Quaderni di Dipartimento

Unions Power, Collective Bargaining and Optimal Monetary Policy

Ester Faia
(Goethe University Frankfurt, Kiel IfW and CEPREMAP)

Lorenza Rossi
(Università di Pavia)

126 (10-10)

Dipartimento di economia politica
e metodi quantitativi
Università degli studi di Pavia
Via San Felice, 5
I-27100 Pavia

Ottobre 2010

Unions Power, Collective Bargaining and Optimal Monetary Policy*

Ester Faia
Goethe University Frankfurt, Kiel IfW and CEPREMAP†

Lorenza Rossi
University of Pavia

First draft October 2008. This draft October 2010.

Abstract

We study Ramsey policies and optimal monetary policy rules in a model with sticky prices and unionized labour markets. Collective wage bargaining and unions monopoly power dampen wage fluctuations and amplify employment fluctuations relatively to a DNK model. The optimal monetary policy must trade-off between stabilizing inflation and reducing inefficient unemployment fluctuations induced by unions' monopoly power. In this context the monetary authority uses inflation as a tax on unions' rents. The optimal monetary policy rule targets unemployment alongside inflation.

JEL Classification Numbers: E0, E4, E5, E6.

Keywords: optimal monetary policy, labour market unionization, threat points

*We thank conference participants at EES "Labour Market and the Business Cycle" at Kiel IfW and to the Meetings of the Society for Computational Economics 2009.

†Correspondence to: Department of Money and Macro, Goethe University Frankfurt, House of Finance, office 3.47, Grueneburgplatz 1, 60323, Frankfurt am Main, Germany. E-mail: faia@wiwi.uni-frankfurt.de. Webpage: www.wiwi.uni-frankfurt.de/profs/faia.

1 Introduction

In most euro area countries labour unions and collective bargaining[1] play an important role in determining labour market dynamics. It is often argued that centralized bargaining tends to dampen wage dynamics and to amplify inefficient unemployment dynamics[2]. While the presence of inefficient unemployment dynamics calls for active monetary policies, dampened wage dynamics might hinder the effects of the monetary transmission mechanism. Despite the importance of those type of labour market institutions for macroeconomic performance, they have been largely neglected for the analysis of optimal monetary policy within DSGE models.

Those issues are addressed within a model with price rigidities and unionized labour markets. The assumption of price rigidity allows us to account for a direct link between unemployment and inflation. Workers' unionization implies that the labour market is non-walrasian and that wages are set as a mark-up over their reservation value. The presence of a wage mark-up produces a wedge in the labour market equilibrium conditions which induces inefficient unemployment fluctuations. In addition the model features persistent wage dynamics. Two elements are crucial in this respect. First, unions set wages by maximizing a weighted average of the workers' aggregate surplus from the job and aggregate employment[3]. Workers' surplus from the job is given by the difference between the aggregate wage and the reservation wage, which represents unions *threat points*, namely the wage process below which workers would not enter negotiations. We assume that reservation wages are a geometric average of past and competitive wages. This assumption allows to introduce real wage rigidity into the model in a tractable way and consistently with evidence in Blanchard and Katz [7] and Ball and Moffitt [5]. Secondly, negotiations take the form of a *right to manage bargaining*: after wages are set collectively, individual firms determine employment along the labour demand schedule[4]. In this context the labour market equilibrium is obtained as solution to a Stackelberg game between the union and the firm, this implies that neither of the two internalize the effects of wage settings on employment dynamics. Indeed, since firms take wages as given, they react to shocks by adjusting the employment margin. Such a mechanism tends to dampen wage and

[1] A recent survey conducted for 23 EU countries, the US and Japan by the Wage Dynamic Network of the ECB and summarized by Du Caju, Gautier, Momferatou and Ward-Warmedinger [24] establishes that in most countries negotiations take place at sectoral level and that unions play an important role.

[2] The relation between wage bargaining centralization and macroeconomic performance dates back to Calmfors and Driffill [11].

[3] See Brown and Ashenfelter [10], Card [12], Carruth and Oswald [14], Dertouzos and Pencavel [21], Farber [28],[29], MaCurdy and Pencavel [41] for empirical support of this function.

[4] This follows the lines of the *monopoly union* model proposed in Dunlop [23] and Oswald [48], which is itself a generalization of the sequential bargaining model proposed in Manning [44].

marginal cost dynamics and tends to amplify employment dynamics, consistently with empirical evidence.

The design of optimal policy is done in two steps. First, the optimal path of variables is characterized by following the Ramsey approach[5]. This approach allows to study optimal policy in economies that evolve around a distorted steady state by relying on public finance principles. Specifically the Ramsey planner maximizes household's welfare subject to a resource constraint, to the constraints describing the equilibrium in the private sector economy, and via an explicit consideration of all the distortions that characterize both the long-run and the cyclical behavior of the economy. A novel aspect, related to the use of a public finance approach, stems from the fact that, to the extent that deviations from the flexible price allocation occur, positive volatility of inflation can be interpreted as a tax on labour unions' rents. Second, the optimal rule is obtained by maximizing agents' conditional welfare. Crucial in our analysis and in the evaluation of welfare is the use of second order approximation of the full competitive equilibrium relations and of the agents' utility[6]. This allows us to account for the effects of second moments on mean welfare which are particularly relevant in economies with large real distortions. All results are obtained by simulating the model under productivity and government expenditure shocks.

We find the following results. First, overall the presence of wage mark-ups and the dependence of reservation wages on past wages dampens wage dynamics and amplifies employment dynamics relative to a standard New Keynesian model with walrasian labour markets. Second, the Ramsey planner will deviate from full price stability. The monetary policy in this environment faces two main distortions. On the one side the model features sticky prices which call for zero inflation policies. On the other side, wage mark-ups induce inefficient employment fluctuations which call for an active monetary policy (deviations from price stability). Indeed, at any point in time, monopoly power allows unions to acquire monopoly rents, hence the policy maker can use inflation as a tax on unions' rent and can bring the economy closer to the Pareto efficient equilibrium. Moreover, in our model firms and unions act non-cooperatively and the solution to their strategic interaction is given by a Markov stationary process. Preventing firms and unions by pre-committing to a full path of wage and employment schedules implies that neither firms not workers consider the impact of their decisions on future marginal costs and inflation. This type of dynamic externality increases the temptation of the policy maker to employ inflation surprises. As the monetary au-

[5] Several recent contribution apply Ramsey policies into New Keyensian models: see Khan, King and Wolman [37] and Schmitt-Grohe and Uribe [59]. Several contributions have employed this approach to study optimal policies in New Keynesian and RBC models with real frictions: see Faia [25].

[6] See also Schmitt-Grohe and Uribe [58] and [59], Faia and Monacelli [26] and Faia [25].

thority is endowed with a single instrument, namely inflation, it must trade-off between stabilizing inflation and stabilizing inefficient unemployment fluctuations caused by unions' monopoly power. In equilibrium it will deviate from full price stability. Third, the optimal volatility of inflation, in response to both productivity and government expenditure shocks, is an increasing function of the parameter relating reservation wages to past wages. This is so since an increase in the path dependence of wages amplifies inefficient unemployment fluctuations by dampening wage adjustment and protracting acquisition of unions' rents. Finally welfare analysis shows that, in response to both shocks, the optimal rule targets unemployment alongside with inflation. The existence of large labour market wedges revives the role of monetary policy in stabilizing labour market conditions.

Our work is related to Maffezzoli [42], Zanetti [63] and Mattesini and Rossi [45]. All those authors analyze models with labour unions. Maffezzoli [42] studies the dynamics of a real business cycle model (RBC) in a non-walrasian labor market with monopolist unions. Zanetti [63] shows that a DNK monetary model with a non-walrasian labor market, as induced by the presence of unions, is able to replicate most of the key aspects of the European business cycle. Our formalization of the unions behavior is more general as, for instance, the unions' objective function considered in model nests the one considered in Zanetti [63] for a certain specification of parameters. None of the previous two papers considers the design of optimal policy and the welfare implications of a labour market governed by unions. Finally, Mattesini and Rossi [45], study optimal monetary policy, by deriving the central bank loss function as a second order approximation of the households' utility function and resorting on first order approximations for the model equations; in their model it is assumed that the deterministic steady state is efficient. Due to both, the differences in the methodology to compute the optimal policy and the differences in the model specification, distortions, such as union wage mark-ups, do not play any role in Mattesini and Rossi [45], in a way that the optimal rule only responds to inflation (and with a mild coefficient to output), while no role is left for labour market variables.

Our paper has several novel aspects. In terms of modeling assumptions, our model considers a more general union's objective function which nests several other models. Furthermore, we assume a workers' real reservation wage which nests the solution of the walrasian labour market and, at the same time, allows us to introduce real wage rigidity endogenously. The main novelty of our paper, however, comes from the approach we use to study optimal monetary policy, which as mentioned above allows us to consider an economy which evolves around a distorted steady state. This leads to novel implications for the design of optimal policy in presence of unions.

The paper proceed as follows. Section 2 describes the model. Section 3 provides a description of the transmission mechanism which characterizes our model. Section 4 presents the analysis of the optimal policy. Section 5 shows results from the search of an optimal rule and the welfare costs for a subset of selected rules. Section 6 concludes. Tables and figures follow.

