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NON-LINEAR DYNAMICS OF REAL WAGES OVER THE BUSINESS CYCLE

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This paper aims at analysing the dynamic properties of real wages over the business cycle. We apply a Bayesian vector autoregressive (BVAR) model and analyse the possible asymmetric behaviour of real wages in response to different macroeconomic shocks. Finally, we use the NBER business cycle periodisation to evaluate how real wages interact with the different shocks during contractions and booms. The results indicate that real wages cyclicality substantially depends on the driving forces of business cycle fluctuations. Different time periods are dominated by different types of shocks. When the business cycle is mainly driven by supply-side shocks real wages present a pro-cyclical behaviour. On the contrary, when the business cycle is driven by aggregate demand shocks real wages move counter-cyclically.

JEL classification codes: E32, J31, C32
Key words: business cycle, real wage dynamics

I. Introduction

This paper aims at analysing the dynamic properties of real wages over the employment cycle.[1] An increasing amount of empirical literature focuses on the dynamic behaviour of real wages over the business cycle. In contrast with the prescriptions of both classical

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[1] In the following, we use employment cycle as a proxy of the business cycle. There exists a large quantity of empirical literature indicating that the US employment cycle roughly corresponds to the timing of the NBER business cycle in the sense that contractions and expansions occur at approximately the same time as the NBER recessions and booms.

and neo-Keynesian models, some empirical evidence suggests a high degree of real wage pro-cyclicality. In particular, the results emerging by analysing the contemporaneous correlation between real wages and a cyclical variable with both panel-data and OLS models clearly indicate a pro-cyclical movement of real wages.[2]

Other studies use VAR models to estimate the dynamic interaction of real wages and a business cycle indicator such as employment or output. These studies have produced mixed evidence. While Neftci (1978) and Sargent (1978) found that real wages are countercyclical, the results obtained by Geary and Kennan (1982) suggest an acyclical movement of real wages. Lastrapes (2002) suggest that the contradicting evidence on real wage cyclicality crucially depends on model specification, data transformation to induce stationarity, the choice of proxy for the aggregate real wage, and the choice of variables to include in the VAR.

Finally, other authors, including Blanchard and Quah (1989), Gamber and Joutz (1993), Mocan and Topyan (1993), Fleishman (1999), Balmaseda et al. (2000), use structural VAR models. In general, they find that real wages are pro-cyclical in response to supply shocks (like a technology shocks or oil price shocks) but are counter-cyclical in response to aggregate demand shocks.

The present paper models the dynamic relationship between employment and real wages by employing a Bayesian VAR framework. In particular, we use a multivariate model and analyse whether the dynamic interactions between employment and wage depends on the business cycle phases. The idea is that different variables might have influenced the dynamic pattern of real wage over the business cycle phases.

The contribution of our paper with respect to the existing literature consists of applying a Bayesian VAR model in order to study whether the degree of cyclicality of real wages might change over the business cycle. In particular, the study analyses possible reactions followed by employment and wages to different macroeconomic shocks and proposes a possible explanation for the cyclical behaviour of real wages over the business cycle. This explanation is essentially based on the analysis of the nature of negative and positive shocks influencing the business cycle over the selected sample period.

The remainder of the paper proceeds as follows. In Section II, we employ a vector autoregressive model thought to be representative of the main dynamics governing employment and wages over the business cycle. In Section III, we apply an impulse response analysis and characterize the behaviour of employment and wages over the

[2] See Bils (1985) and Solon et al. (1994), Otani (1980), Sumner and Silver (1989), Abraham and Haltiwanger (1995), Basu and Taylor (1999) and Hart and Malley (2000).

business cycle. In Section IV historical decomposition analysis evaluates the relative importance of different macroeconomic disturbances on real wages time pattern during specific business cycle phases. In Section V, concluding remarks end the paper.

II. Model and estimation

The conventional approach to measuring the cyclical behaviour of real wages consists of employing bivariate linear models in order to asses the dynamic relationship between real wage growth and some measure of the cycle such as unemployment or employment growth. Moreover, these studies usually avoid the possibility that the degree of cyclicality of real wages might vary over the business cycle. The purpose of our empirical analysis is to explore whether real wage dynamics might be asymmetrically influenced by different macroeconomic shocks hitting the economy during recession and expansion.

