Wage, Productivity and Unemployment Microeconomics Theory and Macroeconomic Data

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Abstract

We confront microeconomic theory with macroeconomic data. Unemployment results from two main micro-level decisions of workers and firms. Most of the efficiency wage and bargaining theories predict that over the business cycle, unemployment falls below its natural rate when the worker's real wage exceeds the reservation wage. However, these theories have weak empirical support. Firm's decision predicts that when the worker's real wage exceeds the marginal product of labor, unemployment increases above its natural rate. Accounting for this microeconomic decision helps explain almost all the fluctuations of U.S. unemployment.

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1. Introduction

The U.S. unemployment rate increased between December 2007 and June 2009 because of the Great Recession, but began to fall, slowly since the early 2010. It dropped from 9.8 percent in March 2010 to 6.7 percent in March 2014. This is still higher than the average unemployment rate of 5.8 percent over the period 1948-2014. Labor market outcomes, especially the unemployment rate, are critical to U.S. monetary policymakers.

The modern theories of unemployment include, for example, efficiency wage (e.g., Shapiro and Stiglitz, 1984) and the dynamic search and matching (e.g., Mortensen and Pissarides, 1994). The empirical support for efficiency wage and dynamic search and matching models is weak. Dynamic search and matching models of unemployment predict that the volatility of the employment – vacancy ratio and average labor productivity are the same while the U.S. data show that the standard deviation of the unemployment-vacancy ratio is 20 times larger than that of average labor productivity, Shimer (2005).

Essentially, one cannot analyze unemployment dynamic without analyzing the relationship between wages, productivity, and unemployment. Efficiency wage and bargaining models have such relationship, which is called the wage curve, e.g., Blanchflower and Oswald (1994). Blanchard and Katz (1997) show that models of unemployment based on efficiency wages, matching or bargaining models, and competitive wage determination, all generate such a wage curve relationship. In the wage curve, the dependent variable is the natural log of real wage. The independent variables are the natural log of the reservation wage, the productivity level, and the rate of unemployment (could be a natural log-transformed measure of unemployment). Given the level of productivity, the relationship between the log of real wages relative to the reservation wage, and the unemployment rate, is negative. These theories interpret this correlation that when unemployment is high, the real wage falls – given productivity.

However, there is a microeconomic interpretation. A worker faced with a decision to accept or reject a job with a particular wage offer would take the job if the real wage rate is greater than his or her reservation wage, given the level of productivity. Hence, the unemployment rate to fall. The worker rejects the job offer if the real wage is less than his or her reservation wage, hence, unemployment increases. However, these models do not account for another important decision, i.e., the firm's decision. In the Beveridge curve (BC) analysis of vacancy and unemployment, for example, there is no representation of the firm's demand for labor, Daly *et al.* (2012). They suggested adding a "job creation curve" to the BC. The decision is that firms continue to hire workers over the business cycle as long as the real wage rate is less than the marginal product of labor; stops hiring when the real wage is equal to the marginal product of labor; and layoffs workers when the real wage is higher than the marginal product of labor.

The objective of this paper is to examine the effects of these two micro-level decisions on unemployment. We explain unemployment dynamics by empirically testing the contributions of the two important micro-level decisions. We will show that the first decision could explain up to 50 percent of the dynamics of unemployment, and that the weak empirical support of unemployment theories is due to ignoring the firm's decision. The firm's decision and the worker's decision together explain almost all the fluctuations of U.S. unemployment.

We use U.S. quarterly data from 1999 to 2013. The data and sources are in the adta appendix. There is one important point that the relationships we are analyzing are those that occur over the business cycle. We show that these two decisions can account for almost all the variations of the U.S. unemployment over the business cycle. The paper is organized as follows. Next, we explain the worker's and the firm's decisions that we call microeconomic level decisions, and how they are related to unemployment. In section 3 we provide measurements and tests. In section 4 we discuss the relationship with the Phillips curve and the wage curve. Section 5 concludes.

2. Microeconomic level decisions and measurements

2.1 The worker's decision

Consider the worker's decision to accept or reject a wage offer, which is the mechanism underlying the wage curve. A worker who faces a decision to accept or reject a wage offer compares the offered real wage to a reservation wage, which is the wage equivalent of being unemployed. The reservation wage is an unobservable variable. If the real wage rate is greater than the reservation wage, the worker accepts the offer, takes the job, and unemployment falls. The opposite is true. Thus, the covariance between the *wage gap, which is the real wage minus the reservation wage,* and the unemployment rate, is negative.

How much of the variation in unemployment over the business cycle is accounted for by this mechanism? To answer this question we have to measure the real wage and the reservation wage. The former is less complicated than the latter, but we do not have a unique way to measure them because expected inflation or expected price level are not directly observable. The best measure must be robust to a variety of measures of expectations.

2.1.1 Measuring the real wage

Let the real wage be $w = W / P^e$, where W is the nominal wage rate, and P^e is the expected price level. We could also adjust the nominal wage to a measure of the expected inflation rate π^e.

We can have a number of measures of P^e and π^e depending on how many different measures of expected inflation we have. We will use the CPI as a measure of the price level. Let the expected price level be a 6-quarter moving average of the CPI. In addition we consider four different measures of expected inflation: (1) a 6-quarter moving average of the rate of change of the CPI; (2) the Philadelphia fed's survey measure of inflation expectations; and (3) the Michigan University's survey measure of inflation expectations. Then we can adjust the average hourly wage rate to these measures of expected price level and expected inflation. We arrive at four different measures of the real wage. Figure (1) plots the HP-filtered measures. The real wage, $w1$, is the associated with average inflation measured as a 6-quarter moving average of CPI inflation; $w2$ is associated with Philadelphia fed's survey measure of inflation expectations; $w3$ is associated with the Michigan University's survey measure of inflation expectations; and $w4$ is associated with the expected price level.

Clearly, these measures are robust to various price and inflation adjustments. However, note that what matters for us is the wage gap, the gap between the real wage and the reservation wage, which we will examine next.

2.1.2 Measuring the reservation wage

The reservation wage is the wage equivalent of being unemployed. Most of the theoretical model of wage setting could be represented by the following wage equation under simplifying assumptions about the functional form and indicators of labor market tightness:

$$\ln w_t = \mu \ln w_t^R + (1-\mu)\ln y_t - \beta u_t + \varepsilon_t , \quad (1)$$

Where w is the real wage, w^R is the reservation wage, y is labor productivity, where labor productivity is GDP/working age population, and u is $\log(U/1-U)$, where uppercase U is the unemployment rate.[i] The parameter μ is [0, 1]. For example, in the efficiency wage model of Shapiro and Stiglitz (1984) – the shirking model – productivity does not influence wages directly, hence $\mu = 1$. In the bargaining models, e.g., Mortensen and Pissarides (1994), $0 < \mu < 1$, since wages depend on the surplus from match, thus on productivity.