2 The model

There is a continuum of households who consume and invest. Households' members organize themselves in labour unions. The latter are atomistic and take prices as given. Unions set aggregate wages based on a *right to manage bargaining* (see Nickell [47]) process that allows firms to set employment along the labour demand schedule. The presence of a monopoly union generates unemployment in equilibrium, hence in equilibrium workers can be either employed or unemployed. As in large part of the literature (see Ireland [35] among others), each household consists of a large number of individuals (members), each of them supplies labor inelastically and shares income with other household members. This implies that consumption does not depend on a worker's employment status. Finally firms are monopolistic competitive, produce different varieties of goods and face a cost of adjusting prices a' la Rotemberg [56].

2.1 Households

The representative household is made up by a continuum of members represented by the unit interval. The household's lifetime utility depends on consumption C_t and on the disutility of work N_t as follows:

$$U_t = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\sigma}}{1-\sigma} - \chi \frac{N_t^{1+\phi}}{1+\phi} \right\} \tag{1}$$

where $E_0\{\}$ denotes the mathematical expectations operator conditional at information at time t. C_t is a Dixit-Stiglitz [22] consumption basket, whereas N_t denotes the number of employed households at time t. As is large part of the literature, each household consists of a large number of individuals, each individual supplies one unit of labor inelastically and shares income with other household's members. This implies that consumption does not depend on a worker's employment status.[7] Thus the representative household maximizes its utility subject to the budget constraint:

[7] We abstract from any transiction in and out the labor force, which as in Merz [46] is assumed to be constant and equal to one. Alternatively, as in Blanchard and Galì [8] we could have assumed that the equilibrium wage is set at a level such that at all times all individuals are either employed or willing to work. The choice of one or the other assumption does not change our main results.

$$(1+i_t)^{-1}B_{t+1}+C_tP_t-T_t=W_tN_t+B_t+\Pi_t \tag{2}$$

where B_t are nominal holdings of one period discounted bonds, W_t are nominal wages, T_t are government net transfers and Π_t are the profits of monopolistic firms, whose shares are owned by the households. Households choose consumption $\{C_t\}_{t=0}^{\infty}$ and bonds $\{B_{t+1}\}_{t=0}^{\infty}$ taking as given the set of processes $\{P_t,\, W_t,\, i_t\}_{t=0}^{\infty}$ and the initial wealth B_0 so as to maximize (1) subject to (2).

For any given state of the world, the following efficiency condition must hold:

$$C_t=E_tC_{t+1}\left(\beta\frac{(1+i_t)}{\pi_{t+1}}\right)^{-\frac{1}{\sigma}}. \tag{3}$$

where $\pi_t=\frac{P_t}{P_{t-1}}$ is the inflation rate. Equation (3) describes a set of optimality conditions for bond holding. Optimality requires that the Euler condition, (3) is satisfied alongside with a no-Ponzi condition on nominal bonds. Notice that, as in large part of the recent literature, money plays the role of nominal unit of account[8].

2.2 Final Good Sector

A continuum $[0,1]$ of intermediate goods are aggregated into the final good using the following technology: $Y_t=\left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}}\,di\right]^{\frac{\theta}{\theta-1}}$.The final good sector operates in perfect competition. Profits maximization yields the following optimal demand for final goods:

$$Y_t(i)=\left(\frac{P_t(i)}{P_t}\right)^{-\theta}Y_t \tag{4}$$

where θ represents the elasticity of substitution across varieties and $P_t=\left[\int_0^1 P_t(i)^{1-\theta}\,di\right]^{\frac{1}{1-\theta}}$.

2.3 Intermediate Good Sector

A typical firm produces a differentiated good with a technology represented by the following decreasing return to scale production function:

$$Y_t(i)=A_tN_t(i)^{\delta} \tag{5}$$

[8]See Woodford [62], chapter 3.

where $i \in (0,1)$ is a firm specific index and A_t is an aggregate productivity shock, which follows an $AR(1)$ process of the (log-linear) form $\log A_t = \rho_a \log A_{t-1} + \varepsilon_t^a$, with $\rho_a < 1$ and $\varepsilon_t^a \sim N(o, \sigma_a)$. Each firm i has monopolistic power in the production of its own variety and therefore has leverage in setting the price. In doing so it faces a quadratic cost of adjusting nominal prices (measured in terms of the finished goods), $\frac{\varphi_p}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t$,where $\varphi_p > 0$ proxies the degree of nominal price rigidity. The firm chooses $\{P_t(i), N_t(i)\}_{t=0}^{\infty}$ to maximize the sum of expected discounted profits:

$$\begin{aligned}
\max_{\{N_t(i),P_t(i)\}} \frac{\Pi_t}{P_t} &= E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left\{ \frac{P_t(i)}{P_t} Y_t(i) - \frac{W_t(i)}{P_t} N_t(i) - \frac{\varphi_p}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t \right\}, \\
s.to Y_t(i) &= \left(\frac{P_t(i)}{P_t}\right)^{-\theta} Y_t^D = A_t N_t(i)^{\delta}
\end{aligned}$$

where $Y_t^D = C_t + G_t$ is the aggregate demand, G_t is exogenous government expenditure and $\lambda_t = C_t^{-\sigma}$. Let's define mc_t, the Lagrangian multiplier on the demand constraint, as the real margin cost. Since all firms will charge the same price in equilibrium, symmetry is assumed ex-ante. The following first order conditions, with respect to labor demand and prices, hold:

$$\frac{W_t}{P_t} = \delta mc_t N_t^{\delta-1}(i) A_t \tag{6}$$

$$\begin{aligned}
0 &= [1 - (1 - mc_t)\theta] - \varphi_p (\pi_t - 1)\pi_t + \\
&\quad + \varphi_p \beta E_t \left\{ \left(\frac{\lambda_{t+1}}{\lambda_t}\right)(\pi_{t+1} - 1)\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right\}
\end{aligned} \tag{7}$$

Equation (7) leads to a traditional Phillips curve in expectations.

2.4 Labour Unions

In this model households' members supply their labor to only one firm and try to extract some producer surplus by organizing themselves into a monopolist firm-specific trade union[9]. This means that, the economy is populated by a continuum of trade unions, labeled by $i \in (0,1)$. Therefore, each union is too small to influence the outcome of the market. Unions negotiate the wage on behalf of their members by maximizing a non-linear function of wages and employment. Specifically they maximize a Stone-Geary utility function. This choice is motivated by three observations. First, the literature on labour union resorts extensively on this type of objective function[10]. Second,

[9] As in large part of the literature we do not model explicitly the process of union formation. On this point see Horn and Wolinsky [33] and Westermark [61].

[10] See Pencavel [49] and, more recently, De la Croix et al. [20], Raurich and Sorolla [52], Chang et al. [15] and Mattesini and Rossi [45].

there is some strong empirical evidence that unions act based on this type of non-linear objective functions[11]. Third, as argued in Dunlop [23] and Ross [55], the alternative utilitarian approach, first considered by Oswald [48] in which unions maximizes the sum of workers' utility defined over wages, does not allow for political and institutional considerations.

Unions choose wages, $\frac{W_t(i)}{P_t}$, to maximize the following modified Stone-Geary utility:

$$V\left(\frac{W_t\left(i\right)}{P_t}, N_t\left(i\right)\right) = \left(\frac{W_t\left(i\right)}{P_t} - \frac{W_t^r}{P_t}\right)^{\gamma} N_t\left(i\right)^{\varsigma} \tag{8}$$

The objective function of the union includes both excess wage, in which $\frac{W_t^r}{P_t}$ represents the reservation wage and employment[12]. As in Mattesini and Rossi [45], the parameters γ and ς are respectively the elasticities of the union's objective $V(\cdot)$ to the excess wage $\frac{W_t(i)}{P_t} - \frac{W_t^r}{P_t}$ and to the employment level $N_t\left(i\right)$. In other words, if unions are wage oriented then $\gamma > \varsigma$, on the other hand if they are employment oriented $\gamma < \varsigma$. The larger the difference $\varsigma - \gamma$, the more the union approaches the extreme of a *democratic* (or *populist*) union. When $\gamma = 1$, $\varsigma = 1$, the union becomes risk neutral as in Maffezzoli [42] and Zanetti [63].

The real reservation wage, $\frac{W_t^r}{P_t}$, is the minimum wage that workers would accept or the one at which workers are indifferent between taking a job or remaining unemployed, hence its functional form rationalizes labour force participation constraint. Under this perspective the reservation wage must be larger or equal to a wage norm which states that voluntary participation will occur to the extent that the wage norm covers at least for the welfare costs of labour disutility:

$$\frac{W_t^r}{P_t} \geq \frac{W_t^a}{P_t} = \left(\chi C_t^{\sigma} N_t^{\phi}\right) \tag{9}$$

The assumption that the alternative wage norm considered by the unions is the one realized under a competitive labor market is also consistent with evidence provided by Card [12]. Further considerations supported from empirical evidence in Blanchard and Katz [7] and Ball and Moffitt [5] lead us also to assume that reservation wages also depend on past wages. Hence the overall functional form for reservation wages, assuming that they are the same across unions, reads as follows:

$$\frac{W_t^r}{P_t} = \left(\frac{W_{t-1}}{P_{t-1}}\right)^{\phi_w} \left(\chi C_t^{\sigma} N_t^{\phi}\right)^{(1-\phi_w)} \tag{10}$$

Such a functional form bears also the advantage of allowing direct comparison of the model with

[11] See Brown and Ashenfelter [10], Card [12], Carruth and Oswald [14], Dertouzos and Pencavel [21], Farber [28],[29], MaCurdy and Pencavel [41] among others.

