37/38
Monetary policy	7/5	9/8	4/5	11/12	-/14	-/1	16/12
Price markup	6/2	33/34	47/32	6/4	-/0	-/7	4/2
Wage markup	14/4	41/41	13/13	33/12	-/32	-/3	13/11
Labour pref.	-/9	-/0	-/1	-/24	-/4	-/80	-/3
	40 quarter horizon						
Productivity	42/64	4/5	53/70	2/7	-/2	-/8	8/11
Risk premium	2/2	2/1	1/1	4/6	-/10	-/0	14/14
Govt spending	3/1	½	1/1	7/2	-/3	-/0	4/7
Investment	8/8	8/8	8/9	9/10	-/10	-/2	33/36
Monetary policy	3/2	8/7	3/2	4/5	-/7	-/0	13/10
Price markup	3/1	27/28	28/12	3/2	-/0	-/2	4/2
Wage markup	40/9	50/48	7/5	72/25	-/65	-/2	24/19
Labour pref.	-/15	-/0	-/0	-/44	-/2	-/86	-/2

Notes: The first entry denotes the share of the variance decomposition explained by the shock in the model without unemployment; the second entry denotes the share in the model with unemployment.

Figure 1:
Two nominal wage concepts

Levels:

Growth rates

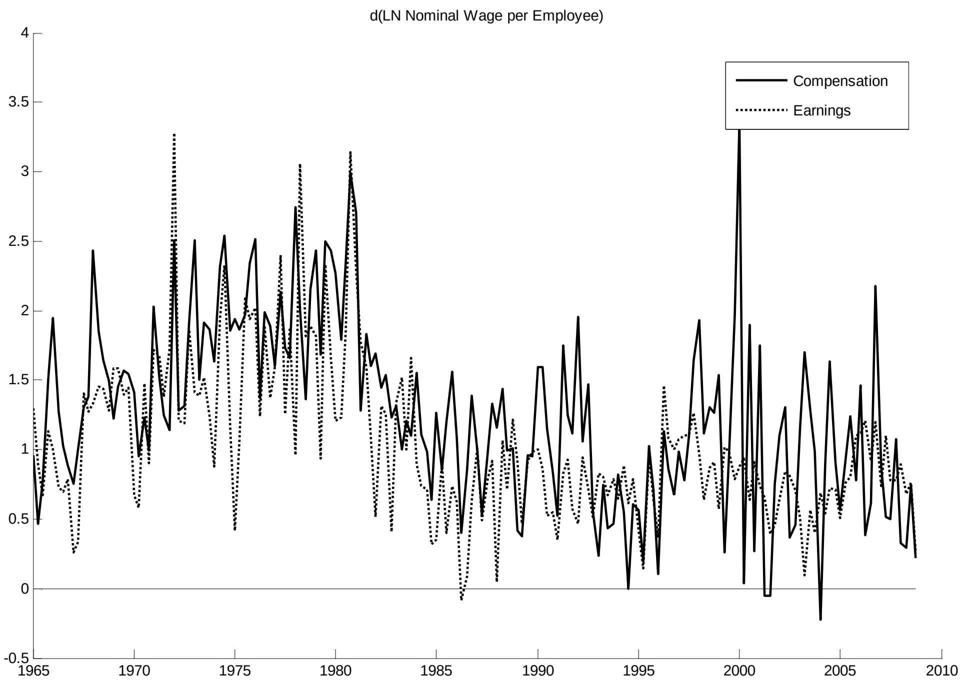


Figure 2