The data used in the empirical analysis are seasonally adjusted quarterly observations for the United States.[3] The sample period goes from 1965:1 to 2008:1. Table 1 displays the mean and the variance of both employment growth and real wages over different business cycle phases. The sample is divided according to the

Table 1. Moments of historical data

	Employment growth		GDP growth		Real weekly earnings		Real Compensation	
	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
Recession								
1973:4-1975:1	-0.13	12.96	-1.45	11.13	-5.27	6.16	-0.48	3.21
1980:1-1980:3	-0.78	3.55	-2.49	24.35	-6.30	30.25	0.00	1.09
1981:3-1982:4	-1.87	1.98	-0.95	18.57	-1.59	2.86	0.75	5.68
1990:3-1991:1	-1.23	0.38	-1.68	2.43	-3.44	4.00	-0.50	3.64
2001:1-2001:4	-1.04	1.49	0.23	2.00	0.61	2.69	2.15	11.07
2007:4-2008:1	0.51	0.90	0.77	0.07	-2.18	1.70	-1.75	2.21
Expansion								
1971:1-1973:3	3.24	2.01	5.20	16.80	2.19	11.68	2.48	6.17
1975:2-1979:4	3.45	3.90	4.37	14.53	-0.77	9.99	1.27	7.73
1980:4-1981:2	1.92	1.00	4.13	39.58	-0.35	1.75	0.03	0.76
1983:1-1990:2	2.84	1.29	4.26	4.80	-0.38	4.35	0.78	5.85
1991:2-2000:4	2.02	1.22	3.50	3.17	0.68	2.18	1.64	9.95
2002:1-2007:3	0.86	1.12	2.84	2.45	0.32	3.89	1.13	10.84

[3] See Appendix A for a detailed description of the data used in the empirical analysis.

chronology of the U.S. business cycle identified by the NBER's Business Cycle Dating Committee (the sample period covers 6 recessionary episodes and 6 expansionary episodes). We also report the same statistics for the GDP growth rate and for the real wage measured with real compensation.

As expected, the mean of employment growth is negative during recession and positive during expansion. As we only have two observations for the last recession, we decided to end the sample period of our empirical analysis in 2007:3. This means that we do not analyse the dynamic behaviour of real wage over the last recessionary phase started in 2007:4.

Our reference model is a structural VAR, where the set of endogenous variables contains the growth rate of the world oil price (π_t^{oil}), the employment growth rate (n_t), the inflation rate (π_t), the growth rate of real wages (w_t), and the federal funds rate (i_t). The model can be summarized as follows:

$$A(L)y_t = \mu + \varepsilon_t, \tag{1}$$

where $y_t = \left[\pi_t^{oil}\ n_t\ \pi_t\ w_t\ \ i_t\right]'$; ε_t is a vector of VAR innovations, $A(L)$ is a polynomial matrix in the lag operator, and μ is a constant term. The lag structure has been chosen by employing standard lag-length selection statistics for VAR models. Following the results of the Schwarz and Hannan and Quinn information criteria we impose two lags.[4] The innovations are related to a vector of VAR structural shocks with mean zero and a diagonal variance-covariance matrix through the relation $\varepsilon_t = A_0 v_t$. The identification scheme is easily summarized then in the following contemporaneous structure:

$$A_0 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix}.$$

It should be noted that the recursive scheme give rise to an exactly identified model.[5] We also consider uncertainty about the parameters of the model, and assume

[4] We also check for robustness using alternative lag lengths. Changing the lag structure by imposing three or four lags does no affect our results. Results are available upon request.

[5] See Appendix B for robustness analysis.

that they are random variables. Standard Bayesian techniques are employed to estimate the VAR (see, e.g., Sims and Zha 1998), and produce posterior distributions of quantities of interest. If our degree of uncertainty is high, we can attach a diffuse prior on the parameters. This has the advantage that posterior densities will be centred on OLS estimates.

Concretely, the VAR can be rewritten (e.g. Altavilla and Ciccarelli 2010) as:

$$y_t = \left(I \otimes X_t\right)\beta + \varepsilon_t, \tag{2}$$

where ε_t is the vector of VAR innovations assumed to be *i.i.d* $N(0,\Sigma)$. It is easy to show that by combining the likelihood function of this model with the diffuse prior information $p\left(\beta,\Sigma\right) \propto \left|\Sigma\right|^{-\frac{n+1}{2}}$, the joint posterior $p(\beta,\Sigma|Y)$ is a Normal-Inverse Wishart distribution, with:

$$p\left(\Sigma|Y\right) = iW\left[\left(Y - \mathbf{X}\widehat{B}\right)'\left(Y - \mathbf{X}\widehat{B}\right), T - k\right], \tag{3}$$

$$p\left(\beta|Y,\Sigma\right) = N\left[\widehat{\beta}, \Sigma \otimes \left(\mathbf{X}'\mathbf{X}\right)^{-1}\right], \tag{4}$$

where $\widehat{\beta}$ and $\widehat{\Sigma}$ are the OLS estimates of β and Σ; $\widehat{\beta}$ and $\mathbf{X}$ are the matrix versions of $\widehat{\beta}$ and X_t, respectively. Therefore, inference on any functions of the parameters is easily conducted by first sampling Σ and then, given this draw, by sampling β. Impulse response functions are then derived accordingly, and their associated uncertainty stems directly from the uncertainty surrounding the parameters of the model.

Given that the identification scheme is exact, there is a one-to-one mapping between Σ and A_0, and therefore it is relatively easy to recover the latter from the former. Uncertainty about Σ will translate into uncertainty about A_0.

III. Impulse-response analysis

Having estimated the model, it is now possible to apply the impulse response analysis. The natural object of this analysis is to measure the time profile of the incremental effect of variables' innovation on the future state of the economy.