[12] This is consistent with a study by MaCurdy and Pencavel [41].

the walrasian competitive equilibrium, which can be easily obtained by setting unions' bargaining power and the wage stickiness parameter, ϕ_w, to zero.[13]

The bargaining process is modeled following the tradition of the right to manage approach introduced by Nickell [47]. The employment rate and the wage rate are determined in a non-cooperative dynamic game between unions and firms. We restrict the attention to Markov strategies, so that in each period unions and firms solve a sequence of independent static games. Each union behaves as a Stackelberg leader and each firm as a Stackelberg follower. Therefore each union maximizes equation (8) subject to the labor demand (6). Once the wage has been chosen, each firm decides the employment rate along its labor demand function. Since unions are small at the economy level they take aggregate variables as given.

Since the labor demand elasticity with respect to the real wage, $\frac{1}{1-\delta}$, is constant, first order conditions of the union's maximization problem with respect to $W_t(i)$, deliver the following wage schedule:

$$\frac{W_t}{P_t} = \mu_w \frac{W_t^r}{P_t} \tag{11}$$

where $\mu_w = \frac{\varsigma}{\varsigma - \gamma(1-\delta)} > 1$ whenever the non-negativity constraint is respected, i.e. $\varsigma > \gamma(1-\delta)$. Notice that, $\frac{\partial \mu_w}{\partial \varsigma} < 0$ while $\frac{\partial \mu_w}{\partial \gamma} > 0$. The real wage chosen by the monopolist union is a markup μ_w over the real reservation wage. Unions' markup is a function of δ, and also of the parameters γ and ς, that is, of the relative importance that unions give to wages and employment. Figure 1 shows the effect on wage markup of varying γ, when ς is set equal to 0.5 (the same parameter was chosen by Dertouzos and Pencavel [21]) As expected the higher is the value of γ, i.e. the weight that unions attach to the excess wage $\frac{W_t(i)}{P_t} - \frac{W_t^r}{P_t}$, the higher is the wage markup[14] and the rent that the unions extract.

Two observations are in order at this point. First, the presence of a wage mark-up renders the allocation, under non-walrasian labour markets, inefficient compared to the one under the competitive market. We will return on this important point more extensively later. Second, the assumption that the reservation wage is indexed over both past wages and competitive wages allow us to introduce real wage rigidity in a tractable way. The importance of real wage rigidity for macro models has been widely recognized in recent theoretical and empirical studies (see for instance Smets and Wouters [60] and Hall [31] among others).

[13] It is worth to notice that if the real wage set at time $t-1$ satisfies the partecipation constraint (of the same period), then for small values of the shocks, the real reservation wage at time t will also satisfy the actual participation constraint. In other word, the real wage path would not violate the partecipation constraint.

[14] If the union is risk neutral as in Zanetti [63] and Maffezzoli [42], i.e., if we set $\gamma = 1$, $\varsigma = 1$, then the wage markup is $\mu_w = \frac{1}{\delta}$.

2.5 Equilibrium Conditions

After imposing market clearing and aggregating, the resource constraint reads as follows:

$$A_t N_t^{\delta} = C_t + G_t + \frac{\varphi_p}{2} (\pi_t - 1)^2 Y_t \qquad (12)$$

2.6 Competitive Equilibrium and Wedges

Definition 1. *For given nominal interest rate* $\{i_t\}_{t=0}^{\infty}$ *and for given set of the exogenous processes* $\{A_t, G_t\}_{t=0}^{\infty}$ *a determinate competitive equilibrium for the distorted competitive economy is a sequence of allocations and prices* $\{C_t, \pi_t, mc_t, \frac{W_t}{P_t}, N_t\}_{t=0}^{\infty}$ *which, for given initial* B_0 *satisfies equations* (3), (7), (6), (11), (12).

The economy considered is distorted by the presence of a wedge in the labour market. Equilibrium in the labour market is obtained by equalizing labour demand schedule, as given by equation (6), with the optimal wage set by the union, as given by equation (11). As in the standard right to manage bargaining model for given wages firms set the level of employment based on their labour demand schedule. The resulting firms' marginal cost is given by:

$$mc_t = \frac{1}{\delta} \frac{(N_t)^{1-\delta}}{A_t} \frac{\varsigma}{\varsigma - \gamma (1 - \delta)} \frac{W_t^r}{P_t} \qquad (13)$$

Several considerations on the labour market equilibrium arise.

First, as shown by equation (13), firms marginal cost is directly affected by unions' monopoly power and by the dynamic properties of the reservation wage. In this respect, and contrary to standard new keynesian models, labour unitary costs do not depend solely on labour productivity but are distorted by union mark-up.

Second, as long as reservation wages respond persistently to shocks, due to indexation on past wages, marginal costs do so as well. The persistent response of marginal costs feeds then into inflation through the Phillips curve relation. This is the sense in which right to manage bargaining models allow for a direct link between wage persistence and marginal cost and inflation persistence. Sluggish response of wages, marginal costs and inflation tends to dampen the transmission mechanism of monetary policy, hence to render the inflation stabilization objective more difficult to achieve.

Let's now look at the role of the union monopoly wedge for employment dynamic. Employment in equilibrium is obtained using equations (6), (11) and (18), or equivalently, equation (10) and

(13):

$$N_t = \left[\frac{\delta A_t mc_t}{\mu_w} \left(\frac{W_{t-1}}{P_{t-1}} \right)^{-\phi_w} (\chi C_t^{\sigma})^{(\phi_w - 1)} \right]^{\frac{1}{1-\delta+\phi(1-\phi_w)}} \tag{14}$$

First, consider the case of zero wage rigidity, $\phi_w = 0$. In this case the employment level is given by:

$$N_t = \left[\frac{\delta A_t mc_t}{\mu_w} (\chi C_t^{\sigma})^{(-1)} \right]^{\frac{1}{1-\delta+\phi}} \tag{15}$$

Let's now compare this level with he one arising in the walrasian labour market. The latter is obtained by merging equations (6) and (9):

$$N_t^w = \left[\delta A_t mc_t (\chi C_t^{\sigma})^{(-1)} \right]^{\frac{1}{1-\delta+\phi}} \tag{16}$$

Two considerations emerge from the comparison. First, the employment level under the monopoly union is lower than the one arising under the competitive market, N_t^w. Given the existence of unions' rents, the monetary authority can use an inflation tax to restore competition and increase employment. Indeed, in a sticky price model marginal costs, which are given by the inverse of monopolistic firms' mark-ups, become pro-cyclical: an increase in demand reduces the mark-up due to the sluggish adjustment in prices. Since the level of employment, as from equation (15), is positively related to marginal costs at any point in time, an increase in demand, achieved through an easing of the monetary stance, reduces inefficient unemployment fluctuations.

Second, due to the right to manage structure of the bargaining process, the employment schedule is derived after the wage schedule. This increases the sensitivity of employment to shocks as firms and unions act non-cooperatively and fail to recognize the dynamic consequences of shocks on employment. Since employment and output fluctuate beyond the Pareto efficient level, the monetary authority is tempted to use surprise inflation to foster growth and stabilize the economy. This is the sense in which non-walrasian labour markets call for active monetary policies.

Given the structure of our economy, the monetary authority faces a tension between inflation and employment stabilization. On the one side, it is optimal to offset the cost of adjusting prices, $\frac{\varphi_p}{2} (\pi_t - 1)^2$, by setting gross inflation equal to one. Replicating the flexible price allocation would indeed eliminate nominal frictions. On the other side, it is optimal to use surprise inflation in order to move the economy toward the Pareto frontier. As the monetary authority is endowed with a single instrument, overall optimality requires setting inflation at an intermediate level between zero and the level that would push employment toward the Pareto frontier.

Proposition 1. *For the model economy described in Definition 1, a flexible price allocation is not feasible, therefore not implementable under zero inflation policies.*

Proof. Consider the economy with constant return to scale production function and preferences with constant labour elasticity[15]. In this economy the wage equation reads as follows:

$$\frac{\theta - 1}{\theta} = \frac{w_t}{A_t} \tag{17}$$

which implies that wages must adjust one to one with productivity. In a non-walrasian setting, as the one emerging from a model with labour unions, such an allocation is not feasible. Consider the reduced form of the Phillips curve in our model:

$$\begin{aligned} 0 \;=\; & \left[1 - \left(1 - \frac{1}{\delta}\frac{(N_t)^{1-\delta}}{A_t}\frac{\varsigma}{\varsigma - \gamma(1-\delta)}\left(\frac{W_{t-1}}{P_t}\right)^{\phi_w}\left(\chi C_t^{\sigma} N_t^{\phi},\right)^{(1-\phi_w)}\right)\theta\right] \\ & -\varphi_p(\pi_t - 1)\pi_t + \varphi_p \beta E_t\left\{\left(\frac{\lambda_{t+1}}{\lambda_t}\right)(\pi_{t+1} - 1)\pi_{t+1}\frac{Y_{t+1}}{Y_t}\right\} \end{aligned} \tag{18}$$

After imposing zero inflation policy the above expression becomes:

$$\frac{\theta_t - 1}{\theta_t} = \left[\frac{1}{\delta}\frac{(N_t)^{1-\delta}}{A_t}\frac{\varsigma}{\varsigma - \gamma(1-\delta)}\left(\frac{W_{t-1}}{P_t}\right)^{\phi_w}\left(\chi C_t^{\sigma} N_t^{\phi},\right)^{(1-\phi_w)}\right] \tag{19}$$

From equation (19) it stands clear that the marginal cost (therefore the mark-up) in our model can never be constant in response to productivity shocks.