Blanchard and Katz (1999) argue that the reservation wage depends on the generosity of benefits (unemployment benefits and other benefits), and other income supports the workers expect to have while they are unemployed. The institutional dependence of unemployment benefits on past wage level, may suggest that the reservation wage also depends on past wages. The reservation wage depends also, on what the unemployed do with their time – the utility of leisure, which may include home production and income that could be earned in the informal sector. The reservation wage may also depend on non-labor income. Under a Harrod-neural technological progress, an increase in productivity leads to an increases in both labor and non-labor income. Thus, the reservation wage may depend on both past wages and productivity levels. They argue that it is “empirically reasonable” to assume that technological progress does not lead to a persistent trend in unemployment, which puts an additional restriction that is the reservation wage is homogenous of degree one in the real wage and productivity in the long run. This is a testable hypothesis, which we will examine later. Blanchard and Katz (1999) assume the following simple illustrative equation for the reservation wage:

$$\ln w_t^R = a + \lambda \ln w_{t-1} + (1-\lambda)\ln y_t + \zeta_t, \tag{2}$$

where $0 < \lambda < 1$.

Thus, we have at least two options to measure the reservation wage. First, we can estimate the State-Space Kalman filter system of equation (1). We experimented with two different specifications, e.g., in levels, log levels, with unemployment, and with cyclical unemployment. We estimate the variances as additional parameters. The log version fits very well.

The signal equation is:

$$\ln w_t = \ln w_t^R + \alpha_1 \ln y_t + \tilde{u}_t + \nu_t; \tag{3}$$

the state equation;

$$\ln w_t^R = \ln w_{t-1}^R + \eta_t; \text{ and} \tag{4}$$

the variance of the shock η_t

$$\sigma_\eta^2 = \alpha_2,$$

which is estimated jointly.

We estimate the system above using a Maximum Likelihood method. The unemployment variable $\tilde{u}$ is the HP-filtered log unemployment as defined earlier, where the symbol ~ denotes the cyclical component. The other measure of the reservation wage is to calibrate equation (2) using a number of values for λ.[ii]

Table (1) reports the correlation coefficients between some estimates of the, HP-filtered, log reservation wage using both of the methods explained above, along with log real wage. We use a sensitivity analysis. The reservation wage data are denoted $w_1^R - w_{10}^R$ in addition to the Kalman filter estimate. The first six estimates $w_1^R - w_6^R$ are from calibrating equation (2), where we impose the homogeneity restriction on equation (2). The values for are given below.

Parameter values used to calibrate $\ln w_t^R = a + \lambda \ln w_{t-1} + (1-\lambda)\ln y_t + \zeta_t$ - Homogeneity restriction imposed	
w_1^R	$[a = 2.65, \lambda = 0.50]$
w_2^R	$[a = 2.65, \lambda = 0.75]$
w_3^R	$[a = 2.65, \lambda = 0.85]$
w_4^R	$[a = 2.65, \lambda = 0.90]$
w_5^R	$[a = 2.65, \lambda = 0.95]$
w_6^R	$[a = 2.65, \lambda = 0.99]$
Parameter values used to calibrate $\ln w_t^R = a + \lambda_1 \ln w_{t-1} + \lambda_2 \ln y_t$ - Homogeneity restriction not imposed so the weights on lagged wages and productivity do not sum up to one	
w_7^R	$[a = 2.65, \lambda_1 = 0.90, \lambda_2 = 0.15]$
w_8^R	$[a = 2.65, \lambda_1 = 0.95, \lambda_2 = 0.10]$
w_9^R	$[a = 2.65, \lambda_1 = 0.95, \lambda_2 = 0.25]$
w_{10}^R	$[a = 2.65, \lambda_1 = 0.99, \lambda_2 = 0.10]$

Finally, we have the reservation wage estimated using the Kalman filter and the real wage. Table (1) shows that these measures are highly correlated over the business cycle regardless of whether the homogeneity restriction is imposed, or not. However, a small value of λ, e.g., 0.50, which means a larger weight on productivity, produces a reservation wage estimate that is less correlated with the other estimates. Essentially, the reservation wage is dependent more on lagged wages than on productivity. It suggests that the value of λ is not necessarily equal to one as in Shapiro and Stiglitz (1984) and to Blanchard and Katz (1999). Figure (2) plots all the estimates along with the real wage (HP-filtered).

Given our estimates of the real wage and the reservation wage, we calculate the wage gap (the log real wage – log reservation wage), but we drop the extreme estimates, which correspond to the reservation wages with low value of λ, i.e., $\lambda = 0.50$ and $\lambda = 0.75$. We have wage gaps corresponding to the estimated reservation wages, and the Kalman filter. We plot the data in figure (3). The estimates are highly correlated.

The theory predicts that the covariance between the wage gap and unemployment is negative because when the real wage is greater than the reservation wage the worker takes the job, hence unemployment falls. We test the covariance for each estimate of the wage gap and the unemployment rate. We test the correlations using a confidence ellipse, which is distributed $\chi^2_{1,0.95}$. Figure (4) plot the confidence ellipses. Some correlations are positive, which are inconsistent with the theory. These are found in plots 1, 2, 3, which correspond to wage gaps, where the reservation wage are calibrated using equation (2), and the weight λ, is either low (0.50, 0.75 and 0.85) or the homogeneity restriction is not imposed and the weight on productivity is > 0.10. There are two cases, where the correlation is positive; these are plots 7 and 9, which correspond to w_7^R and w_9^R, where $\lambda_1 = 0.90$ and $\lambda_2 = 0.15$ and $\lambda_1 = 0.95$ and $\lambda_2 = 0.25$ for w_7^R and w_9^R respectively. Generally, the test suggests that for the prediction of the theory to hold (i.e. the gap between the real wage and the reservation wage and unemployment are negatively correlated), the homogeneity restriction need not be imposed, but the weight on productivity in equation (2) should still be smaller than the weight on lagged waged. In other words, productivity affects the reservation wage and the real wage, but the effect is smaller than the effect of lagged wages.

Table (2) reports a number of regressions using the wage gaps that are, statistically significantly, negatively correlated with unemployment in figure (4). The wage gap, depending on measurement, can explain up to 50 percent of unemployment's fluctuations over the business cycle.

3. The firm's decision

The firm's decision to hire workers has not been empirically tested in macroeconomic models of unemployment. Over the business cycle, the firm hires workers as long as the marginal product of labor exceeds the real wage; it stops hiring additional workers when the marginal product of labor is equal to the real wage; and it lays-off workers when the marginal product is lower than the real wage. The marginal product of labor can deviate from the real wage over the business cycle, and for a number of reasons.