Impulse responses to “demand” shocks

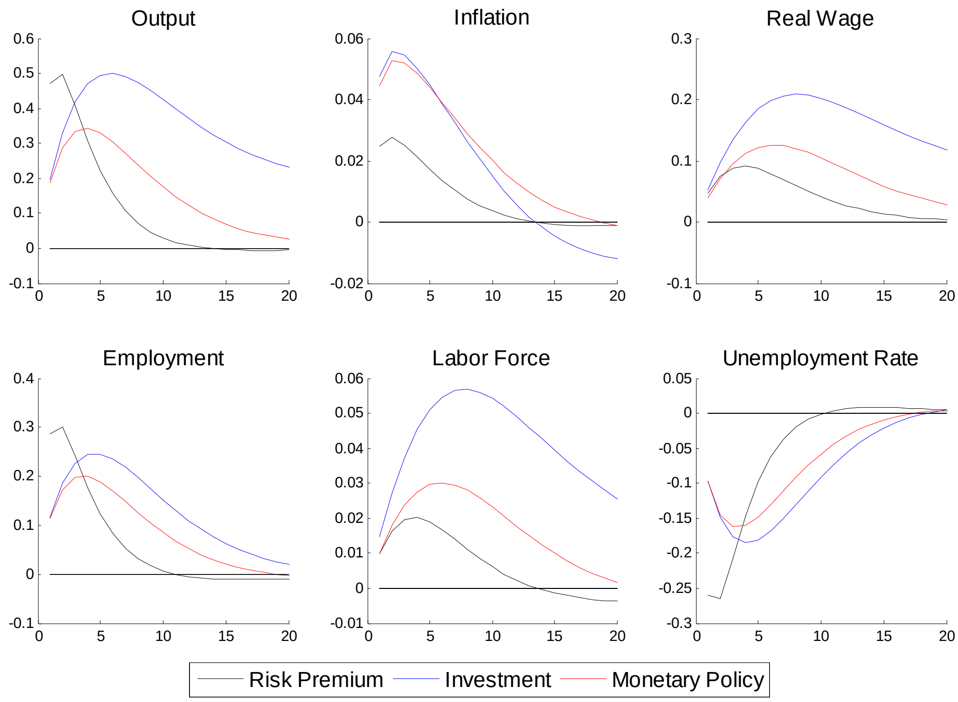


Figure 3
Impulse responses to wage mark-up and labour preference shock

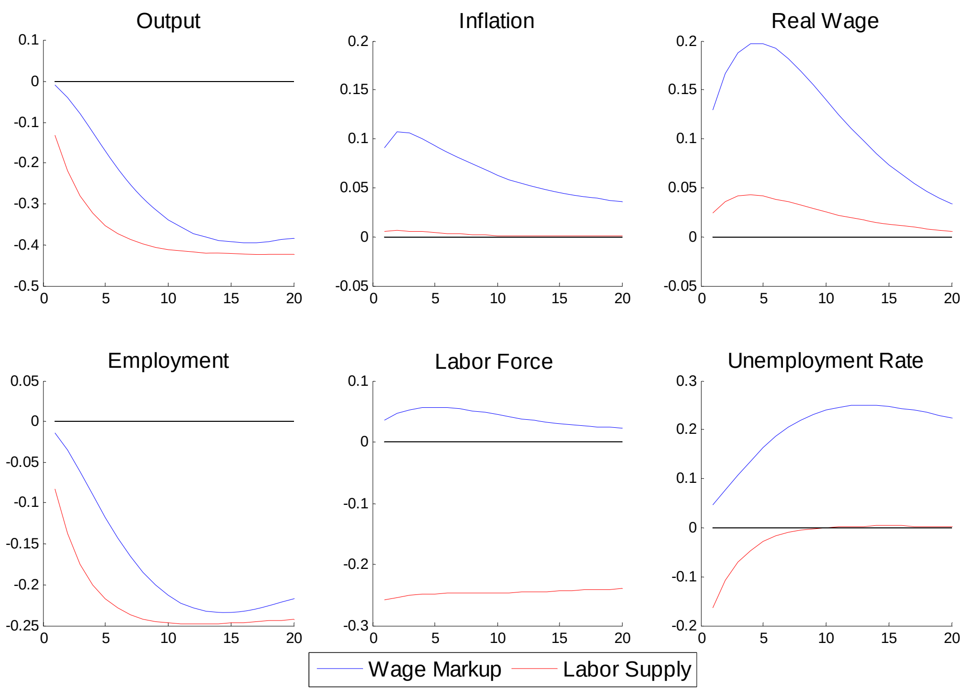


Figure 4
Impulse responses to productivity and price mark-up shock

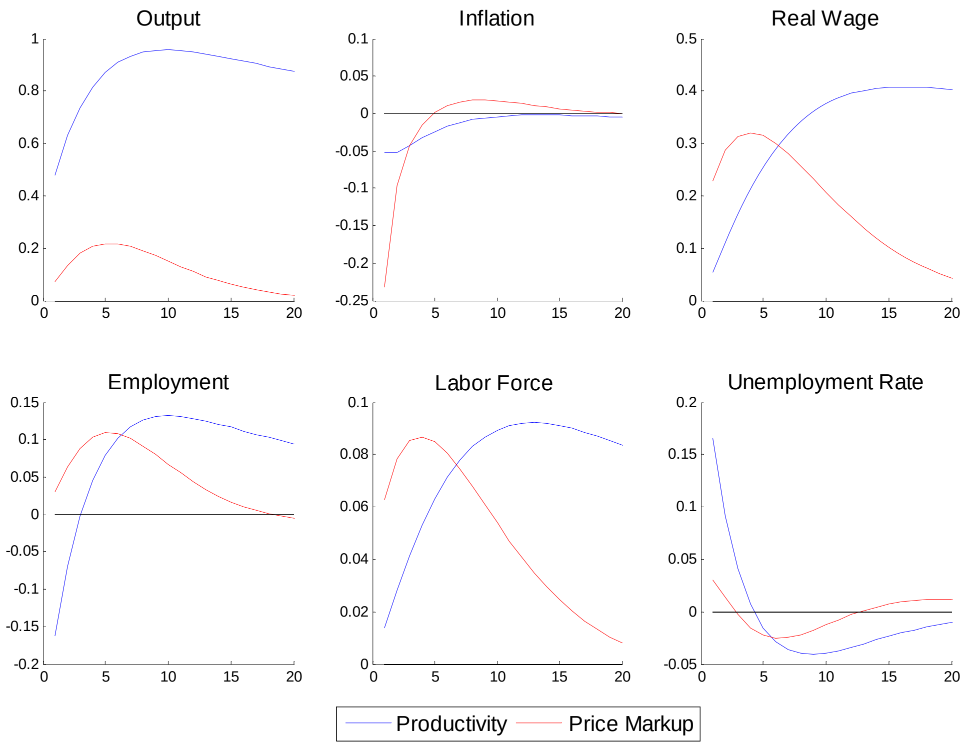


Figure 5
The unemployment rate and the output gap

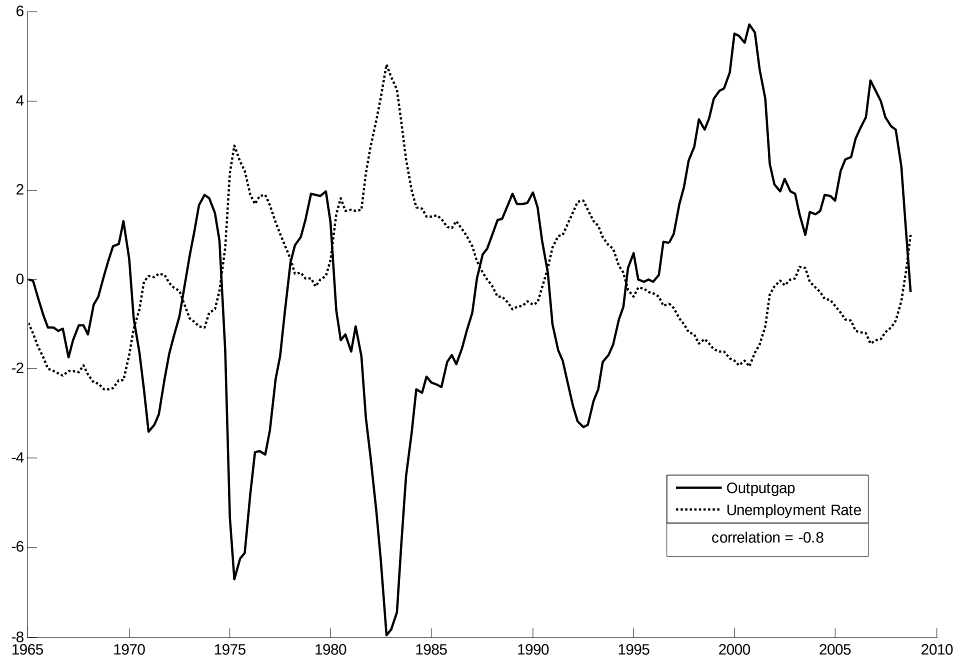


Figure 6
Historical decomposition of unemployment (baseline model)