In response to a positive productivity shock unions will adjust the wage by less than the increase in productivity. The reason for this is twofold. First, due to the assumption of indexation on past wages, real wages are contingent to the past history. The path dependence which characterizes real wages in this model reduces the elasticity of firms' marginal costs to output, therefore induces persistent dynamics. Second, due to the right to manage bargaining structure, firms choose employment along the demand schedule by taking real wages as given. In this context real wages loose their allocative role and the effect of shocks is absorbed mainly by employment fluctuations.

The non-implementability of the constant mark-up policy implies the non-implementability of the zero inflation policy.

3 Response to Shocks Under Taylor Rules

Before turning to the analysis of the optimal policy problem it is instructive to consider the dynamic properties of the model under different monetary policy rules. This is done by showing

[15] This is the benchmark case for which Adao, Correia and Teles [1] prove the optimality of zero inflation policies.

impulse response functions to productivity shocks for a set of selected variables (output, inflation, employment, marginal cost, wages and interest rates). In this context monetary policy sets the nominal interest rate by following a standard Taylor rule with coefficients of 1.5 on inflation and 0.5/4 on output. The rest of the calibration of the model is done as follows.

Preferences. Time is measured in quarters. The discount factor β is set to 0.99, so that the annual interest rate is equal to 4 percent. The parameter on consumption in the utility function σ is set equal to 2 and the parameters on labour disutility, χ and ϕ, are both set equal to 1. Sensitivity checks have performed on alternative preference parameters spaces: results are unchanged.

Production. Following Basu and Fernald [6], the value added mark-up of prices over marginal cost is set to 0.2. This generates a value for the price elasticity of demand, θ of 6. The cost of adjusting prices is translate into an equivalent Calvo probability[16], i.e. $\varphi_p = \frac{(\theta-1)\psi(\delta+\theta(1-\delta))}{\delta(1-\psi)(1-\beta\psi)}$, this allows to generate a slope of the log-linear Phillips curve consistent with empirical and theoretical studies. The parameter ψ is set equal to 0.5 (as in Christiano et al [17]) and represents the probability that firms do not revise prices in the Calvo model.

Labour markets. The output elasticity of labour, δ, is set to 0.72 following Christoffel et al. [18]. Knowing the value of δ and assuming that $\varsigma > \gamma(1-\delta)$ and a wage mark-up of 1.5, calibration for the unions' objective elasticity is set as follows: $\varsigma = 0.5$ and $\gamma = 0.6$. The baseline calibration captures the idea that unions tend to put higher weights on wages as shown by empirical studies. In the analysis of optimal policy, results are derived also under alternative parameters spaces. The baseline wage stickiness parameter, ϕ_w, is calibrated to 0.4 a value compatible with estimates by from Smets and Wouters [60].

Exogenous shocks and monetary policy. The process for the aggregate productivity shock, A_t, follows an AR(1) and based on the RBC literature is calibrated so that its standard deviations is set to 0.008 and its persistence to 0.95. Log-government consumption evolves according to the following exogenous process, $\ln\left(\frac{g_t}{g}\right) = \rho_g \ln\left(\frac{g_{t-1}}{g}\right) + \varepsilon_t^g$, where the steady-state share of government consumption, g, is set so that $\frac{g}{y} = 0.25$ and ε_t^g is an i.i.d. shock with standard deviation σ_g. Empirical evidence for the US in Perotti [50] suggests $\sigma_g = 0.008$ and $\rho_g = 0.9$. Interest rate smoothing is set based on empirical studies for US and Europe (see Clarida, Gali' and Gertler [19], Angeloni and Dedola [3] and Andres, Lopez-Salido and Valles [2] among others) and set ϕ_r equal to 0.9.

[16]Remember that with decreasing return to scale, in the production funtion of the intermediate good-producing firms, the coefficient which multiplies real marginal costs in the log-linearized NK Phillips curve is equal to $\kappa = \frac{(1-\psi)(1-\psi\beta)}{\psi}\frac{\delta}{\delta+\theta(1-\delta)}$, which collapses to $\kappa = \frac{(1-\psi)(1-\psi\beta)}{\psi}$ for $\delta = 1$, i.e. with constant return to scale.

Figure 2 shows impulse response functions to 1% increase in productivity under flexible wages, $\phi_w = 0$, and under wage rigidity, $\phi_w = 0.4$, a value compatible with estimates by Smets and Wouters [60]. The qualitative responses of variables is similar in both scenarios. An increase in productivity raises output and real wages and reduces inflation. Due to sticky prices employment falls; since prices adjust slowly in the short run, firms take advantage of the productivity increase by reducing labour demand. The fall in employment brings about a fall in firms' marginal costs. The fall in inflation is associated with a fall in interest rates as the monetary policy reacts according to a Taylor type rule. The quantitative response of variables is instead different under the two scenarios. When wages adjust slowly, employment tends to be both more volatile and more persistent as it is more severely affected by the shock. Marginal costs depend both on wages and employments dynamic: while the first adjust more slowly, the second tends to be more volatile in presence of wage stickiness. The effect coming from the employment dynamics tends to prevail, therefore marginal costs also tend to be more volatile under wage rigidity. On the other side inflation inherits more the persistence stemming from the wage dynamic.

Figure 3 shows the response of selected variables to 1% increase in productivity under two different values of the wage mark-up, μ_w, 1.1 and 1.8. Given a value of $\varsigma = 0.5$, those vales for the wage mark-up imply a γ equal respectively to 0.1 and 0.8. Once again the qualitative response of variables tends to be similar across the two scenarios. Quantitatively instead, higher wage mark-ups induce higher persistence on wages and inflation and higher volatility in employment and output. Higher mark-ups arise when labour unions place higher weights on wages relatively to employment. This allows firms to adjust employment more aggressively in response to shocks. Overall higher mark-ups, by increasing the labour market wedge, tend to increase inefficient unemployment fluctuations and to dampen wage dynamics. On the one side, history dependence in wage dynamics induces higher persistence in marginal costs and inflation, on the other side high unemployment volatility brings about high volatility in output.

For brevity results for the government expenditure shocks are not reported. Results for this shock are in line with the ones shown for the productivity shocks. Overall higher wage mark-ups and higher indexation to past wages tend to dampen wage and inflation dynamics and tend to amplify employment and output dynamics. It is worth mentioning that in all cases output and employment show a hump shaped response implying that the model is able to reproduce the persistent responses shown in the data.

4 Optimal Monetary Policy

The optimal policy is determined by a monetary authority that maximizes the discounted sum of utilities of all agents given the constraints of the competitive economy. Such an approach allows to analyze economies which evolve around a distorted steady state as it is in our case and to analyze the second order effects of such distortions (see Khan, King and Wolman [37], Schmitt-Grohe and Uribe [59], Faia [25]). We assume that *ex-ante commitment* is feasible. The first task is to select the minimal set of competitive equilibrium conditions that represent the relevant constraints in the planner's optimal policy problem following the primal approach described in Lucas and Stokey [40]. In most New Keynesian models it is not possible to combine all constraints in a single implementability constraint, hence an hybrid approach is followed in which the competitive equilibrium conditions are summarized via a minimal set of equations, which in this case can be summarized as follows:

$$w_t = \mu_w \left(w_{t-1}\right)^{\phi_w} \left(\chi C_t^{\sigma} N_t^{\phi}\right)^{(1-\phi_w)} \tag{20}$$

$$w_t = \delta mc_t N_t^{\delta-1} A_t \tag{21}$$

$$0 = \left[1 - \left(1 - mc_t\right)\theta\right] - \varphi_p \left(\pi_t - 1\right)\pi_t + \varphi_p \beta E_t \left\{ \left(\frac{\lambda_{t+1}}{\lambda_t}\right) \left(\pi_{t+1} - 1\right)\pi_{t+1} \frac{Y_{t+1}}{Y_t} \right\} \tag{22}$$

$$A_t N_t^{\delta} = \ C_t + G_t + \frac{\varphi_p}{2}\left(\pi_t - 1\right)^2 Y_t \tag{23}$$

where $w_t = \frac{W_t}{P_t}$. The monetary authority will choose the policy instrument, namely the inflation rate, to implement the optimal allocation obtained as solution to the following Lagrangian problem. Few observations are in order concerning the choice of the constraints. First, as fiscal policy is passive (only lump sum transfers occur), the government budget constraint does not enter the set of constraints. Second, given the absence of liquidity frictions, the Ramsey plan delivers a real equilibrium which is determined for given nominal interest rate. This allows us to exclude the Euler equation.

Definition 2. *Let $\lambda_{1,t}$, $\lambda_{2,t}$,$\lambda_{3,t}$, $\lambda_{4,t}$ represent the Lagrange multipliers on the constraints (20), (21), (22) and (23) respectively. For given B_0 and processes for the exogenous shocks $\{A_t, G_t\}_{t=0}^{\infty}$, the allocations plans for the control variables $\Xi_t \equiv \{C_t, N_t, mc_t, \pi_t, w_t\}_{t=0}^{\infty}$ and for the co-state variables $\Lambda_t \equiv \{\lambda_{1,t}, \lambda_{2,t}, \lambda_{3,t}, \lambda_{4,t}\}_{t=0}^{\infty}$ represent a first best constrained allocation if they solve the following maximization problem:*

$$Min_{\{\Lambda_t\}_{t=0}^{\infty}} Max_{\{\Xi_t\}_{t=0}^{\infty}} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \right\} \tag{24}$$

subject to (20), (21), (22) and (23).