Thurow (1968) provides some insight. The wedge exists because: (1) Taxes can create a wedge if the incidence of the indirect taxes is on labor. (2) Monopoly power can explain differences between the marginal product of factor inputs and their prices. (3) Constant substitution between factor inputs along growth path could create a wedge between the real wage and the marginal product of labor. As the stock of capital rises, labor is displaced. Given output, less labor input causes its marginal productivity to be higher than its rate of return, i.e. real wages. This wedge can persist if the transition cost along the growth path is high. (4) Firms set the wage rate by the marginal product of the *marginal* worker rather than the marginal product of the *average* worker, due to heterogeneity. Maré and Hyslop, (2006, 2008) provide evidence that less skilled labor is hired at the up-turn of the New Zealand business cycle. If this were the case, then wages will have to be lower than the marginal product of the average worker. (5) Risk premiums create a wedge between the marginal product of labor and the real wage. (6) When social returns are not equal to private returns, actual returns must be corrected for taxes when possible. (7) Endogenous growth models assume an increasing return to scale rather (i.e., less than doubling factor inputs is needed to double output), which means that capital and labor will more than exhaust total output.

The covariance between the wedge (real wages minus the marginal product of labor) and the unemployment rate over the business cycle is positive. Unemployment increases when the wedge is > 0 because the firm lays-off workers.

Computing the wedge requires an estimate of the marginal product of labor. We assume a simple representative agent, where production is given by the Cobb – Douglas production function. The first-order condition would equation the marginal product of labor to the real wage.

Let the production function be a constant return to scale Cobb – Douglas:

$$Y = AK^{1-\gamma}L^{\gamma}, \tag{5}$$

Where Y is real GDP, K is the stock of capital and L is labor, which is measured either in hours-worked or working age population. The parameter γ is the share of labor.

The marginal product of labor is:

$$\frac{\partial Y}{\partial h} = mpl = \gamma A K^{1-\gamma} L^{\gamma-1} = \gamma Y / h, \tag{6}$$

which we can calibrate given K, L, and γ.

The stock of capital is measured using data on fixed capital formation, and an assumed value of the initial stock of capital and the depreciation rate. We assume that the stock of capital in the U.S. is approximately three times as big as GDP (e.g., Obstfeld and Rogoff, 1996) and the depreciation rate is somewhere between 5 and 8 percent annually. For labor, we use the working age population (15-64).

There are issues about measuring the share of labor, Krueger (1999). Karabarbunis (2014) provides four measures, and reports the correlation coefficients. First is BEA unadjusted, which is total compensation to employee / national income.[iii] Second is BEA adjusted, where he treats compensations to employee as unambiguous labor income, proprietor's income and net taxes on production and imports as ambiguous income, and all other categories such as rental income, corporate profits, and business transfers as unambiguous capital income. Third is BLS corporate, which does not require imputations of the labor earnings of sole proprietors, he uses labor share for the corporate sector. It is the ratio of corporate compensations to employee / gross value added of the corporate sector.[iv] Fourth is BEA corporate, which is the **s**hare in the non-financial sector. These measures are highly, statistically significantly, correlated. Table (3) reports the correlation matrix. Figure (5) plots our estimates of the share of labor as in BEA above, which turns out to be sufficient for our purpose. It has been declining over time. To calibrate the marginal product of labor we use our estimates of the stock of capital, working age population and the share of labor.

Gali (2005) argued that the time series properties of hours worked and employment or working age population can give rise to differences in measurements. To check the robustness of our estimate we calibrate the marginal product of labor using hours worked and working age population separately. Figure (6) plots both estimates.

We report the correlations between various measures of the wedge in table (4). They differ in the way the real wage is computed. Figure (7) plots the four measures. Figure

(8) plot the different measures of the wedge with unemployment. The correlation is significant and positive as predicted by the theory.

We summarize the effects of the wage gap and the wedge on unemployment using an unrestricted VAR.

$$X_t = c + \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + \cdots + \Phi_p X_{t-p} + \varepsilon_t, \qquad (7)$$

where, X is an $(n \times 1)$ vector containing three variables, which are the HP-filtered measures of the wage gap, the wedge and unemployment. The wage gap is our measure of the difference the real wage and the reservation wage. The real wage is $w = W / P^e$. We use the Kalman filter's measure of the reservation wage (see figure 4). The wedge is the real wage minus the marginal product of labor, which we presented earlier. The error term is also a vector ε_t, which is distributed i.i.d. $N(0, \Omega)$

Figure (9) plots the VAR's *generalized* impulse response functions of unemployment to the innovations of the wage gap and to the wedge. Ordering of the variables in the VAR is no longer a problem since the generalized impulse response function since Pesaran and Shin (1998) describe the impulse response function, where they construct an orthogonal set of innovations that does not depend on the VAR ordering. We use a Monte-Carlo with 10000 iterations to estimate the standard errors. The wage gap shock decreases unemployment and the wedge shock increases unemployment over the business cycle. Variance decomposition shows the growing importance of the wage gap and the wedge between the real wage and the marginal product of labor on unemployment. From period 6 to 12, they explain more than 50 percent of the variance of unemployment.

Earlier we showed that the wage gap explains about 30 – 50 percent of the fluctuations in unemployment over the business cycle. Table (5) reports some regression results to show that the wedge and the change in the wedge can explain an additional 40 percent of the fluctuations in unemployment. The two variables, the wage gap and the wedge, explain nearly 80 percent of unemployment. Most of the remaining unexplained variation is the dynamic, which is attributed to smoothing the data by the HP filter (Razzak, 1997)

4. Conclusion

The empirical record of modern unemployment theories and models such as the efficiency wage theory, e.g., Shapiro and Stiglitz (1984) Shirking model and the dynamic search and matching of Mortensen and Pissarides (1994) is weak. Dynamic search and matching models of unemployment predict that the volatility of the employment – vacancy ratio and average labor productivity are the same while the U.S. data show that the standard deviation of the unemployment-vacancy ratio is 20 times larger than that of average labor productivity, Shimer (2005).

Unemployment theories and models account for the wage gap, which is the difference between the real wage and the reservation wage only. In this setup, the increase in unemployment reduces real wages given reservation wages and productivity. The wage gap between the real wage and the reservation wage is best interpreted as the decision the worker's make when faced with a wage offer. The worker accepts the job offer with a certain real wage when the real wage exceeds his or her reservation wage, given productivity. There is, however, another microeconomic-level decision not accounted for by most models of unemployment. It is the firm's decision to hire labor. Over the business cycle, firms hire workers as long as the real wage is lower than the marginal productivity of labor; they stop hiring workers when the real wage is equal to the marginal productivity of labor; and they lay off workers when the real wage exceeds the marginal productivity of labor.

By modeling both microeconomic decisions, the macroeconomic data are consistent with the micro decisions above. We use quarterly data from 1999 to 2013 for the U.S. to measure the real wage, the reservation wage, and the wedge between real wage and the marginal product of labor and show that these shocks have impulse response functions as predicted by the microeconomic theory and their variances explain more than 50 percent of the variation of unemployment. We also show that while the wage gap explains up to 50 percent of the unemployment dynamic, the wedge between the real wage and the marginal product of labor can explain an additional 30 percent of unemployment dynamics. The remaining unexplained dynamic of unemployment is a statistical artifact related to the use of smoothing.