The use of the impulse response functions in the analysis requires a priori identification of the fundamental disturbances in the system. As stressed above, the model is identified by assuming a recursive structure. The restricted model allows for a simultaneous feedback from real wages to employment growth but not vice versa. This structure implies that real wages contemporaneously react to changes in employment, but it is not able to affect the employment growth within the same quarter. Moreover, the standard restriction in the closed economy (namely that macroeconomic variables do not simultaneously react to policy variables, while the simultaneous reaction from the macroeconomic environment to policy variables is allowed for), is imposed by placing employment and inflation above the interest rate in the ordering. Precisely, as widely accepted in the empirical monetary policy transmission literature, the nominal interest rate is ordered last. The resulting lower triangular matrix is exactly identified.[6]

The estimated responses to a 1% shock to the endogenous variables are reported in Figure 1.[7] We also report a 68% Bayesian credible interval for each response. These intervals reflect the uncertainty surrounding the parameters of the estimated model - as measured by the distance between the 84th and the 16th percentile.

Moreover, Table 2 outlines some key characteristics of the estimated response functions. In particular, it gives information about the maximum impact and the cumulative responses of the employment and real wage to different macroeconomic shocks. The table also considers the time that a shock takes to exert its maximum effect on the two variables of interest, as well as the time that it takes to die out.

Figure 1 shows that real wages move procyclically in response to an oil price shock. More specifically, from Table 2 we can observe that an oil price shock produces a cumulative reduction in the employment growth of 150 basis points while real wages decreases by almost 130 basis points after 24 quarters. The timing of the responses is quite dissimilar. While the employment reaction reaches its maximum effect (almost 30 basis points) after 7 quarters, the maximum response of real wages is faster and deeper: more than 40 basis points after 2 quarters.

These results are in line with the large literature focusing on the theoretical and empirical understanding of the macroeconomic consequences of oil price shocks (e.g. Hamilton 1983, 1996; Hooker 1996, 2002). As stressed in Huang et al. (2004) the bulk of evidence produced with different types of data, sample periods, real wage definitions, and estimation procedures clearly suggests that real wages have switched from being countercyclical to being pro-cyclical before the onset of major oil price shocks in the 1970s.

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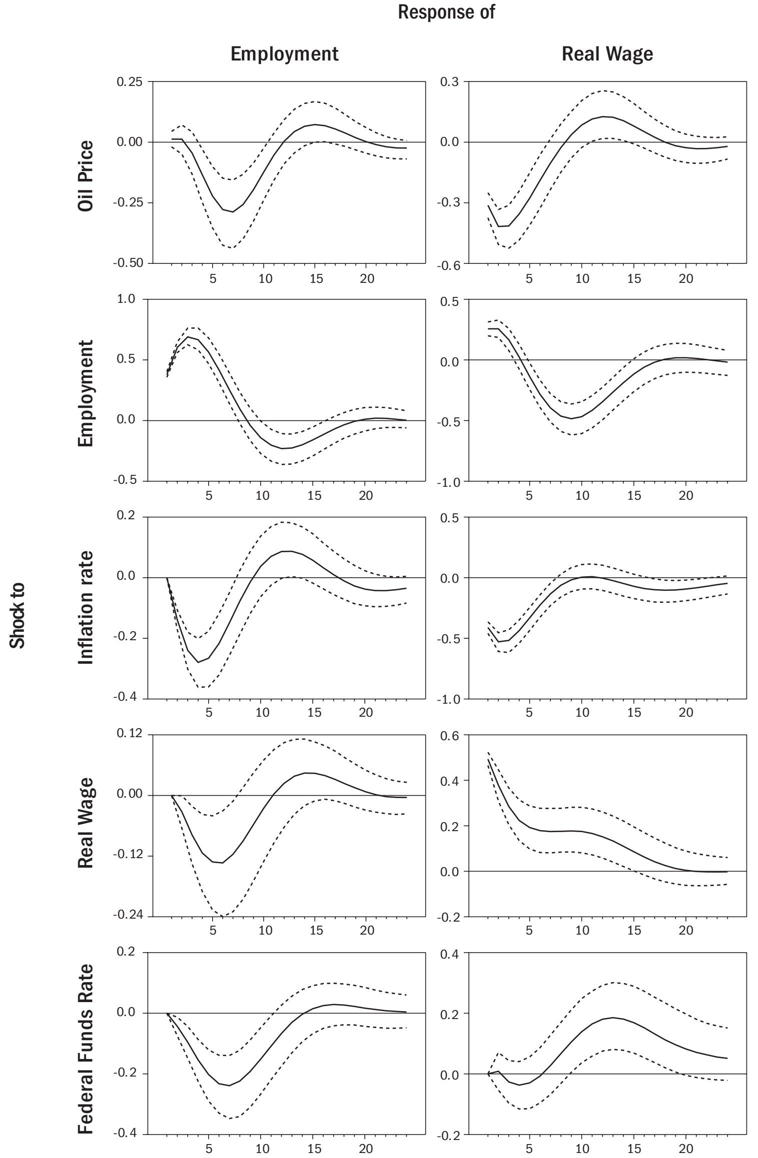
[6] In general, this is achieved by imposing $k(k-1)/2$ exclusion restrictions above the main diagonal of the structural matrix B. Where k is the number of variables.