Notice that constraint 22 exhibits future expectations of control variables. For this reason the maximization problem is intrinsically non-recursive[17]. We follow the approach illustrated in Marcet and Marimon [43], which allows to write the problem in a recursive stationary form by enlarging the planner's state space with additional (pseudo) co-state variables, which bear the meaning of tracking, along the dynamics, the value to the planner of committing to the pre-announced policy plan. The co-state variable $\chi_{3,t}$ obeys to the following law of motions, $\frac{\chi_{3,t+1}}{\beta} = \lambda_{3,t}$.

4.1 Long Run Optimal Policy

We asses the optimal monetary policy design in the long-run by looking at the long run unconstrained optimal inflation rate. In analogy with the Ramsey-Cass-Koopmans model, such steady state amounts to computing the *modified golden rule* steady state. The unconstrained optimal long-run rate of inflation (arising from the modified golden rule) is the one to which the planner would like the economy to converge to if allowed to undertake its optimization unconditionally. It is obtained by imposing steady state conditions ex-post on the first order conditions of the Ramsey plan. In particular the following result arises:

Lemma 1. *The (net) inflation rate associated with the unconstrained long run optimal policy is zero.*

Proof. Consider the first order condition with respect to inflation of the Ramsey plan':

$$0 = (\lambda_{3,t} - \chi_{3,t})(1-\beta)(2\pi_t - 1) - \lambda_{3,t}\theta(\pi_t - 1) \tag{25}$$

Since in steady state $\lambda_3 = \chi_3$, and given that $\theta > 0$ and that $\lambda_3 > 0$, it follows that $\pi = 1$.

Hence the Ramsey planner would like to generate an average (net) inflation rate of zero. The intuition for why the long-run optimal inflation rate is zero is simple. Under commitment, the planner cannot resort to ex-post inflation as a device for eliminating the inefficiency related to the labor markets. Hence the planner aims at choosing that rate of inflation that allows to minimize the cost of adjusting prices as summarized by the quadratic term $\frac{\vartheta}{2}(\pi_t - 1)^2$.

4.2 Ramsey Policy in Response to Shocks

Let's now analyze the dynamic properties of the Ramsey plan in a calibrated version of the model. The dynamic responses of the Ramsey plan are computed by taking second order approximations[18]

[17] See Kydland and Prescott [38].
[18] See Schmitt-Grohe and Uribe [58].

of the set of first order conditions around the steady state. Calibration of the model follow the one outlined in section 3.

Figure 4 shows impulse response functions to a one percent positive productivity shock for consumption, employment, marginal costs and inflation. Due to the increase in productivity output and consumption increase. The monetary policy in this environment faces two distortions, sticky prices and a labour market wedge which induces inefficient employment fluctuations. The first distortion calls for zero inflation policy to close the gap with the flexible price allocations, while the second distortion calls for an active monetary policy. The temptation to stabilize the labour market is even stronger as employment fluctuations are amplified by the right to manage bargaining process. As the monetary authority is endowed with a single instrument, it must trade-offs between the two competing distortions. As a result optimal policy deviates from full price stability. Specifically the monetary authority wants to take full advantage of the productivity increase, therefore it reduces inflation to support higher demand. Interestingly inflation shows a significant overshoot after a few periods. This captures the value of commitment as the monetary policy tries to influence future expectation to obtain faster convergence toward the steady state.

In response to government expenditure shocks (Figure 5) optimal monetary policy implies a fall in consumption and inflation. An increase in government expenditure crowds out consumption demand. As demand falls, this triggers a fall in inflation. Overall however the deviations of the price level from the full price stability case are rather small. This is so since the shock does not affect directly labour productivity.

To fully assess the properties of optimal policy, the optimal volatility of inflation is analyzed under different parameter settings. Figure 6 shows that the optimal volatility of inflation increases when the wage stickiness parameter increases. An increase in the degree of wage path dependence has two effects. On the one side it increases wage mark-ups, therefore it increases the labour market wedge and amplifies inefficient fluctuations in employment. On the other side, higher indexation to past wages, by dampening wage dynamic, tends to amplify inefficient employment fluctuations. Both effects tend to tilt the balance of the monetary authority toward larger deviations from price stability.

5 Welfare Analysis and Optimal Rules

The Ramsey plan, as specified above, delivers the optimal policy function of variables for the economy considered and in response to shocks. In practice however most central banks follow simple operational rules that respond to endogenous and observable variables. The analysis of optimal policy in this section is therefore devoted to obtain a specification for the optimal operational policy rule. Such a rule is obtained by searching, within the class of Taylor-type rules, for the parameters that maximize households welfare subject to the competitive equilibrium conditions that characterize the model economy. The class of rules considered satisfies the following criteria: a) they are simple since they involve only observable variables, b) they guarantee uniqueness of the rational expectation equilibrium, c) they maximize the expected life-time utility of the representative agent.

A crucial role acquires in our context the appropriate definition of welfare. The model economy considered features large distortions and in this context stochastic volatility affects both first and second moments of those variables that are critical for welfare. Hence, one cannot safely rely on standard first order approximation methods to compare the relative welfare associated to each monetary policy arrangement. Since in a first order approximation of the model's solution, the expected value of a variable coincides with its non-stochastic steady state, the effects of volatility on the variables' mean values is by construction neglected. Hence policy arrangements can be correctly ranked only by resorting to a higher order approximation of the policy functions[19]. Additionally one needs to focus on the *conditional* expected discounted utility of the representative agent. This allows to account for the transitional effects from the deterministic to the different stochastic steady states respectively implied by each alternative policy rule. Define Ω as the fraction of household's consumption that would be needed to equate conditional welfare $\mathcal{W}_0$ under a generic interest rate policy to the level of welfare $\widetilde{\mathcal{W}}_0$ implied by the optimal rule. Hence Ω should satisfy the following equation:

$$\mathcal{W}_{0,\Omega} = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U((1+\Omega)C_t) \right\} = \widetilde{\mathcal{W}}_0$$

Under a given specification of utility one can solve for Ω and obtain:

$$\Omega = \exp\left\{ \left(\widetilde{\mathcal{W}}_0 - \mathcal{W}_0 \right) (1-\beta) \right\} - 1$$

The analysis of the optimal rules and the welfare comparison with ad hoc rules is done based on the following Taylor-type class of rules:

[19] See Kim and Kim [36] for an analysis of the inaccuracy of welfare calculations based on log-linear approximations in dynamic open economies.

$$\ln\left(\frac{i_t}{i}\right) = (1-\phi_r)\left(\phi_\pi \ln\left(\frac{\pi_t}{\pi}\right) + \frac{\phi_y}{4}\ln\left(\frac{Y_t}{Y}\right) + \frac{\phi_n}{4}\ln\left(\frac{N_t}{N}\right)\right) + \phi_r \ln\left(\frac{i_{t-1}}{i}\right) \quad (26)$$

The class of rules considered features deviations of each variable form the target. As the model features a real distortion in the labour market, we consider the class of rules which targets employment alongside with inflation and output. This is the relevant mean of comparison as currently most central banks follow, implicitly or explicitly, strict inflation targeting or price stability rules.

The monetary authority search for the optimal rule by maximizing the welfare of agents subject to the constraints represented by the competitive economy relations. Numerically, the search is conducted over the parameter space given by $\{\phi_\pi, \phi_y, \phi_n, \phi_r\}$ [20] and delivers both the coefficient of the optimal rule as well as a welfare comparison across alternative rules.

The optimal rule features the following coefficients: $\phi_\pi = 7, \phi_y = 0, \phi_n = 0.8, \phi_r = 0.3$. The following considerations arise. First, the optimal rule features an aggressive response to inflation. Despite the presence of real frictions, nominal frictions remain an important distortion in this model and they are also exacerbated by the presence of wedges in the wage setting process. In this model the effectiveness of monetary policy is abated to the extent that the dynamic of wages and inflation is dampened. Hence stabilizing inflation requires a more aggressive response. Second, the optimal rule features no response to output. This result is consistent with previous studies (see Schmitt-Grohe and Uribe [57], Faia and Monacelli [27]) who argued that in presence of a distorted economy the appropriate definition of output gaps requires correct estimates of potential output. Targeting alternative output gap measures leads to welfare losses. Third, the optimal rule features a positive coefficient on employment, $\phi_n = 0.8$. The emergence of inefficient unemployment fluctuations due to unions' monopoly power requires that the monetary authority acquires a role in stabilizing the labour market. Finally the optimal rule features only a mild response to past interest rates. Indeed a reaction to past interest rates would add persistence to an economy characterized by an already high degree of path dependence due to the sluggish wage dynamics.

To conclude in figure 6 we report the conditional welfare gains of changing the parameters on inflation and employment. For this experiment we hold the parameters on output and interest rate constant at their optimal level and we vary the parameters on inflation and employment in

[20] For the grid we consider the following intervals: $\phi_\pi \in (1,7), \phi_y \in (0,1), \phi_n \in (0,1), \phi_r \in (0,0.9)$. The is the large possible grid given the empirically relevant range for the policy parameters. For this experiment the wage mark-up has been set to 1.2 and the parameter on past wages, ϕ_n, has been set to 0.6.

a close interval of the optimal value. Consistently with previous results, the figure shows that welfare gains reach a maximum for $\phi_n = 0.8$, however welfare gains decrease for larger values of this parameter indicating that excessive focus on labour market stabilization might be welfare detrimental. Interestingly the figure shows that welfare gains from targeting inflation beyond a value of 2 are very mild.