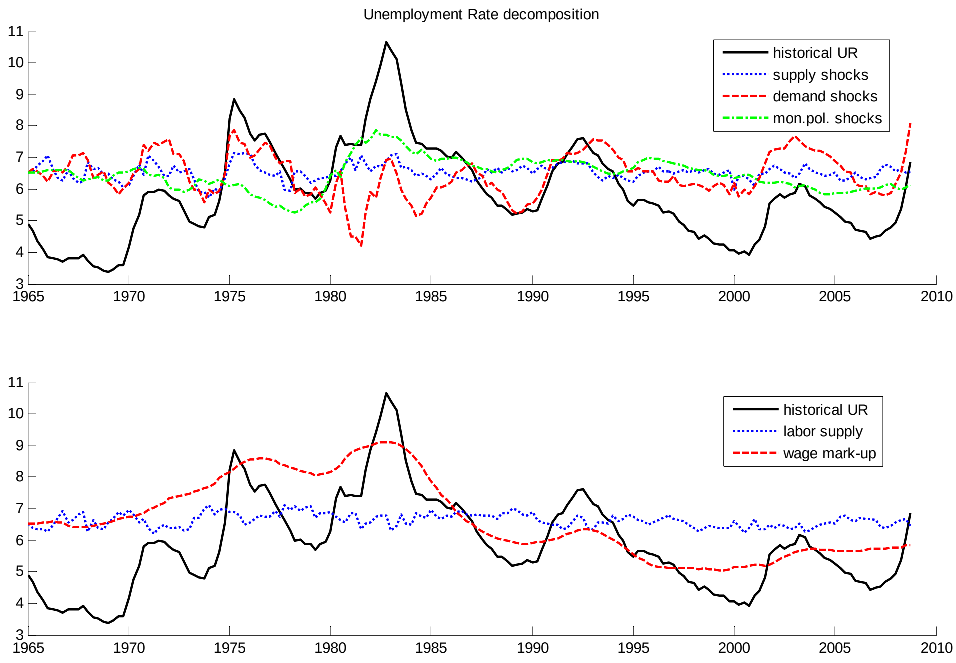


Figure 7
Historical decomposition of output gap (baseline model)

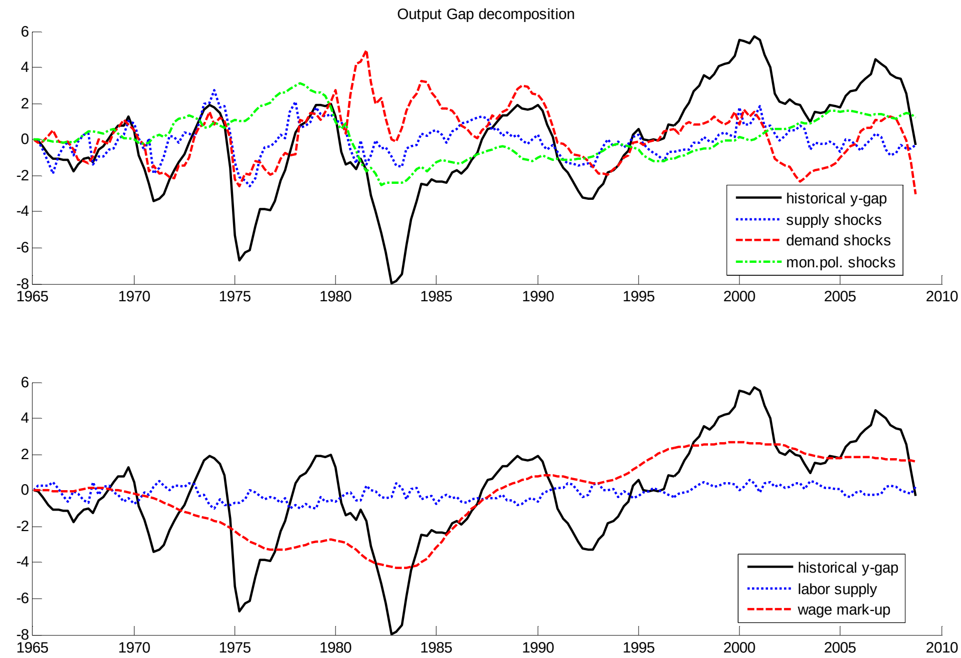


Figure 8
Historical decomposition of inflation (baseline model)