[7] In order to analyse whether our results for interest rate might be influenced by the inclusion of the inflation rate in the model, we also simulate the same model without inflation. Detailed results are reported in Appendix B.

Figure 1. Impulse response analysis



Moreover, the observed short-term pro-cyclicality of real wages in response to oil price shocks is theoretically consistent with the notion of oil price shocks as aggregate supply shocks. More precisely, given labour and capital inputs, an increase in oil prices affects the marginal cost of production and then shifts the aggregate supply curve upward and to the left along a stable aggregate demand curve reflecting a lower supply. As a consequences, output decreases and prices increase. If the degree of rigidity of nominal wages is higher than the one of the nominal prices, the rise in the price level leads to a decrease in the real wage.

Although our model does not explicitly take into account the wage-setting process, we can still gain some insights by asking how labour market institutions might influence the observed procyclical movement of the real wage to inflation and oil price shocks.

Recent papers (e.g., Dickens et al. 2007; Holden and Wulfsberg 2008) have shown that downward nominal wage rigidity is associated with higher union density. This evidence can be rationalized by analyzing how unions might react when facing an adverse shock. More precisely, if unions internalize the macroeconomic consequences of their strategy, inflation volatility will be lower in countries where the wage bargaining systems is highly centralized.

Consider for instance a negative supply shock leading to a rise in inflation that in turns translates into a slow-down in real economic activity. In order to compensate the loss in purchasing power leading from the increase in inflation, workers might claim higher nominal wage. In countries where there is a high degree of nominal wage flexibility (i.e., with weaker unions) the initial supply shock will be amplified as firms face higher production costs. On the contrary, in countries where there is a centralized wage-setting mechanism, unions internalize the macroeconomic costs of their high wage claims, and let real wages adjust. As a consequence, country with higher nominal wages flexibility, such as US, experience higher real wage procyclicality.

Figure 1 also depicts the effect of an aggregate demand shock on real wages and employment. From a theoretical point of view, when a demand shock hits the economy, the real wage may move procyclically or countercyclically according to the relative stickiness of prices and wages. In the context of sticky-price models, a strong procyclical relationship between real wage and employment arises (see e.g. McCallum 1986; Gamber and Joutz 1993). In sticky-wages models, nominal wage rigidity reinforces the countercyclical response of the real wage to demand shocks and the real effect of these shocks on output growth. As a consequence, a strong countercyclical relationship between real wages and employment arises. Huang et al. (2004) develop a dynamic general equilibrium model that analyses where, depending on the interaction between nominal wage and price rigidities, demand-driven business cycle fluctuations produce counter-cyclical movements in real

Table 2. Estimated response function features of the benchmark model

Responses of employment					
Shock to	Oil price	Employment	Inflation	Real wage	Interest rate
Maximum effect	-0.29	0.69	-0.28	-0.13	-0.24
Cumulative effect	-1.28	2.31	-1.16	-0.52	-1.57
Time to maximum	7	3	4	5	6
Time to die out	12	8	10	11	14
Responses of real wage					
Shock to	Oil price	Employment	Inflation	Real wage	Interest rate
Maximum effect	-0.42	-0.48	-0.53	0.49	0.19
Cumulative effect	-1.50	-2.90	-3.54	3.24	1.94
Time to maximum	2	9	2	1	13
Time to die out	9	18	10	20	24

wages. Swanson (2004), for example, uses industry data and finds that the majority of sectors have paid real product wages that vary inversely (that is, counter-cyclically) with the state of their industry. Also Spencer (1998) found that a positive shock to aggregate demand causes a significant temporary fall in real wages in the post-war United States.

Other authors have analyzed the reaction of real wages to monetary shocks during the post-war period in United States. Some studies, including Barth and Ramey (2001), Christiano et al. (1997) and Blanchard and Quah (1989) suggest that the dynamic reaction of real wages to monetary shocks has changed over time. More precisely, contractionary monetary shocks were followed by an increase in real wages during the interwar period and by a fall in real wages during the post-war period. These findings corroborate the results obtained by Gamber and Joutz (1997) that real wages respond positively to money supply, or aggregate demand shocks, implying that nominal output prices are more rigid than wages in the face of such shocks.

Contrary to these findings, Figure 1 shows that real wages move countercyclically in response to an aggregate demand shock. More precisely, while real wages increase, the employment growth decreases. The estimated effect of an interest rate shock on employment look reasonably well behaved and give rise to the usual hump-shaped dynamics (see, e.g., Altavilla and Ciccarelli 2009, and references therein). The response of real wages reaches a maximum of almost 20 basis points after 13 quarters, whereas the reaction of employment is negative and more rapid: -24 basis points after 6 quarters.