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Table 1: Reservation Wage Correlations (HP-filtered)

	w_1^R	w_2^R	w_3^R	w_4^R	w_5^R	w_6^R	w_7^R	w_8^R	w_9^R	w_{10}^R	Kalman reservation wage	
w_1^R	1.000000											
w_2^R	0.650233	1.000000										
w_3^R	0.460663	0.973860	1.000000									
w_4^R	0.382314	0.950613	0.996266	1.000000								
w_5^R	0.315967	0.926062	0.987421	0.997245	1.000000							
w_6^R	0.269057	0.906512	0.978607	0.992632	0.998792	1.000000						
w_7^R	0.450089	0.970710	0.999482	0.996755	0.989409	0.981082	1.000000					
w_8^R	0.376595	0.948400	0.995391	0.999645	0.997904	0.993519	0.996729	1.000000				
w_9^R	0.566496	0.994425	0.992383	0.978042	0.960621	0.945926	0.990434	0.976435	1.000000			
w_{10}^R	0.371603	0.946690	0.994886	0.999605	0.998238	0.994117	0.996278	0.999985	0.975274	1.000000		
Kalman	0.232124	0.862254	0.937944	0.953891	0.962094	0.964621	0.941003	0.955216	0.903047	0.955942	1.000000	
Reservation												
Wage	0.456463	0.955083	0.979319	0.975144	0.966935	0.957911	0.979904	0.975256	0.972599	0.974719	0.959104	1.000000

$w_1^R - w_6^R$ are calibrated reservation wages using equation (2) imposing the homogeneity restriction, where a is 2.65, the mean of log real wages as defined log (W / P^e), W is the average hourly wage, and P^e is 6-quarter moving average of CPI; and λ is 0.50, 0.75, 0.85, 0.90, 0.95 and 0.99 for WR1 to WR6. For WR7-WR10 are calibrated reservation wages using equation (2) without imposing the homogeneity restrictions. w_7^R $\lambda_1 = 0.90$ and $\lambda_2 = 0.15$; w_8^R $\lambda_1 = 0.95$ and $\lambda_2 = 0.10$; w_9^R $\lambda_1 = 0.95$ and $\lambda_2 = 0.25$ and w_{10}^R $\lambda_1 = 0.99$ and $\lambda_2 = 0.10$

Table 2
Dependent variable $\tilde{u} = \ln(U/1-U)$ (i)
(1999Q2 – 2013Q3)

Coefficient Estimates (P values)				
wage gap 5 (ii)	-0.36 (0.0000)	-	-	-
wage gap 6 (ii)	-	-0.41 (0.0000)	-	-
wage gap 8 (iii)	-	-	-0.26 (0.0001)	-
wage gap (*Kalman*) (iv)	-	-	-	-0.16 (0.0001)
$\bar{R}^2$	0.34	0.53	0.15	0.25
σ	0.0012	0.0010	0.0014	0.0013

(i) $\tilde{u}$ is the HP filtered series of $\ln(U/1-U)$, where U is the unemployment rate.

(ii) Wage gaps are HP filtered $\ln w - \ln w^R$, where w is real wages and w^R is the reservation wage. The real wage is average hourly wage deflated by a 6-quarter moving average CPI. In wage gaps 5 and 6, w^R is calibrated using $\ln w^R = a + \lambda \ln w_{t-1} + (1-\lambda)\ln y$, where a is the mean log real wage equal to 2.65, y is productivity measured as GDP/working age population ratio, and λ is 0.95 and 0.99 respectively.

(iii) In wage gap 8, w^R is calibrated using $\ln w^R = a + \lambda_1 \ln w_{t-1} + \lambda_2 \ln y$, where $\lambda_1 = 0.95$ and $\lambda_2 = 0.10$ so that the homogeneity restriction is not imposed.

(iv) The wage gap based on the Kalman filter's estimates of the reservation wage.

(v) P values are in parentheses.

(vi) Standard errors and covariance matrix are estimated by the Newey-West method with Bartlett Kernel bandwidth = 4).

Table 3
The Correlation Matrix of Measures of the Labor Shares
(HP filtered)

	BEA unadjust	BEA adjuste	BLS corporate	BEA corporate
BEA unadjusted	1.00			
BEA adjusted	0.96	1.00		
BLS corporate	0.85	0.86	1.00	
BEA corporate	0.86	0.87	0.95	1.00

Source (Karabarbunis , 2014)

Table 4
The Correlation Matrix of Measures of the Wedge
(HP filtered)

	Wedge 1	Wedge 2	Wedge 3	Wedge 4
Wedge 1	1.00			
Wedge 2	0.98	1.00		
Wedge 3	0.97	0.98	1.00	
Wedge 4	0.98	0.97	0.96	1.00

Wedge is the real wage minus the marginal product of labor.
The marginal product of labor is $0.6K^{0.4}L^{0.60-1}$, where L is working age population.
Wedge1, 2, 3, and 4 differ in how the real wage is measured only.
Wedge 1:real wage is the nominal wage adjusted for expected inflation measure as a 6-quarter moving average of annual CPI inflation.
Wedge 2: real wage is the nominal wage adjusted for expected inflation measured by the Philadelphia fed survey measure.
Wedge3: real wage is the nominal wage adjusted for expected inflation measured by the University of Michigan survey measure.
Wedge4: real wage is the nominal wage deflated by a 6-quarter moving average of the CPI level.

Table 5

Regressions: Dependent variable $\tilde{u} = \ln(U/1-U)$ (i)

	Coefficients			
Wage gap 5 (ii)	-02.0 (0.0007)	--	--	--
Wage gap 6 (ii)	--	-0.24 (0.0000)	--	--
Wage gap 8 (iii)	--	--	-0.15 (0.0118)	--
Wage gap (Kalman) (iv)	--	--	--	-0.18 (0.0043)
Wedge (v)	0.20 (0.0005)	0.17 (0.0009)	0.23 (0.0001)	0.23 (0.0001)
Δ Wedge	0.51 (0.0000)	0.43 (0.0000)	0.55 (0.0000)	0.53 (0.0000)
$\bar{R}^2$	0.73	0.78	0.69	0.70
σ	0.0008	0.0007	0.0008	0.0008

(i) $\tilde{u}$ is the HP filtered series of $\ln(U/1-U)$, where U is the unemployment rate.

(ii) Wage gaps are HP filtered $\ln w - \ln w^R$, where w is real wages and w^R is the reservation wage. The real wage is average hourly wage deflated by a 6-quarter moving average CPI. In wage gaps 5 and 6, w^R is calibrated using $\ln w^R = a + \lambda \ln w_{t-1} + (1-\lambda)\ln y$, where a is the mean log real wage equal to 2.65, y is the natural log of productivity measured as GDP/working age population ratio, and λ is 0.95 and 0.99 respectively.