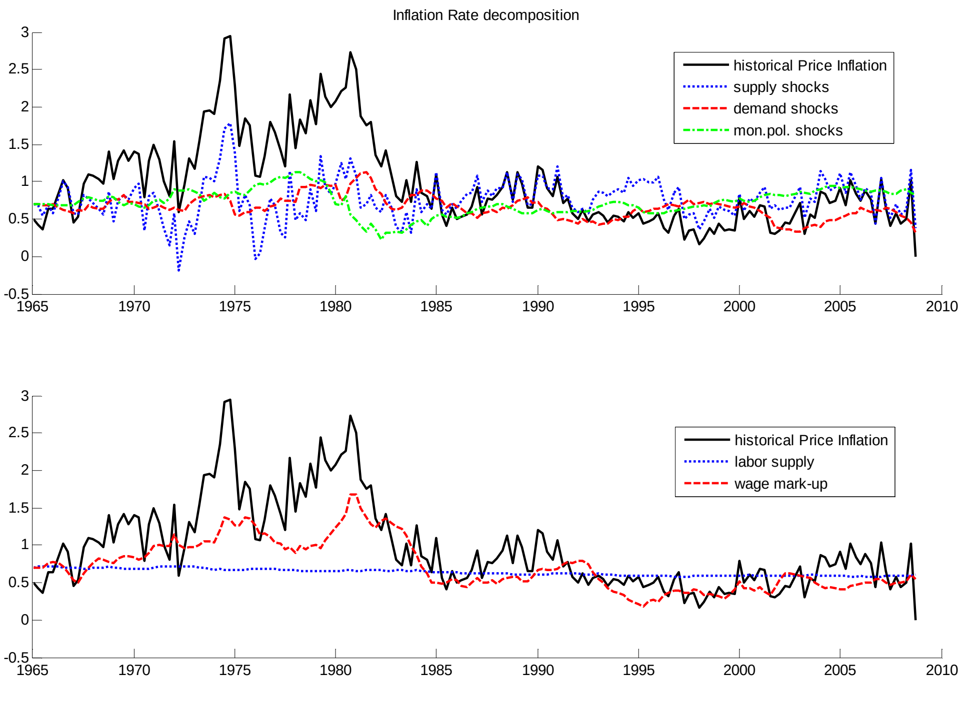


Figure 9
Historical decomposition of wage inflation (compensation - baseline model)