6 Conclusions

The design of optimal monetary policy when wages are set by trade unions has important implications, mostly in euro area countries in which collective bargaining and union power are deeply entrenched. We use a New Keynesian model in which labour unions negotiate wages collectively through a right to manage bargaining. In equilibrium wages are given by a mark-up over a reservation level, which in turn depends on past wages and aggregate employment. Overall the model produces, consistently with empirical evidence, higher volatilities of employment and higher persistence in wages, marginal cost and inflation compared to a standard New Keynesian model. Importantly the model induces inefficient unemployment fluctuations that call for active monetary policies. The design of optimal policy, which is done through Ramsey policies, implies that cyclical inflation must deviate from zero, the more so the higher the degree of wage rigidity. The optimal monetary policy rule should target employment alongside with inflation, this is so as the monetary authority must trade-off between closing the gap with the flexible price allocation and stabilizing inefficient fluctuations in the labour market.

References

[1] Bernardino Adao & Isabel Correia & Pedro Teles, 2003. "Gaps and Triangles", *Review of Economic Studies*, Blackwell Publishing, vol. 70(4), pages 699-713.

[2] Andrés, Javier, David López-Salido and Javier Vallés (2001). "Money in a Estimated Business Cycle Model of the Euro Area". Banco de España, WP 0121.

[3] Angeloni, Ignazio, and Luca Dedola (1998). "From the ERM to the EMU: New Evidence on Convergence in the Euro Area". ECB w.p.

[4] Atkinson, Anthony B., and Stiglitz, Joseph E. (1976). "The design of tax structure : direct versus, indirect taxation". *Journal of Public Economics*, Vol. 6 (1/2), pp. 55-75.

[5] Ball, L., Moffitt, R., 2001. Productivity growth and the Phillips curve. Mimeo, Johns Hopkins University.

[6] Basu, Susanto, and John Fernald. (1997). "Returns to Scale in U.S. Production: Estimates and Implications". *Journal of Political Economy*, vol. 105-2, pages 249-83.

[7] Blanchard O. and Katz L.F. (1999). "Wage Dynamics: Reconciling Theory and Evidence". *American Economic Review*, 89 (2), 69-74.

[8] Blanchard O. and Galì J. (2008). "A New Keynesian Model with Unemployment". mimeo.

[9] Booth A. (1984). "A Public Choice Model of Trade Union Behavior and Membership". *The Economic Journal*, 94, No. 376, 883-898.

[10] Brown, J N. and Ashenfelter Orly C. (1986). "Testing the Efficiency of Employment Contracts". *Journal of Political Economy*, 94(2), June: 547-566.

[11] Calmfors, L. and Driffill, J., "Bargaining structure, corporatism, and macroeconomic performance". *Economic Policy*, No. 6, 1988.

[12] Card, D. (1986) "Efficient Contracts with Costly Adjustment: Sort Run Employment Determination for Airline Mechanics". *American Economic Review,* 76, 1045-1071.

[13] Carlstrom, C., Fuerst, T. (2000). "Forward vs. backward-looking Taylor rules". Federal Reserve Bank of Cleveland Working Paper No. 9.

[14] Carruth, Alan A. and Andrew J. Oswald (1985). "'Miners' Wages in Post-War Britain: An Application of a Model of Trade Union Behavior". *Economic Journal*, 95(380), 1003-1020.

[15] Chang, J. J., Shaw M., and Lai C. (2007). "A "Managerial" trade union and economic growth". *European Economic Review*, pp. 365-384.

[16] Chari, Varadarajan V., Lawrence J. Christiano and Patrick J. Kehoe. (1991). "Optimal Fiscal and Monetary Policy: Some Recent Results". *Journal of Money, Credit and Banking*, 23:519 539.

[17] Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans, (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy*, 113, 1-45.

[18] Christoffel K., Kuester K., Linzert T. (2006). "Identifying the Role of Labor Markets for Monetary Policy in an Estimated DSGE Model". ECB Working Paper Series n° 635.

[19] Clarida, Richard, Jordi Gali, and Mark Gertler, (2000). "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory". *Quarterly Journal of Economics*, 115 (1), 147-180.

[20] De la Croix D., Franz C. Palm F. C., Pfann G. A. (1996). "A dynamic contracting model for wages and employment in three European economies". *European Economic Review*, 40, 429-448.

[21] Dertouzos J. N., and Pencavel J. h., (1981). "Wage and Employment Determination Under Trade Unionism: the Case of the Tipographical Union". *Journal of Political Economy*, 89, 1162-81

[22] Dixit A. K., Stiglitz J. E., (1977). "Monopolistic Competition and Optimum Product Diversity". *American Economic Review*, 67, 297-308.

[23] Dunlop J. T. (1944). "Wage Determination under Trade Unions". London, Macmillan.

[24] Du Caju, P., E. Gautier, D. Momferatou and M. Ward-Warmedinger, (2008). "Institutional Features of Wage Bargaining in 23 Euroepan Countries, The US and Japan". W.p. National Bank of Belgium.

[25] Faia, Ester. (2009). “Ramsey Monetary Policy with Labor Market Frictions”. *Journal of Monetary Economics.*

[26] Faia, Ester and Monacelli Tommaso (2008b). “Optimal Monetary Policy in A Small Open Economy with Home Bias”. *Journal of Money, Credit and Banking*, vol. 40, pages 721-750.

[27] Faia, Ester and Monacelli Tommaso (2007). “Optimal Monetary Policy Rules,Asset Prices and Credit Frictions”. *Journal of Economic Dynamics and Control*, vol. 31(10), 3228-3254.

[28] Farber Henry S. (1986). “The Analysis of Union Behavior”. In Ashenfelter O., Card D., a cura di (1986), vol. II, 1039-1089.

[29] Farber, Henry S. (1978). “Individual Preferences and Union Wage Determination: The Case of the United Mine Workers”. *Journal of Political Economy*, 86(5), October: 923-42.

[30] King R., Rebelo S. T. (2000). “Resuscitating Real Business Cycles”. *Rochester Center for Economic Research*, Working Paper No. 467.

[31] Hall, Bob (2005). “Employment Fluctuations with Equilibrium Wage Stickiness”. *American Economic Review*, March 2005, 95(1), pp. 50-65.

[32] Hansen G. (1985). “Indivisible Labor and the Business Cycle”. *Journal of Monetary Economics,* 16 309-328.

[33] Horn, H., and Svensson, L. (1986). “Trade Unions and Optimal Labour Contracts”. *Economic Journal* 96, 323–341.

[34] Hogan, Vincent, 2004. "Wage aspirations and unemployment persistence," *Journal of Monetary Economics,* Elsevier, vol. 51(8), pages 1623-1643.

[35] Ireland, P., (2000). “Interest Rates, Inflation, and Federal Reserve Policy Since 1980”. *Journal of Money Credit and Banking*, 32, 417-434.

[36] Kim, J., and K.S. Kim. (2003). “Spurious Welfare Reversals in International Business Cycle Models”. *Journal of International Economics* 60, 471-500.

[37] Khan, Aubhik, Robert G. King and Alexander L. Wolman. (2003). “Optimal Monetary Policy”. *Review of Economic Studies*, 70(4), 825-860.

[38] Kydland, Finn and Edward C. Prescott. (1980). "Dynamic Optimal Taxation, Rational Expectations and Optimal Control". *Journal of Economic Dynamics and Control,* 2:79-91.

[39] Layard. R., Nickell, S.. Jackman, R. (1991). "Unemployment". Oxford University Press, Oxford.

[40] Lucas, Robert Jr. and Stokey, Nancy L., (1983). "Optimal fiscal and monetary policy in an economy without capital". *Journal of Monetary Economics*, Elsevier, vol. 12(1), pages 55-93.

[41] MaCurdy T. and J. Pencavel (1986). "Testing Between Competing Models of Wage and Employment Determination in Unionized Labour Markets". *Journal of Political Economy,* 94(3).

[42] Maffezzoli M. (2001). "Non-Walrasian Labor Markets and Real Business Cycles" *Review of Economics Dynamics* 4, 860-892.

[43] Marcet, Albert and Ramon Marimon (1999). "Recursive Contracts". Mimeo, Universitat Pompeu Fabra and European University Institute.

[44] Manning, A., (1987). "An integration of trade union models in a sequential bargaining framework". *Economic Journal* 97, 121–139.

[45] Mattesini Fabrizio, Rossi Lorenza, (2008). "Productivity Shocks and Optimal Monetary Policy in a Unionized Labor Market Economy". *The Manchester School*, Vol. 78, n.5, pp.579-612.

[46] Merz, Monika, (1995). "Search in the labor market and the real business cycle". *Journal of Monetary Economics*, Elsevier, vol. 36(2), pages 269-300,

[47] Nickell, S., (1982). "A Bargaining Model of the Phillips Curve". Center for Labor Economics Discussion Paper, No. 130.

[48] Oswald A. (1982). "The Microeconomic Theory of the Trade Union". *Economic Journal*, 92, 576-595.

[49] Pencavel J. h., (1984). "The Trade-off Between Wages and Employment in Trade Union Objectives". *The Quarterly Journal of Economics.*

[50] Perotti, Roberto (2005). "Estimating the Effects of Fiscal Policy in OECD Countries". *Proceedings*, Federal Reserve Bank of San Francisco

[51] Ramsey F.P. (1927). "A Contribution to the Theory of Taxation". *Economic Journal*, Vol. 37, No 145, pp.47-61.

[52] Raurich X., Sorolla V. (2003). "Unemployment and Wage Formation in a Growth Model with Public Capital". *Spanish Economic Review*, 5, 49-61.

[53] Rogerson, R. (1988). "Indivisible Labor Lotteries and Equilibrium". *Journal of Monetary Economics* 21, 3-16.