(iii) In wage gap 8, w^R is calibrated using $\ln w^R = a + \lambda_1 \ln w_{t-1} + \lambda_2 \ln y$, where $\lambda_1 = 0.95$ and $\lambda_2 = 0.10$ so that the homogeneity restriction is not imposed.

(iv) The wage gap based on the Kalman filter's estimate of the reservation wage.

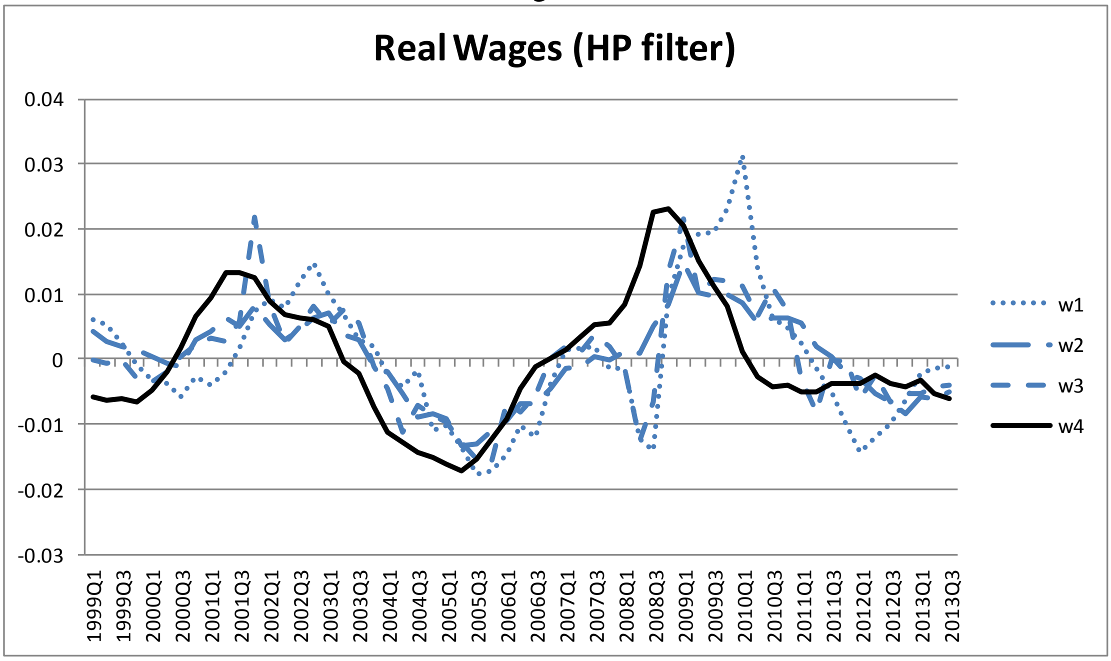
(v) Wedge: real wage is the nominal wage deflated by a 6-quarter moving average of the CPI level.

(vi) Both, the dependent variable and the independent variable in the equation above are deviations from the HP filter.

(vii) P values are in parentheses.

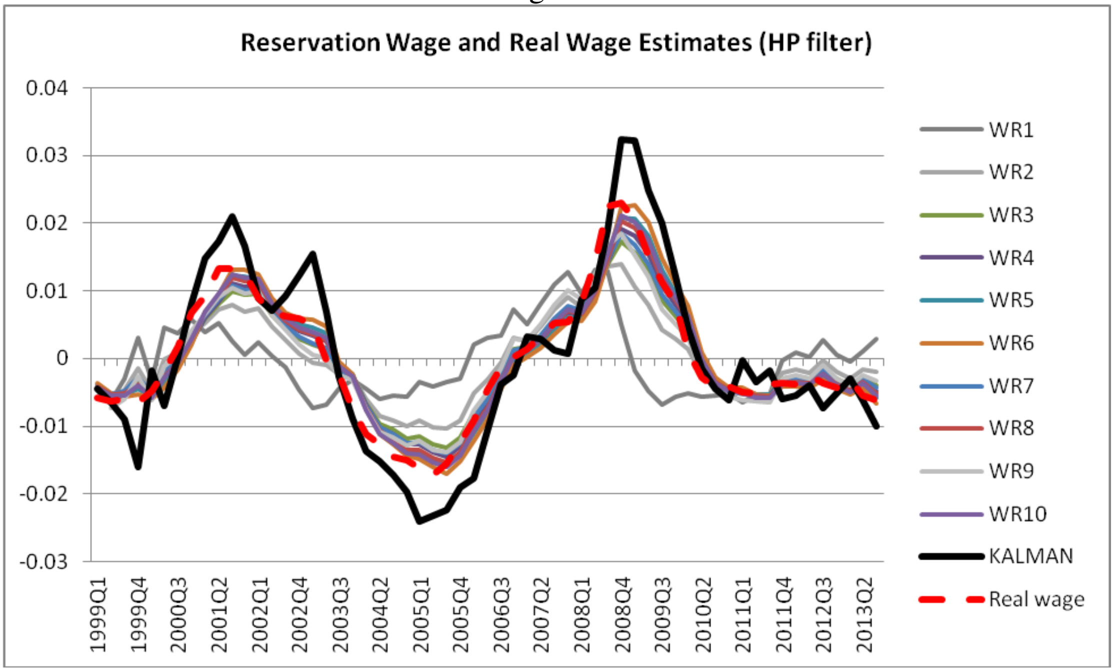
(viii) Standard errors and covariance matrix are estimated by the Newey-West method with Bartlett Kernel bandwidth = 4).

Figure 1



$w_1 - w_3$ are average hourly wage adjusted for expected inflation measures as 6-quarter moving average of CPI inflation, the Philadelphia fed's survey of inflation expectations and the Michigan University's survey of inflation expectations respectively. w_4 is $\log(W/P^e)$, W is the average hourly wage, and P^e is 6-quarter moving average of CPI.

