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Abbritti, Mirko and Boitani, Andrea and Damiani, Mirella

Universita Cattolica del Sacro Cuore, Milano

September 2006

Graduate Institute of
International Studies | Geneva
Economics

HEI Working Paper No: 07/2007

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Mirko Abbritti
Graduate Institute of International Studies and University of Perugia

Andrea Boitani
Catholic University of Milan

Mirella Damiani
University of Perugia

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Unemployment, Inflation and Monetary Policy in a Dynamic New Keynesian Model with Hiring Costs[1]

Mirko Abbritti[*], Andrea Boitani[§], Mirella Damiani[#]
[*]University of Perugia and HEI Geneva; [§] Catholic University of Milan;
[#] University of Perugia

This version: January 2007
(First draft: September 2006)

[1]We thank Charles Wyplosz, Cedric Tille, Stefano Manzocchi, Sebastian Weber, Lorenza Rossi and Mario Piacentini for very helpful comments and suggestions. We are also grateful to the seminar participants at the University of Perugia and at the Graduate Institute of International Studies for their suggestions.

Abstract

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JEL Classification: E24, E31, E32, E52; J64

Keywords: Hiring Costs, Wage Bargaining, Output Gap, New Keynesian Phillips Curve, Monetary Policy

1 Introduction and motivation

1.1 The shortcomings of the NK model

Since the late Nineties a standard New Keynesian (NK) dynamic general equilibrium model has emerged which is widely used as a work-horse for monetary policy. Such a model is built on microfoundations coming from the Real Business Cycle (RBC) i.e. intertemporal optimisation of infinitely lived, fully rational, consumers and firms. The NK model departs from the RBC in assuming imperfect competition in the products market and staggered prices *à lá* Calvo (1983). As a result of this blend of RBC and Keynesian ingredients a NK Phillips curve is derived which implies that monetary policy can have relevant effects on real output, something the RBC model alone cannot deliver[1].

However, in our view, the standard NK model has three main shortcomings: 1) there is no involuntary unemployment, because of the hypothesis of a Walrasian labour market; 2) there is no trade-off between inflation and output gap stabilisation; 3) contrary to empirical evidence, in the model the inflation response to shocks is greater than the output response, whilst output fluctuations cannot be as persistent as they appear to be in the real world.

The absence of involuntary unemployment is a serious shortcoming for a model labelled as "Keynesian", however abridged or reformed. In the standard NK model output fluctuations imply that people vary the hours they work (variation of the intensive margin) but the number of people employed never changes (that is, there is no variation of the extensive margin). Such an un-Keynesian feature of the NK model is at odds with empirical evidence, which does show changes in the number of people working whilst does not show a labour supply as wage elastic as needed for the adjustment to take place along the intensive margin alone (Trigari, 2005).

The absence of a trade-off between inflation and output stabilisation in the standard NK model has been christened "divine coincidence" (Blanchard, Galí, 2005). The divine coincidence "is tightly linked to a specific property of the standard NK model, namely the fact that the gap between the natural level of output and the efficient (first best) level of output is constant and invariant to shocks" (Blanchard, Galí, 2005, p. 2). Such a feature of the standard NK model entails that stabilising the actual output gap (i.e. the difference between actual and "natural" output) is equivalent to stabilising the *welfare relevant* output gap (i.e. the difference between actual output and first best output). As stabilising inflation also stabilises the actual output gap, the standard NK model implies that stabilising inflation brings about stabilisation of the welfare relevant output gap: a divine coincidence indeed. A divine coincidence that makes inflation targeting surrounded by a halo of optimality[2].

As for the inability at delivering enough persistence of output fluctuations after a

[1] This earlier literature, described by Goodfriend and King (1997), has often been labelled as "New Neoclassical Synthesis".

[2] "The present theory implies not only that price stability should matter *in addition* to stability of the output gap, but also that, at least under certain circumstances, inflation stabilization eliminates any need for further concern with the level of real activity. This is because [...] the time-varying efficient level of output is the *same* (up to a constant, which does not affect the basic point) as the level of output that eliminates any incentive for firms on average to either raise or lower their prices". (Woodford, 2003, p. 13)

nominal shock, it may be argued that the presence of nominal rigidities is not able to overcome the RBC feature of the model, in which forward looking workers and firms are able to rapidly adjust their hiring and working decisions in a perfectly competitive labour market. In a Walrasian labour market, fluctuations in employment levels are interpreted as the outcome of voluntary choices and must be accompanied by real wage changes: a *temporary* increase in the current wage leads workers to offer more labour services in the current period, in exchange for more leisure in the future. However, a smoother correlation between wages and employment is frequently observed, and this evidence is at variance with the theoretical RBC predictions, unless the (real) wage elasticity of labour supply is implausibly high[3].