[54] Rogerson R., and Wright R. (1988). "Involuntary Unemployment in Economics with Efficient Risk Sharing". *Journal of Monetary Economic*s 22, 501-515.

[55] Ross, A.M. (1948). "Trade Union Wage Policy". California University Press, Berkeley, CA.

[56] Rotemberg, Julio (1982). "Monopolistic Price Adjustment and Aggregate Output". *Review of Economics Studies,* 44, 517-531.

[57] Schmitt-Grohe, Stephanie and Martin Uribe (2007). "Optimal, Simple, and Implementable Monetary and Fiscal Rules". *Journal of Monetary Economics.*, 54, 1702-1725.

[58] Schmitt-Grohe, Stephanie and Martin Uribe (2004a). "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function". *Journal of Economic Dynamics and Control* 28, 645-858.

[59] Schmitt-Grohe, Stephanie and Martin Uribe, Martin (2004b). "Optimal fiscal and monetary policy under sticky prices". *Journal of Economic Theory*, 114(2), 198-230.

[60] Smets, Frank, and Raf Wouters (2003). "An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area". *Journal of the European Economic Association*, 1(5), 1123-1175.

[61] Westermark, A. (1999). "A Model of Union Formation". Working Paper 1999:8, Department of Economics, Uppsala University.

[62] Woodford, Michael (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University Press.

[63] Zanetti F. (2007). "A Non-Walrasian Labor Market in a Monetary Model of the Business Cycle". *Journal of Economic Dynamics and Control*, 31, 2413-2437.

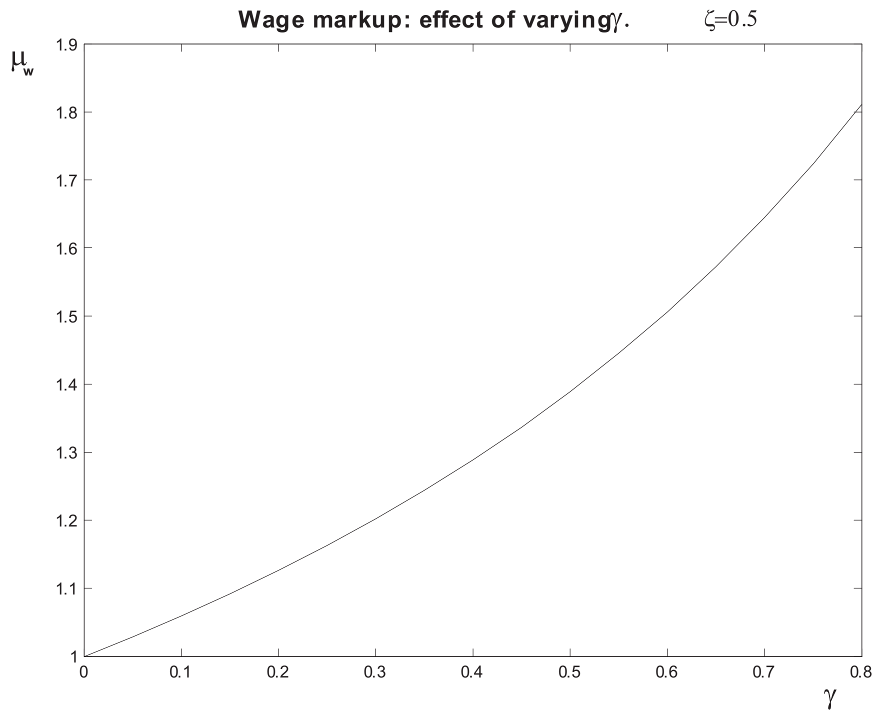

Wage markup: effect of varying γ. ζ=0.5
μ_w
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
γ

Figure 1: .

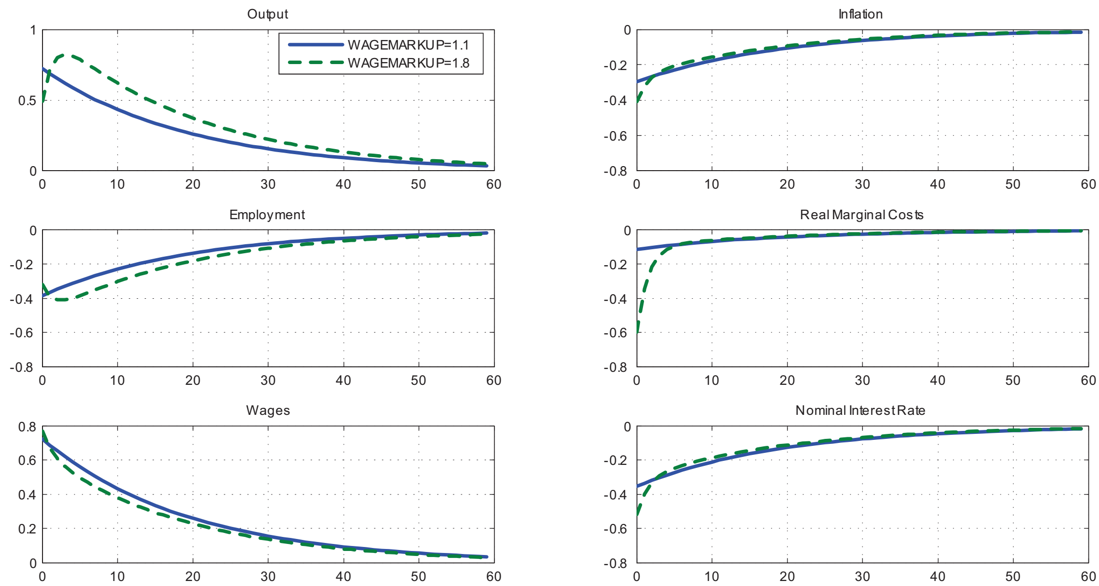


Figure 2: Impulse responses to productivity shocks under standard Taylor rule. Solid line $\phi_w = 0$ dashed line $\phi_w = 0.6$.

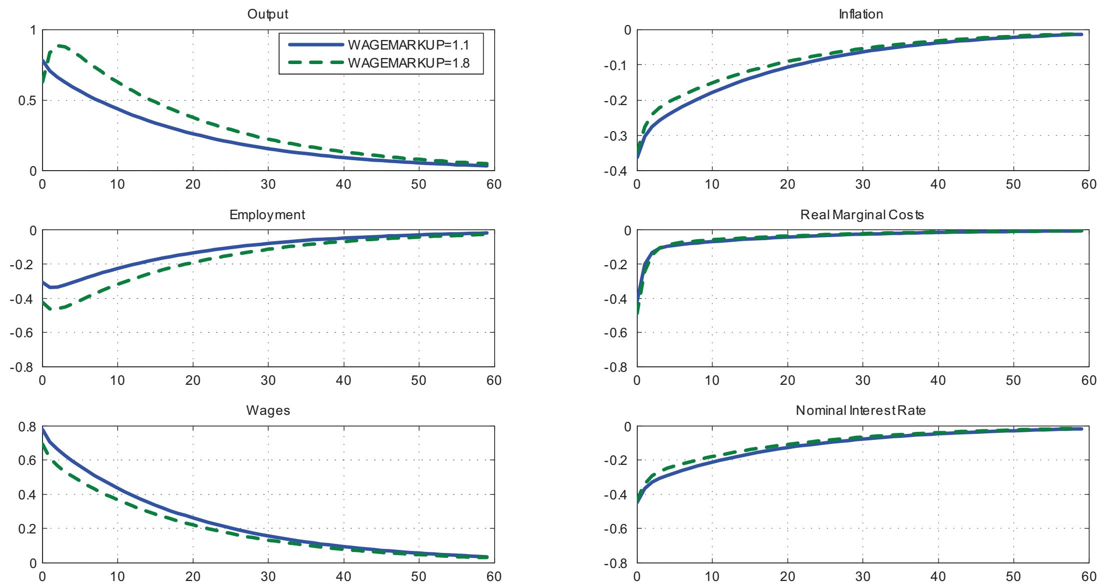


Figure 3: Impulse responses to productivity shocks under standard Taylor rule. Solid line $\mu_w = 1.1$, dashed line $\mu_w = 1.8$.

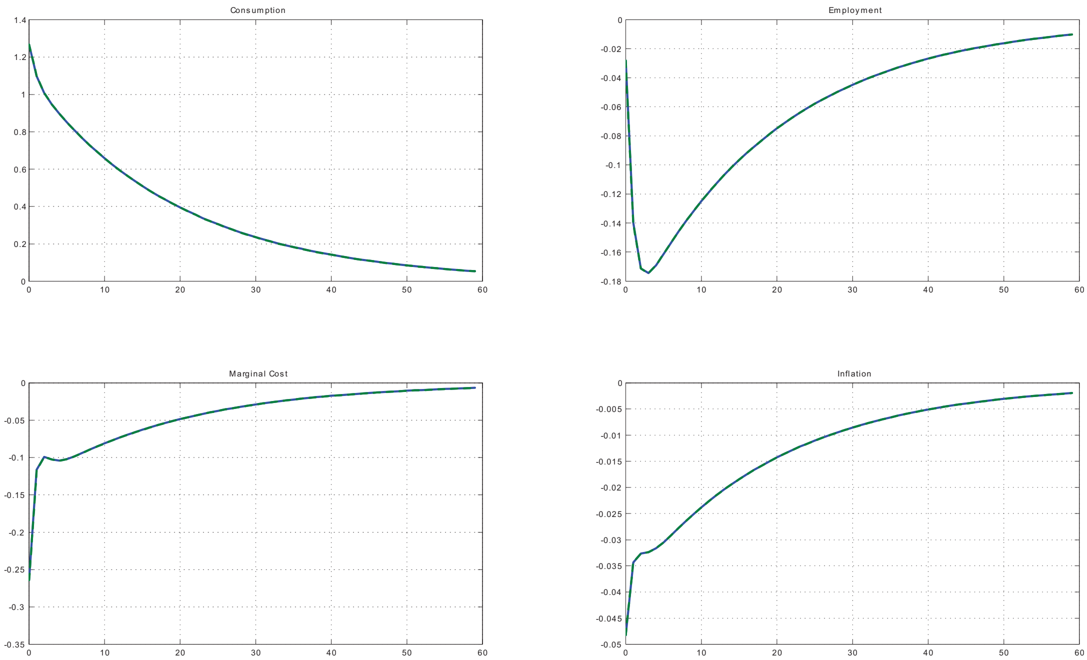


Figure 4: Impulse responses of Ramsey policy under productivity shocks.