The evidence reported in Figure 1 indicates a pronounced asymmetry in the cyclical behaviour of the real wage and employment in response to different macroeconomic shocks. The positive reaction of real wages to contractionary monetary policy shocks as well as the decrease of real wages in response to a positive employment shock suggests a counter-cyclical dynamics of real wage during periods dominated by demand-type shocks.

The results obtained are in line with the implications of the sticky-wage models. In fact, a possible explanation for these results is that price inflation increases faster than nominal wage inflation in the face of demand shocks. As a consequence, price flexibility moderates the rise in real wages and output growth during expansions. This hypothesis is empirically supported by several studies. Cogley (1993), for example, using a VAR methodology to test the neutrality of money, finds that nominal wages are stickier than nominal prices.

Overall, the empirical results clearly indicate that real wages cyclicality substantially depends on the driving forces of business cycle fluctuations. Different time periods are dominated by different types of shocks. When the business cycle is mainly driven by oil price shocks real wages present a pro-cyclical behaviour. On the contrary, when the business cycle is driven by aggregate demand shocks real wages move counter-cyclically.

IV. Historical decomposition of real wages

The theoretical plausibility of competing explanations for the real wage's cyclical behaviour has stimulated great interest to establish their empirical validity. As stressed above, several authors (e.g., Sumner and Silver 1989; Hooker 2002; Lastrapes 2002) suggested that real wage cyclicality crucially depends on the sample period chosen. This particular feature suggests that analysing how different macroeconomic variables have influenced the dynamics of real wages over different periods would help produce a better assessment of real wage cyclicality.

In the present section, we employ a historical decomposition analysis over different sub samples that strictly reflect the business cycle phases as identified by the NBER's Business Cycle Dating Committee. In order to characterise the relationship between real wage cyclicality and the nature of the shocks driving the business cycles, we analyse the contribution of oil price, employment, inflation and nominal interest rate to real wages movements.[8]

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[8] See Appendix A for a detailed description of the data used in the empirical analysis.

Starting from the model estimated above, the historical decomposition (see Sims 1980) is based on a reorganization of the moving average representation of the following form:

$$y_{T+j} = \sum_{s=0}^{j-1} A_s \varepsilon_{T+j-s} + \left[X_{T+j}\beta + \sum_{s=j}^{\infty} A_s \varepsilon_{T+j-s} \right], \tag{5}$$

where the first sum is the part of y_{T+j} due to innovations in periods $T+1$ to $T+j$ (where j is the forecast horizon); the term in square brackets represents the forecast of y_{T+j} given data through T; and, X is the deterministic part of y_{T+j}. In other words, the historical values of real wage are decomposed into a base projection and the accumulated effects of current and past endogenous variables' innovations.

Figure 2 shows the historical decomposition for the first recessionary period (1973:4-1975:1). The solid black lines show the actual path of real wages. The dashed lines show the base projection made using shocks in all variables up to 1973:4 and assuming no further shocks occur thereafter. The solid grey lines show the sum of the base projections and the effect of each endogenous variables' innovations after 1973:4. A visual inspection suggests that a large part of the difference between actual real wages and the base forecast can be attributed to oil price and inflation. This means that shutting down oil price and inflation during these years would have resulted in higher real wages. Moreover, during the same years, the contribution of interest rate and employment in reducing the forecast errors in real wages is negligible. This means, as expected, that during the period 1973-75 the dynamic of real wages has been highly dominated by supply shocks.

Figure 3 displays the average contribution of each selected variable to the fluctuation of real wages over the business cycle phases.[9] Again, the chronology of the business cycle phases follows the one identified by the NBER's Business Cycle Dating Committee. This means, for example, that the information contained in Figure 1 is summarized in the black bars at the top panel (Recession) of Figure 3. The figure clearly indicates that different variables have influenced the dynamic of real wages over the sample. Oil price and inflation largely affected real wage movements during the recession of the early 1970s. On the contrary, the contribution of employment growth to the fluctuation of real wages was considerably larger in 1981–82 and in 2001. Finally, the variable that contributed the least to changes in real wages over the different recessionary episodes is the interest rate. These results