With a Walrasian labour market, it is difficult to offer some plausible rationales for the insensitive reaction of marginal costs to demand shocks. The missing explanation for acyclical real wage patterns is at the root of an intrinsic inability of the standard NK model to reproduce the low sensitivity of real marginal costs to output changes and to replicate the sluggishness in price setting behavior. Only by assuming a high degree of nominal inertia - which prevents firms from full price adjustments - one may preserve the hypothesis of a sensitive marginal cost and still obtain the stickiness in price behaviour observed in reality. However, microeconomic data on price setting show that the majority of firms resets their prices more frequently than once a year (see for instance Blinder et al., 1998, and Carlton, 1986). The effective role of nominal frictions has been raised by Chari, Kehoe and McGrattan (2000), by showing that, for a wide range of parameter values of a specified model with a non-competitive product market, the hypothesis of staggering alone does not succeed in explaining the size and persistence of observed cyclical fluctuations.

1.2 Labour market imperfections and real wage rigidities

Many attempts have recently been made at overcoming the above mentioned shortcomings of the standard NK model. Not surprisingly, most of these attempts point to some sort of labour market imperfection[4]. An early study in this direction (Jeanne, 1998) showed that the introduction of significant real rigidities due to a non-competitive labour market and to an a-cyclical wage dynamics, strengthens nominal rigidities and is compatible with large-scale cyclical fluctuations which persist over time.

In a few recent papers (e.g. Christoffel Linzert, 2005, Trigari, 2005 and Walsh, 2005), search frictions are introduced alongside a Mortensen, Pissarides (1994, 1999) matching function[5]. In this framework workers and firms bargain over wages and share the positive rents arising from a successul match. However, this rule makes the wage proportional to

[3] The empirical evidence reveals a low elasticity of employment to the real wage. See, for instance, Pencavel (1986).

[4] Alongside these attempts another strand of research grew aimed at introducing additional rationales for nominal rigidities: from the *sticky information* approach, developed by Mankiw and Reis (2002), to the *staggered nominal wage contracts approach,* proposed by Christiano, Eichnbaum and Evans (2005), from the *rule of thumb behavior* in price or wage setting, advanced by Galì and Gertler (1999) and Rabanal (2001), to the *lagged indexation* assumption advanced by Smet and Wouters (2003) and Christiano, Eichnbaum and Evans (2005).

[5] Attempts at introducing efficiency wages in a dynamic general equilibrium model have been made by Felices (2002), Alexopoulos (2004), Danthine and Kurmann (2004).

productivity changes or to changes in labour market tightness, which means that labour compensations absorb and filter exogenous shocks. Thus, in case of a positive shock, little space is left for the opening of new vacancies, while in case of an adverse shock, the low recruiting effort of employees is still unexplained. This means that the matching model does not account for the variability of vacancies and does not reproduce the employment fluctuations observed in reality[6].

It is only under some stickiness in the real wage, as that obtained by Hall (2005) with the assumption of a *wage norm,* that the Mortensen and Pissarides approach gains more empirical relevance. However, Hall explicitly admits that he does not "venture into the territory of explaining why the economy appears to choose sticky wages from the wide variety of alternative equilibrium wage patterns" (Hall, 2005, 51). In fact the studies mentioned above combine searching frictions and real wage rigidity in order to obtain a model economy where plausible output and inflation dynamics are obtained.

Blanchard, Galí (2005) bypass the labour market imperfection issue by assuming real wage stickiness straight away. They are able to show that when real wage stickiness alone is introduced in an otherwise standard NK model the divine coincidence disappears, as "the gap between natural and efficient output is no longer constant, and is now affected by shocks" (p. 3). As a consequence, stabilising inflation is no longer equivalent to stabilising the welfare relevant output gap and inflation targeting is no longer optimal: policy makers are faced with a trade-off between stabilising inflation and stabilising the welfare relevant output gap.