Figure 2



$w_1^R - w_6^R$ are calibrated reservation wages using equation (2) imposing the homogeneity restriction, where a is 2.65, the mean of log real wages as defined $\log(W/P^e)$, W is the average hourly wage, and P^e is 6-quarter moving average of CPI; and λ is 0.50, 0.75, 0.85, 0.90, 0.95 and 0.99 for r $w_1^R - w_6^R$ respectively . $w_7^R - w_{10}^R$ are calibrated reservation wages using equation (2) without imposing the homogeneity restrictions. w_7^R $\lambda_1 = 0.90$ and $\lambda_2 = 0.15$; w_8^R $\lambda_1 = 0.95$ and $\lambda_2 = 0.10$; w_9^R $\lambda_1 = 0.95$ and $\lambda_2 = 0.25$; and w_{10}^R $\lambda_1 = 0.99$ and $\lambda_2 = 0.10$

Figure 3

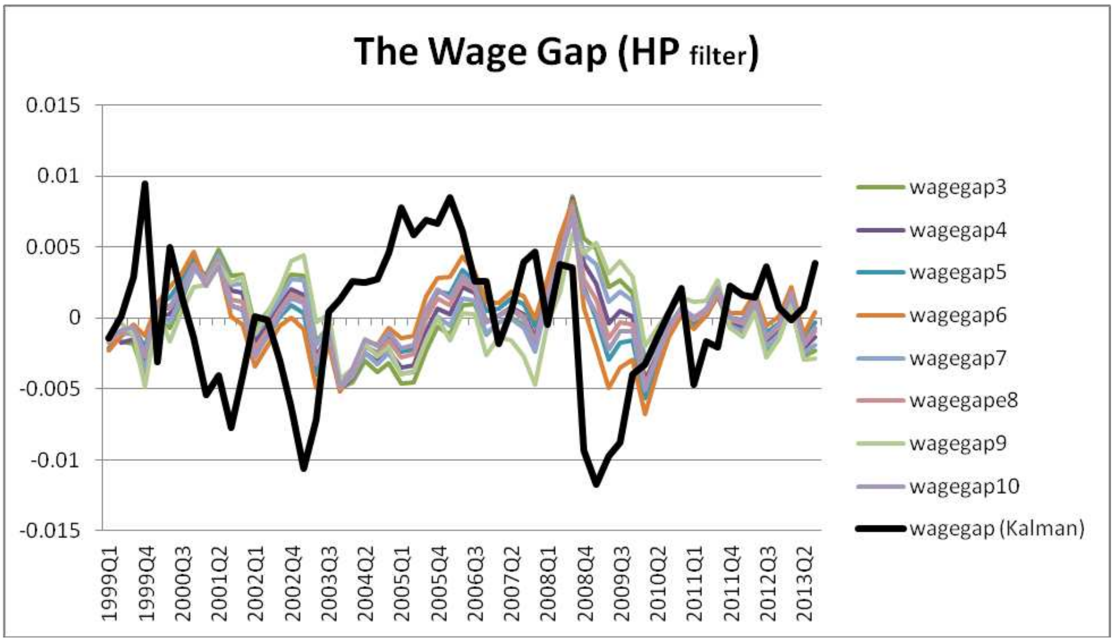
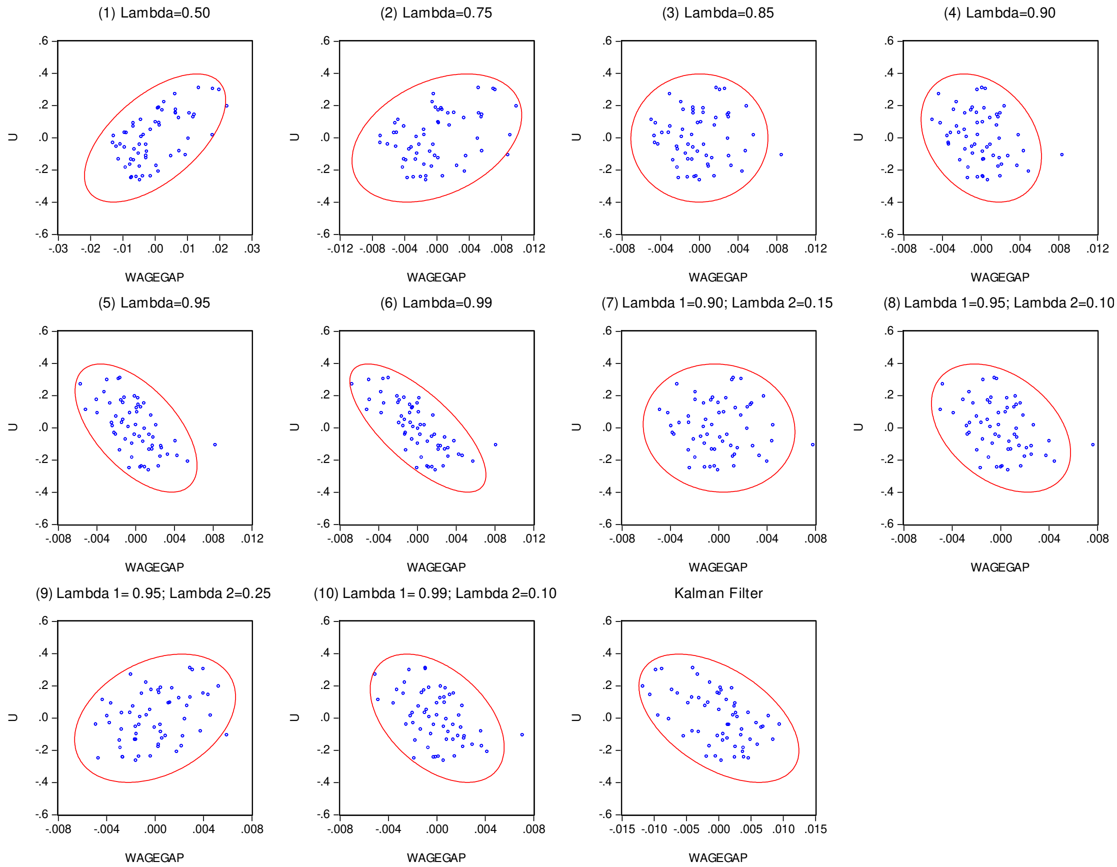

The Wage Gap (HP filter)
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
1999Q1
1999Q4
2000Q3
2001Q2
2002Q1
2002Q4
2003Q3
2004Q2
2005Q1
2005Q4
2006Q3
2007Q2
2008Q1
2008Q4
2009Q3
2010Q2
2011Q1
2011Q4
2012Q3
2013Q2
wagegap3
wagegap4
wagegap5
wagegap6
wagegap7
wagegape8
wagegap9
wagegap10
wagegap (Kalman)

Figure 4

The $\chi^2_{0.95}$ test of the correlation between the wage gap and unemployment (HP filtered)



The wage gap is the HP-filtered $w - w^R$, where w is log real wages and w^R is the log reservation wage. The real wage is average hourly wage deflated by a 6-quarter moving average CPI. The reservation wage is estimated either by calibrating the log equation $\ln w^R = a + \lambda \ln w_{t-1} + (1-\lambda)\ln y$, where y is log productivity, which is real GDP to working age population ratio (plots 1 - 6); or by calibrating $\ln w^R = a + \lambda_1 \ln w_{t-1} + \lambda_2 \ln y$, where the homogeneity restriction is not imposed (plots 7-10); or by estimating $\ln w_t = \ln w_t^R + (1-\mu)\ln y_t - \beta\, \tilde{u}_t + \varepsilon_t$ using the Kalman filter and Maximum Likelihood method. And, $\tilde{u}$ is the HP-filtered $\ln(U/1-U)$, where U is the unemployment rate.