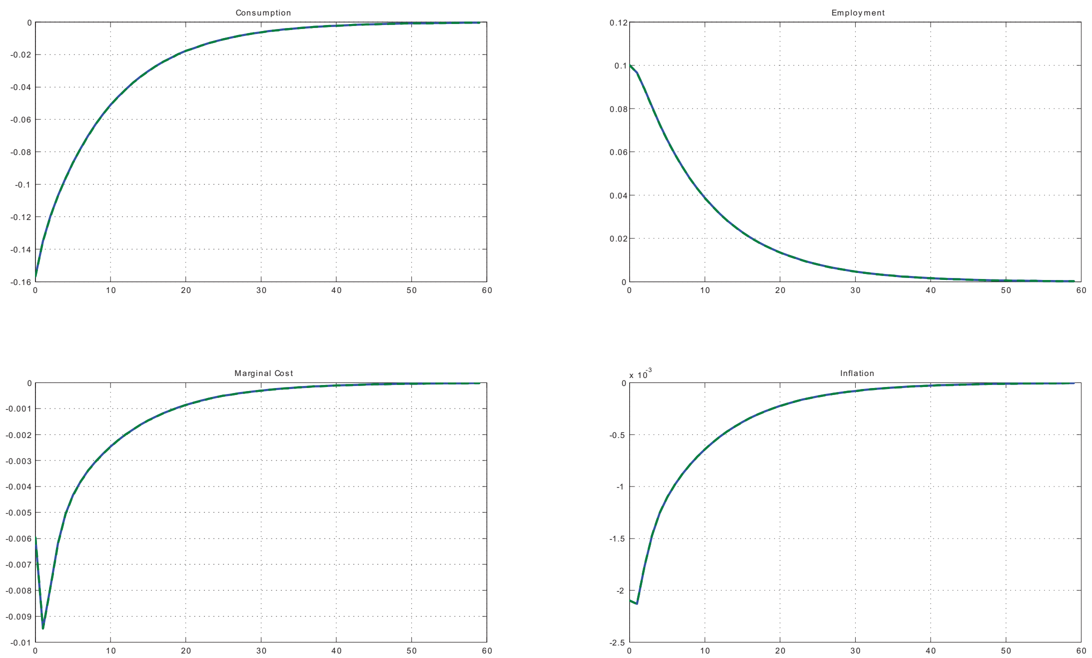
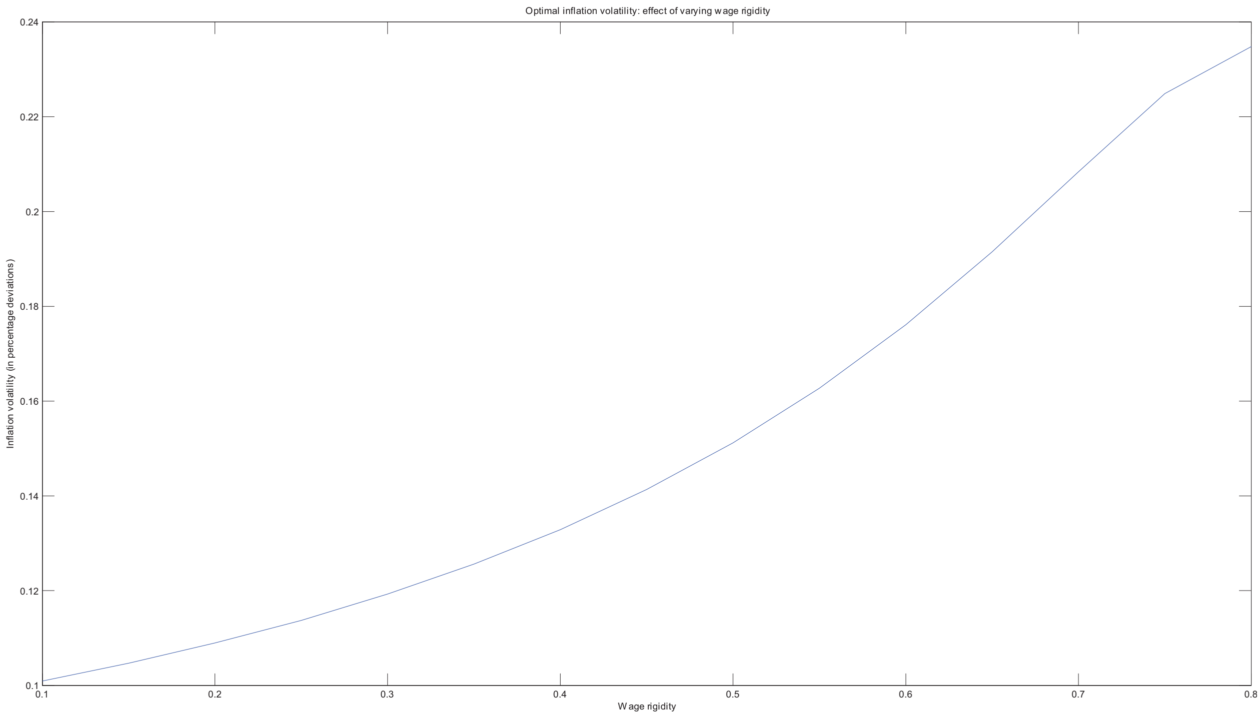
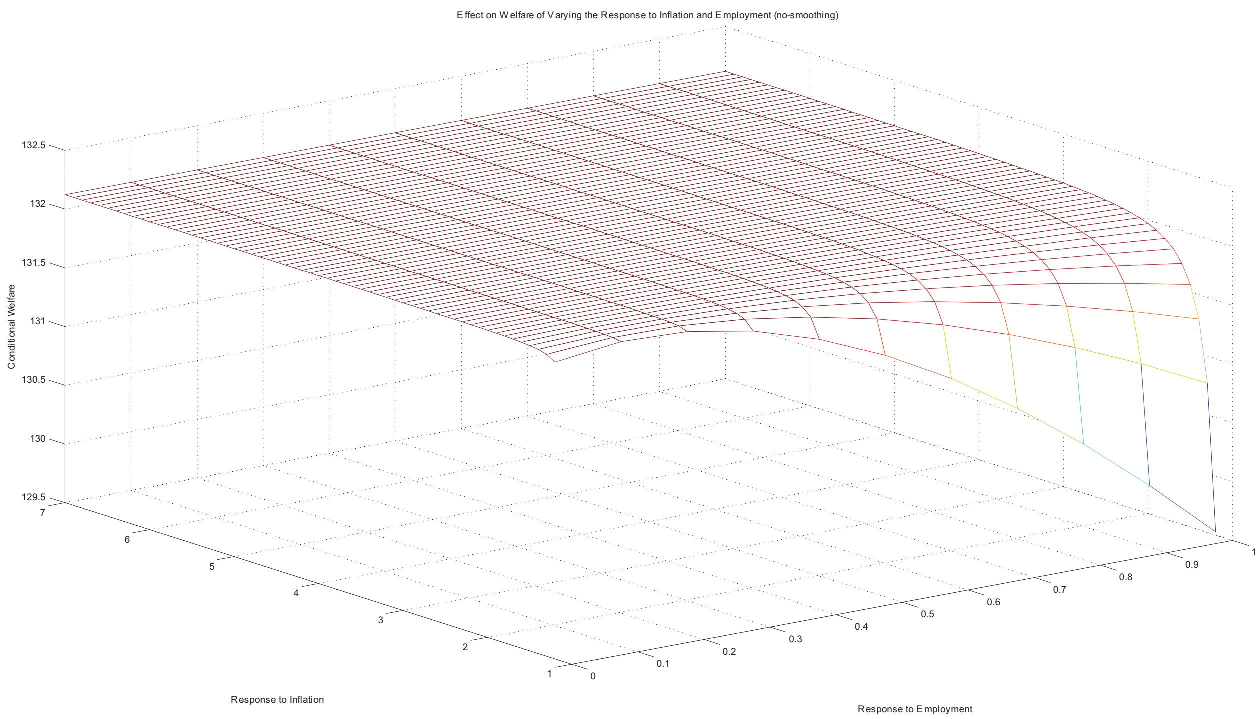


Figure 5: Impulse responses of Ramsey policy under government expenditure shocks.


Optimal inflation volatility: effect of varying wage rigidity
Inflation volatility (in percentage deviations)
Wage rigidity
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8


Effect on Welfare of Varying the Response to Inflation and Employment (no-smoothing)
Conditional Welfare
132.5
132
131.5
131
130.5
130
129.5
Response to Inflation
Response to Employment