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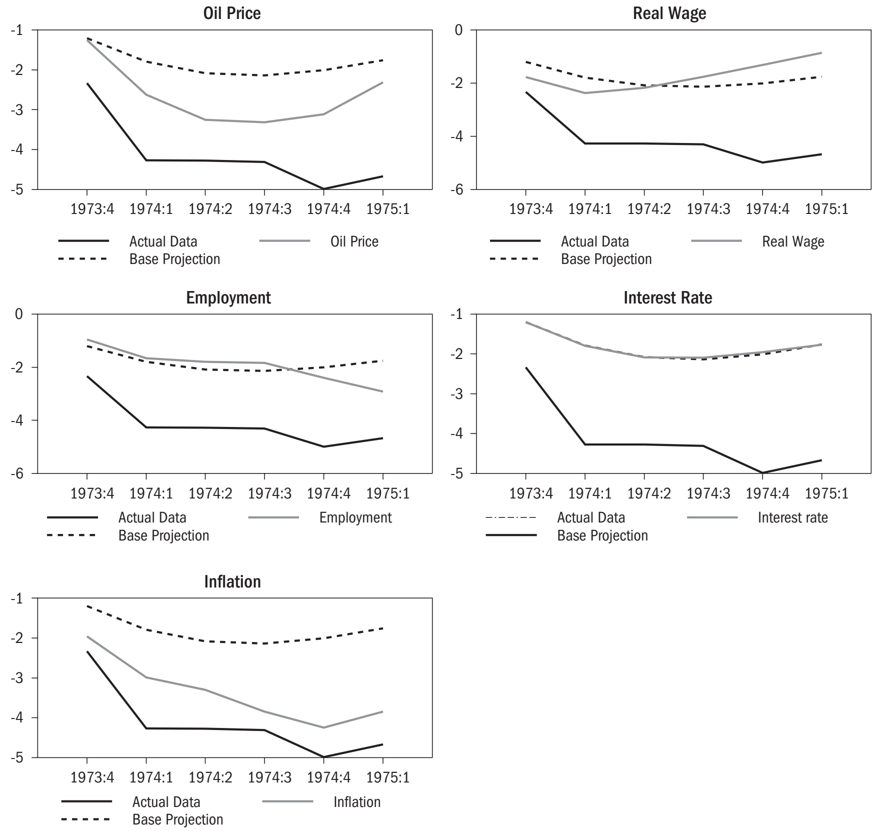
[9] See Appendix C for a more detailed figure on historical decomposition analysis.

Figure 2. Historical decomposition (1973:4-1975:1)

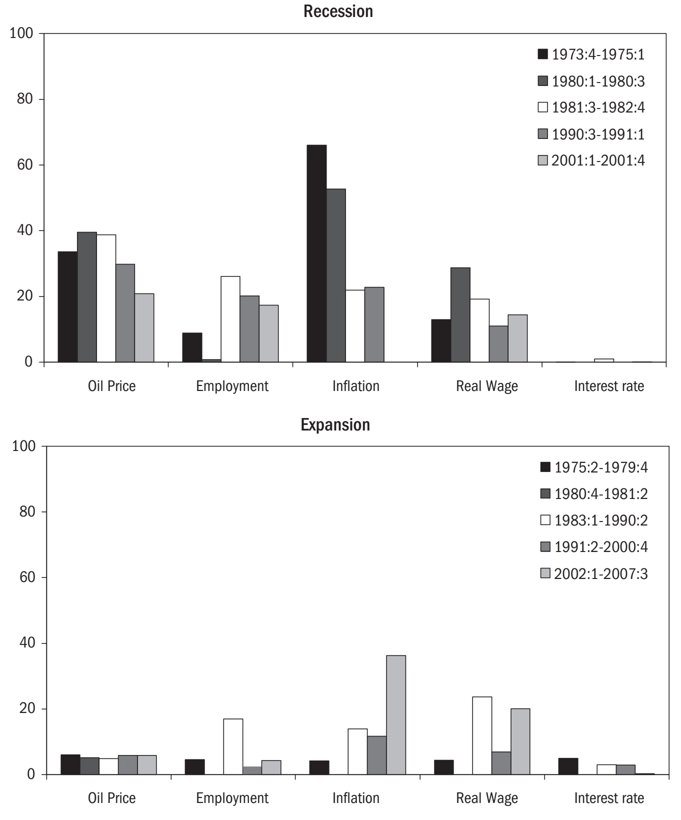


are in line with the findings of several empirical studies (see, e.g., Christiano et al. 2005) suggesting that monetary policy shocks account for only a small fraction of real wage dynamics.

Focusing on the expansionary periods, Figure 3 (bottom panel, Expansion) reveals a smaller contribution of oil price to real wage movements. In general, the dynamics of real wage over the expansionary phases of the business cycle is mostly influenced by the inflation rate and the real wages itself. Notwithstanding, the employment growth significantly contributed to the real wage dynamics during the 80s.

Overall, supply developments appear to play a relatively more important role than demand developments. Interest rate shocks only play a minor role in driving real wages dynamics over the business cycle. Linking the evidence coming from the impulse response analysis with the results of the historical decomposition, we

Figure 3. Historical decomposition – average contribution across cycles



might conclude that real wages are mainly pro-cyclical in the US. Our findings are also in line with the results obtained by Messina et al. (2009). They argue that the degree of real wage cyclicality might substantially depend on the labour market institutions. Differences in the functioning of labour markets might lead to different reactions of real wages to macroeconomic shocks. More precisely, they find that more open economies and countries with stronger unions tend to have less pro-cyclical (or more counter-cyclical) wages.

V. Concluding remarks

This paper evaluated the dynamic properties of real wages over the business cycle. We employed Bayesian vector autoregressive methodologies and analyse whether the relationship between employment and wages might depend on the different macroeconomic shocks hitting the economy over the business cycle.