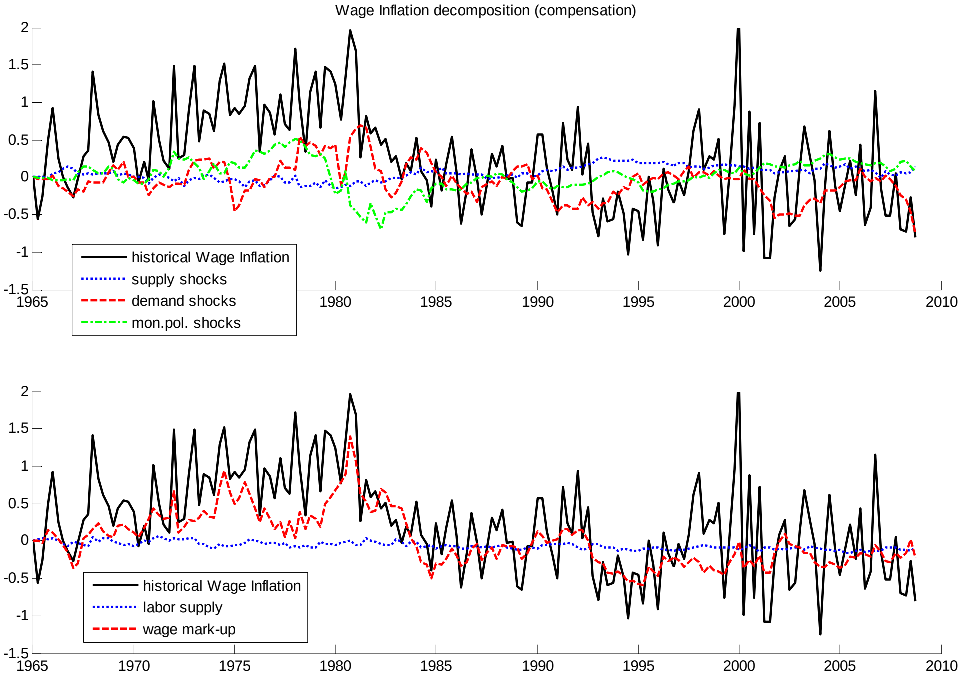


Figure 10
Actual and natural unemployment

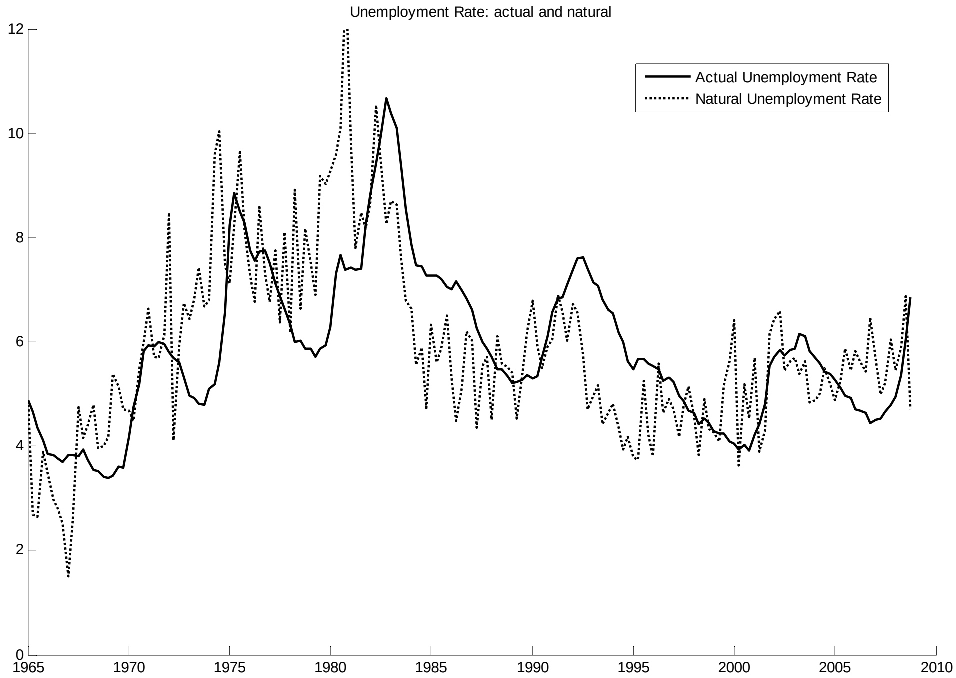
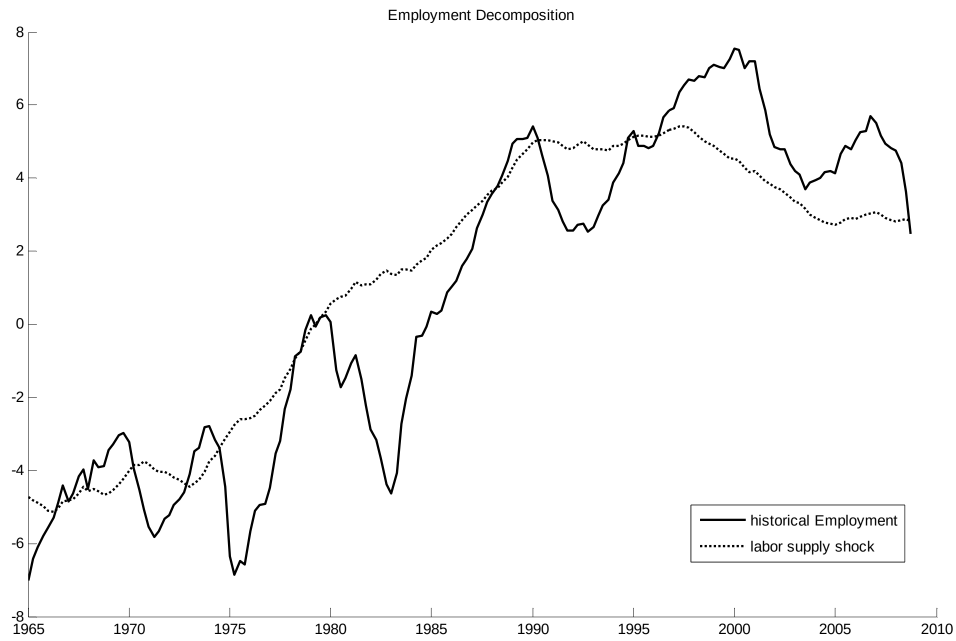