Figure 5
The Share of Labor

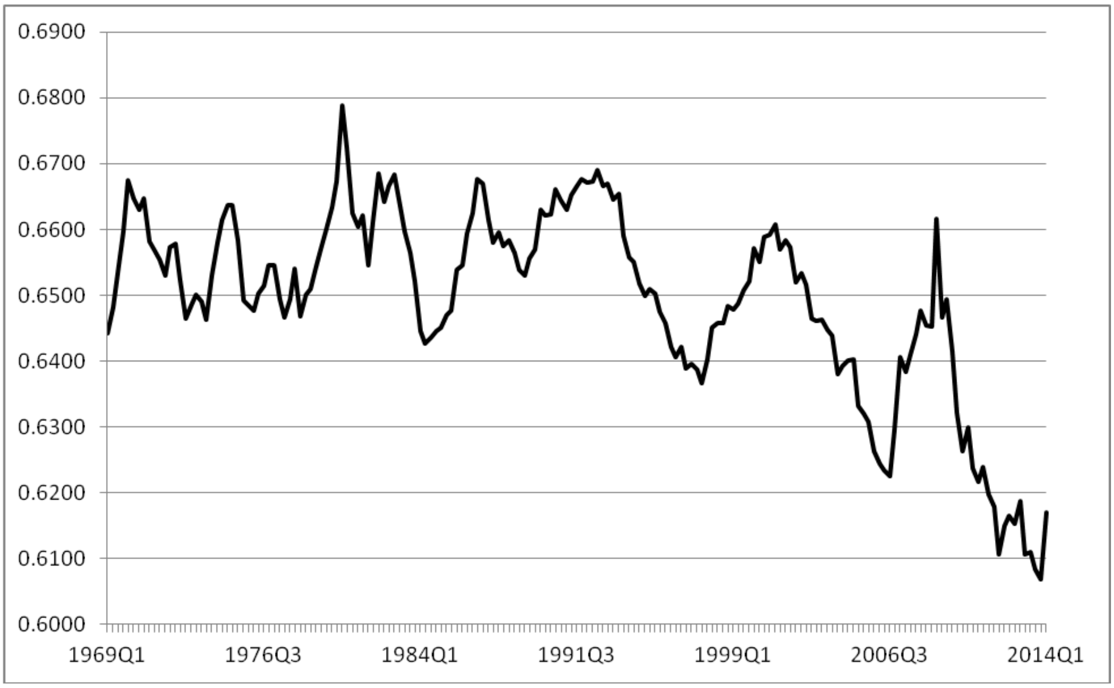


Figure 6
Marginal Product of Labor

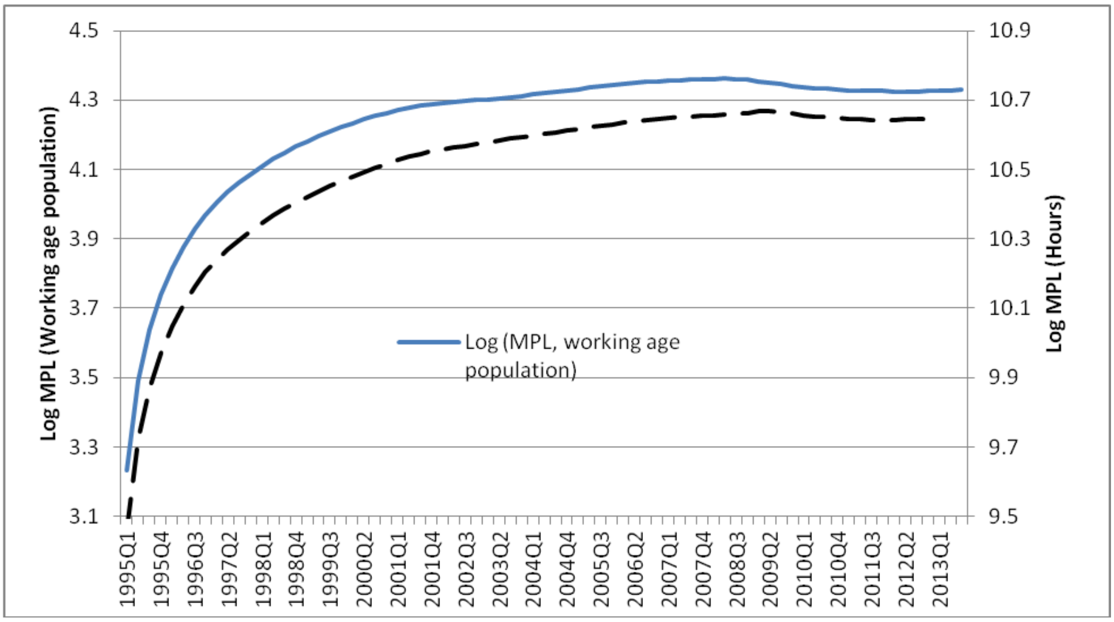


Figure 7
Measures of the Wedge

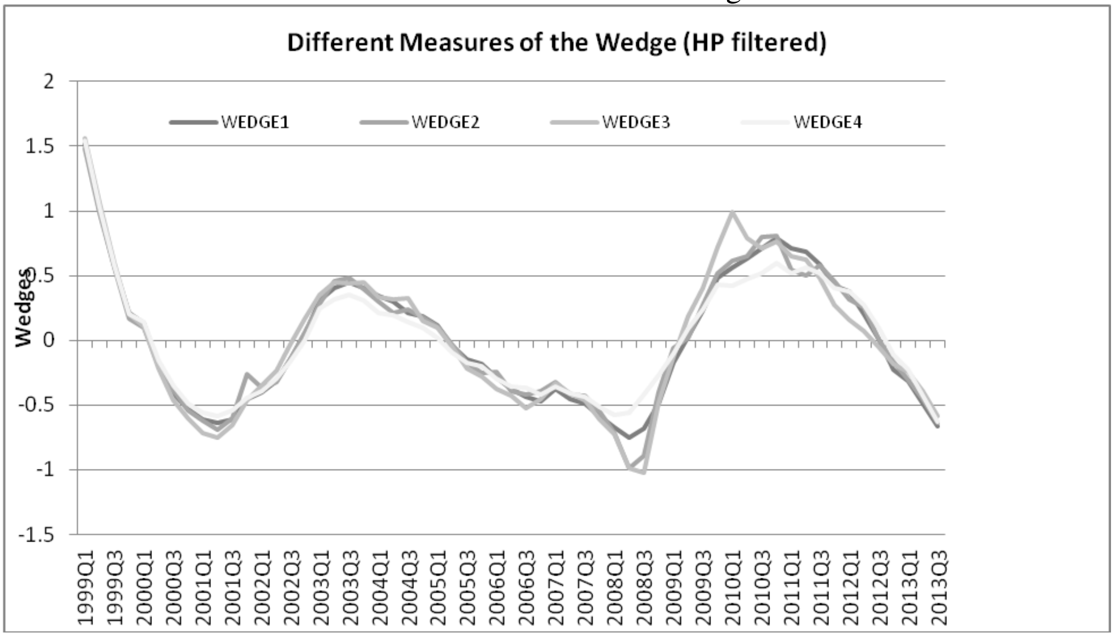


Figure 8
Measures of the Wedge and Unemployment

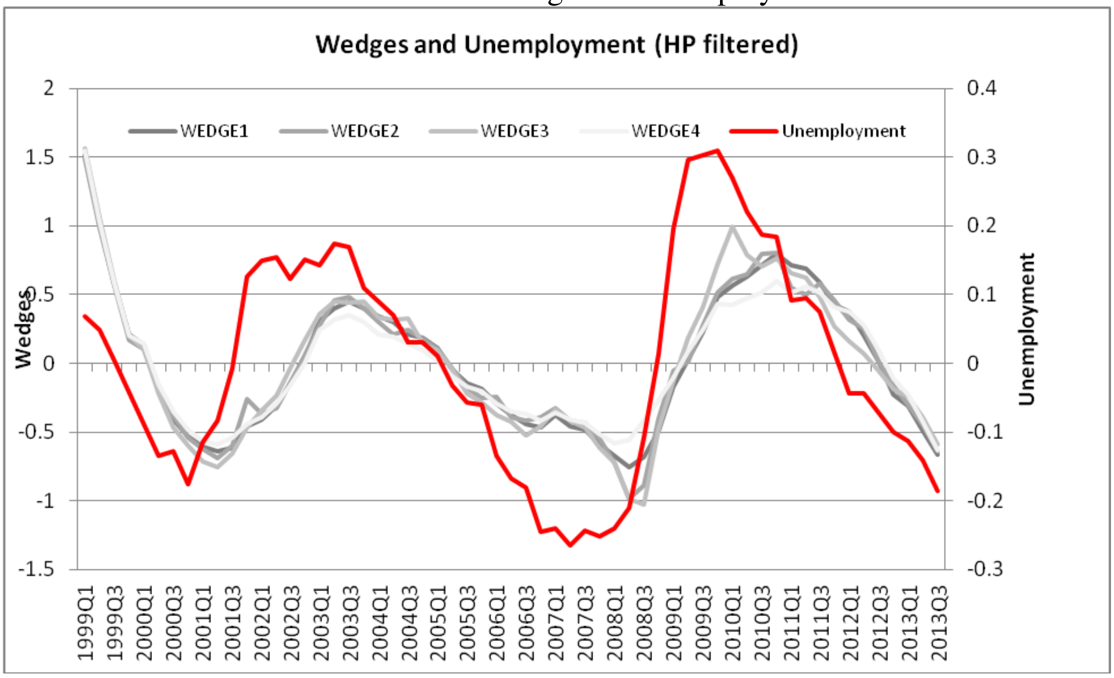
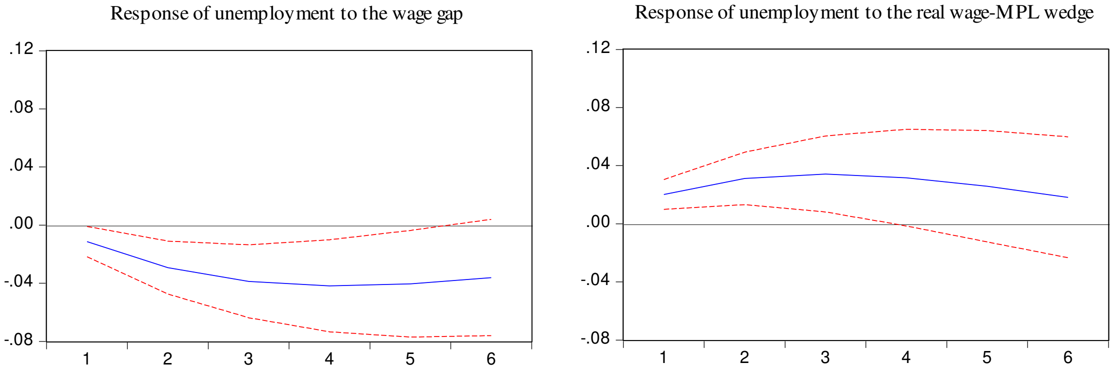


Figure 9

Response to Generalized One S.D. Innovations ± 2 S.E.



Variance Decomposition

Period	S.E.	Wedge	Wage Gap	Unemployment
1	0.038496	26.63352	3.068642	70.29784
2	0.062935	28.48215	7.212507	64.30534
3	0.081093	28.60753	12.32417	59.06830
4	0.094627	27.40724	17.97096	54.62180
5	0.104680	25.40900	23.69166	50.89935
6	0.112047	23.18024	29.05839	47.76137
7	0.117355	21.23961	33.67698	45.08341
8	0.121166	19.99733	37.20395	42.79872
9	0.124018	19.70109	39.39692	40.90199
10	0.126402	20.38655	40.18942	39.42404
11	0.128717	21.85973	39.75057	38.38969
12	0.131227	23.74622	38.47569	37.77809

Data Appendix

Variable	Description and sources
U	Seasonally adjusted civilian unemployment rate. Source: US Department of Labor.
Y	Seasonally adjusted real chain GDP. Source: Department of Commerce, Bureau of Economic Analysis.
P	Seasonally adjusted CPI for all urban consumers, all items. Source: U.S. Department of Labor Statistics.
W	Seasonally adjusted average hourly earnings of production and nonsupervisory Employees: Total Private. Source: U.S. Department of Labor: Bureau of Labor Statistics.
π^e	(1) Federal Reserve Bank of Philadelphia Survey of inflation expectations. (2) The University of Michigan Survey of inflation expectations.
L	Seasonally adjusted Working Age Population: Aged 15-64: All Persons for the United States. Source: OECD; and, average weekly hours. It is the employment rate*total annual hours worked / 52. Source: OECD.
Fixed capital formation	Gross Domestic Product by Expenditure in Constant Prices: Gross Fixed Capital Formation for the United States. Source: OECD.
WAP	Seasonally adjusted working age population: Aged 15-64: All Persons for the United States. Source: OECD

[i] It does not really matter whether we measured the unemployment in log form or not. It is just more convenient for interpreting the coefficients. In a log form we can interpret regression coefficients as elasticity. For example, see Barro (1977).

[ii] The HP filter , the Band Pass filter (Baxter-King, 1997) or the Christiano-Fitzgerald (2005) produce similar cyclical results, albeit the BP filter produces smoother cycles than the HP filter.

[iii] The data are line 1 and 2 of NIPA, table 1.12.

[iv] The data are in line 4 of NIPA, Table 1.14.