We have applied an impulse response analysis in order to characterize the behaviour of employment and wages in response to different shocks. Simulation analysis substantially supported the findings that real wage cyclicality depends on the sources of business cycle fluctuations. More precisely, when the business cycle is mainly driven by supply side shocks, real wages present a pro-cyclical behaviour. On the contrary, when the business cycle is driven by aggregate demand shocks, real wages move counter-cyclically.

In the last part of our empirical analysis, we use a historical decomposition analysis to identify the sources of fluctuations in real wages during the business cycle. We have analysed the contribution of different macroeconomic variables to the fluctuation of real wages over different business cycle phases.

Summarizing, the historical decomposition suggests an important contribution of oil prices and inflation to real wage fluctuations during the early 70s recession. However, this contribution declined in the late 1990s. On the contrary, interest rate only exerts a minor role in driving real wages over the different business cycle phases. Overall, supply developments appear to play a relatively more important role than demand developments.

Appendix

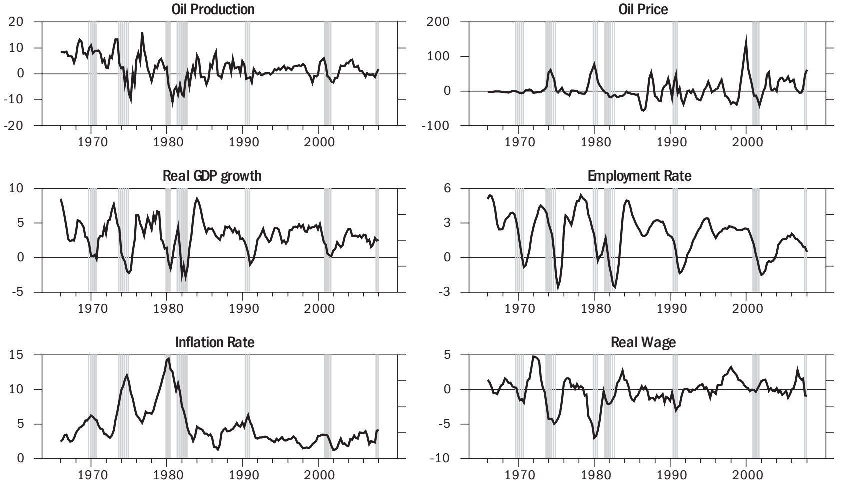
A. Data description

The data used in the empirical analysis are seasonally adjusted quarterly observations for the United States. The sample period goes from 1965:1 to 2008:1. Specifically, data on real wages (average weekly earnings, 1982 dollars; series Id: CES0500000031), employment (total nonfarm, all employees; series Id: CES0000000001), CPI (consumer price index - urban wage earners and clerical workers; series Id: CWUR0000SA0), were drawn form the Bureau of Labor Statistics. Data on real GDP (real gross domestic product, series Id: GDPC96) were drawn form FRED® (Federal Reserve Economic Data). Data on world oil production and oil price (the refiner acquisition cost of imported crude oil) were taken from the US Department of Energy (DoE).[10]

[10] We are grateful to Christiane Baumeister and Gert Peersman for sharing these data. More details on the selected oil variables can be found in Baumeister and Peersman (2008).

Figure A1 displays the time profile of the variables used in the empirical analysis (solid lines). The shaded area in each graph represents recessionary time periods as identified by the NBER business cycle dating committee.

Figure A1. Variables used in the empirical analysis



B. Impulse response robustness analysis

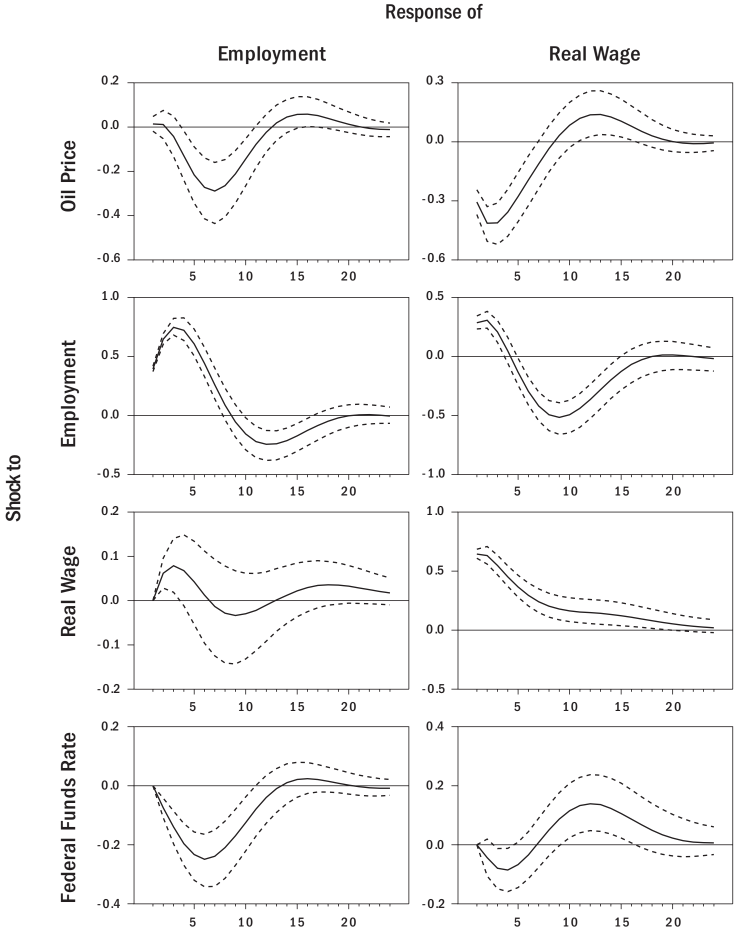
We examine the robustness of the simulation results by adopting two alternative recursive identification schemes where the ordering of the variables is $\left[n_t\ \pi_t^{oil}\ \pi_t\ w_t\ \ i_t\right]'$ and $\left[\pi_t^{oil}\ \pi_t\ n_t\ w_t\ \ i_t\right]'$, where the contemporaneously exogenous variables are ordered first. Moreover, we have also estimate the model using real compensation instead of real weekly hearings and real GDP growth instead of employment growth. We also added oil production as an additional variable in our VAR. Despite some differences, the evidence emerging from this analysis suggests that the size and the timing of the real wage responses are similar across the identification schemes. (To save space, these simulations are not presented, but all results can be made available upon request).