Figure 11
Employment and contribution of labour preference shock



Appendix

Data plots

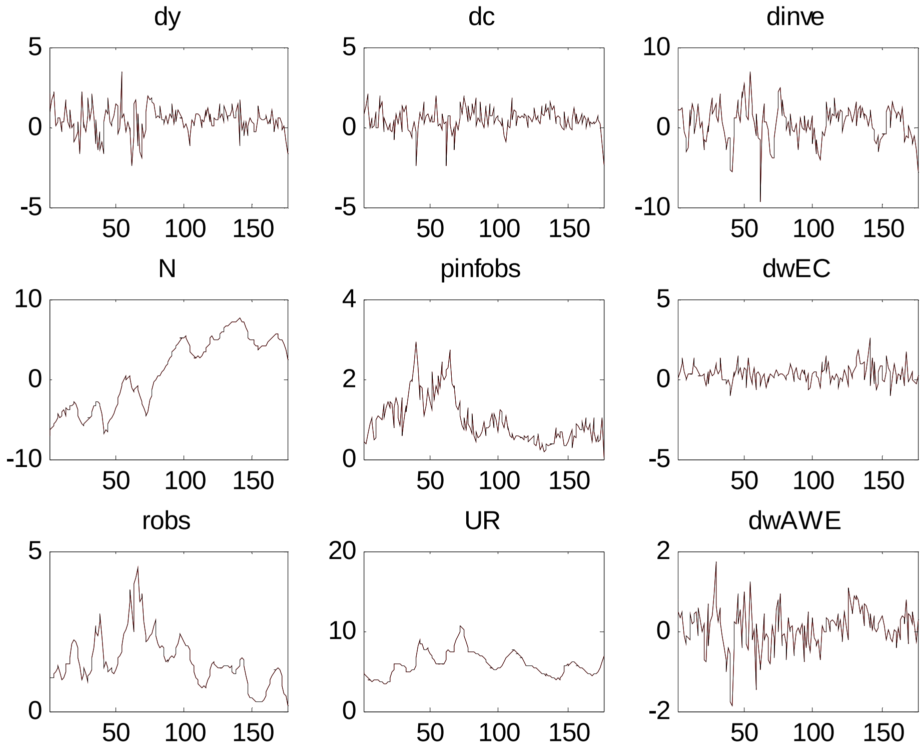


Table A.1: Estimation results for six model versions:

Parameters		Prior Assumptions			GJRWs based on dwEC		GJRWsc_UR based on dwEC		GJRWs based on dwAWE free cwtrend		GJRWsc_UR based on dwAWE free cwtrend		GJRWs_dwAWE dwEC + dwAWE free cwtrend measurement error		GJRWsc_UR_dwAWE dwEC + dwAWE free cwtrend measurement error	
		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
cprobw	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
cprobp	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	monpol 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	monpol 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	monpol 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	monpol 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/Δlabstar=>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

(Source: ESTIMATION Results in Table format_oct2009.xls)

Notes:

Based on dwEC: employee compensation

GJRWs : benchmark version of SW

GJRWsc_UR : adding UR and labor supply

Based on dwAWE: average weekly earnings (free trend growth rate for real wage)

GJRWs : benchmark version of SW

GJRWsc_UR : adding UR and labor supply

Based on dwEC+dwAWE (free trend growth rate for real wage and two measurement errors)

GJRWs_dwAWE : benchmark version of SW

GJRWsc_UR_dwAWE: adding UR and labor supply

Table A.2: Estimation results for versions of the benchmark model (GJRWsc_UR_dwAWE)

					GJRWsc_UR_dwAWE		GJRWsc_UR_dwAWE with correlation (ea,els)		GJRWsc_UR_dwAWE with ea = cal*els		GJRWsc_UR_dwAWE with wc = w+tax	
Parameters		Prior Assumptions										
		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
cmap	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)						-1045.0		-1012.7		-1006.8		-1017.8
mode log posterior						-949.7		-914.84		-907.96		-915.69

- version in Table 1
- version with correlation between (ea,els)
- version with causality from els to a process
- version with tax shock explaining link between the two wage concepts instead of a free constant

Table A.3: Variance decomposition:
Baseline model without unemployment:

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

Baseline model with unemployemnt

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	73.45	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	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