Finally, in order to analyse whether our results for interest rate might be influenced by the inclusion of the inflation rate in the model, we simulate the model without inflation. This means that the model we estimate and simulate can be summarized as follows:

$$A(L)y_t = \mu + \varepsilon_t, \qquad \text{(A1)}$$

where $y_t = \left[\pi_t^{oil}\ n_t\ w_t\ \ i_t\right]'$. As shown in Figure A2, results on real wage cyclicality remain substantially unchanged.

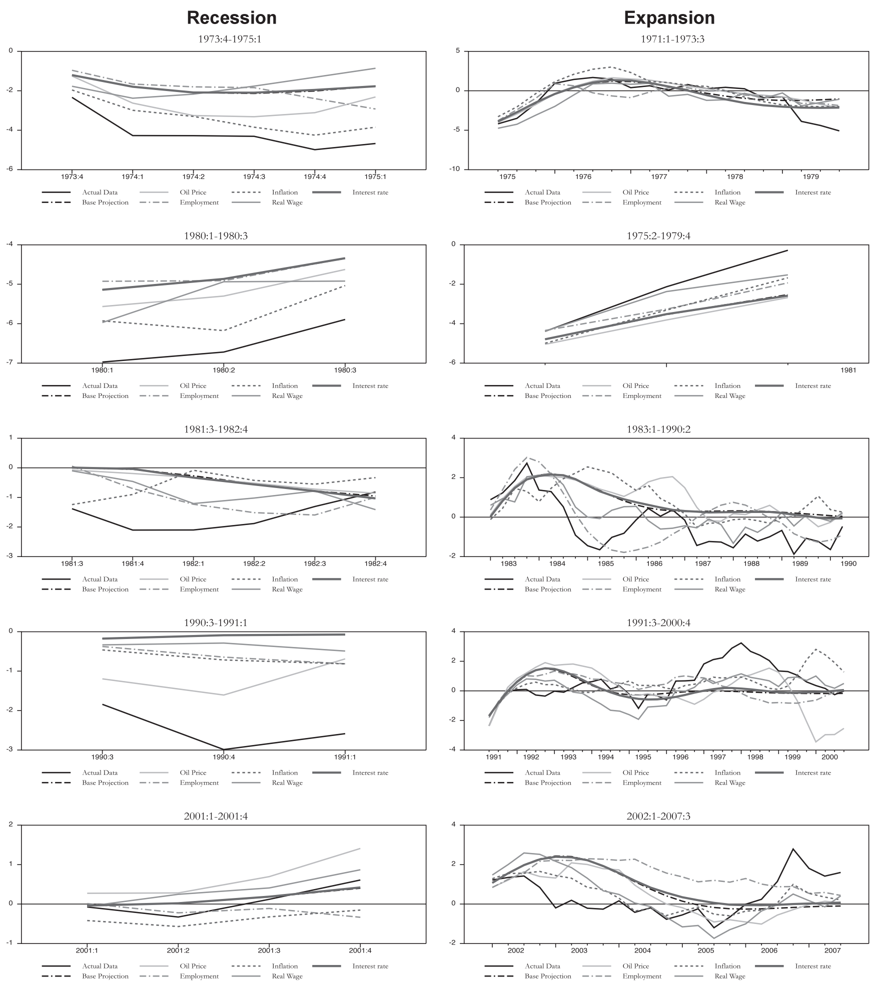
Figure A2. 4-variable BVAR impulse response analysis



C. Historical decomposition

Figure A3 depicts the results of the historical decomposition analysis for each business cycle phases as identified by the NBER's Business Cycle Dating Committee.

Figure A3. Historical decomposition analysis – all sub-samples



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