Both the *matching approach* and the *real wage stickiness approach* are far from satisfactory. On the one hand, within the matching approach unemployment qualifies as frictional and voluntary, a notion quite close to the classical unemployment assumption of Arthur C. Pigou, the author of *Theory of Unemployment*, a title stigmatised as "something of a misnomer" in the General Theory (Keynes, 1936, p. 275)[7]. On the other hand, the real wage rigidity is assumed, but not explained (Krause, Lubik, 2003). Even the merger of the two approaches does not improve the situation: one still obtains only frictional unemployment and makes use of an unexplained real wage rigidity. A quite embarassing result for the New Keynesian Economics, a paradigm devoted "to providing rigorous microeconomic foundations for the central elements of Keynesian economics" and thus aimed to pursue "the resurgence of Keynesian economics" itself (Mankiw and Romer, 1991, p. 1).

1.3 The present paper

In the present paper we focus on a labour market imperfection which is capable to deliver, at once, involuntary unemployment, the end of the divine coincidence and persistent output and employment fluctuations after a shock. Drawing from Howitt (1988) we shall assume that current employment decisions are only partially reversible over time, because

[6] For instance, in the U.S., as argued in Shimer (2005), the standard deviation of the vacancy-unemployment ratio is almost 20 times as large as the standard deviation of productivity, while the search model predicts the same volatility. Analogous evidence is observed by Hall (2005) in case of demand shocks, thus proving that "recessions are times when the labor markets of all industries slacken - not times when workers moves from industry with slack markets to other with tight markets"(Hall, 2005, p. 52).

[7] This has been recalled in Petrongolo and Pissarides (2001, p. 426), who give in the Appendix of their article a brief review of "some history" of the matching function, thus recalling the intuition of Pigou.

of searching and recruiting costs faced by firms. We shall also remove changes in working hours by assumption in order to focus on the effects of fluctuations on employment. More comfortable results than those obtained by the standard NK model are reached without unexplained real wage rigidities, at the same time keeping the analytical complexity of the model at a minimum, unattainable by models based on labour search and matching.

The model presented in this paper delivers involuntary unemployment in the steady state and involuntary fluctuations in unemployment. After calibrating the model, through simulations we are able to show that our model with labour market imperfections outperforms the standard NK model as for the persistence of responses to monetary shocks. Besides, the model can be easily used to assess the impact of different market imperfections on both the steady state and the dynamics of the economy. Thanks to its simplicity, our model can be employed to show how two economies - differing in their degrees of labour and/or goods markets imperfection - react to policy or non policy shocks: cyclical output fluctuations tend to be smaller in a rigid economy than in a flexible economy, whilst inflation volatility is higher in rigid economies than in flexible economies. These findings seem to mimic well the actual experience of the US and European economies, the US being more flexible and displaying more volatile output levels and Europe being more rigid and displaying less volatile output levels (but more volatile inflation).

While we were working on our paper, Blanchard and Galí (2006) implemented a similar idea, i.e the introduction of labour market frictions "*à la* Howitt" in a standard NK model. Although their starting point is similar to ours, their paper goes in a different direction. There are three main differences between the present paper and Blanchard and Galí (2006). First and most importantly, the focus of the two papers is different: the objective of Blanchard and Galí (2006) is the derivation of an optimal monetary policy; ours is to develop a simple framework that allows the analysis of the interactions between nominal rigidities and labour market imperfections/institutions. Second, Blanchard and Galí (2006) need a very specific parametrisation (though not unrealistic) in order to obtain some of their results. Our model, in some sense, is both more general and simpler[8]. Third, their model integrates both hiring costs and an exogenous real wage rigidity "*à la* Hall (2005)". In our model, we just introduce hiring costs, while some degree of real wage rigidity is obtained endogenously. Our framework is therefore more parsimonius and permits to better evaluate the independent impact of labour market imperfections on a stylised economy.

The rest of the paper is organised as follows. In section 2 the most controversial aspects of the standard NK model are sketched out for future reference. Section 3 is devoted to the building blocks of the model with hiring costs, i.e. the (by now standard) derivation of a *new IS curve* from utility maximisation (3.1) and that of hiring, pricing and employment

[8]Blanchard and Galí build their paper under a particular parametrisation that leads to efficient and natural levels of output that are invariant to productivity shocks, i.e. constant if other shocks are absent. Two assumptions are key to obtain this result: a utility function that is log in consumption, and hiring costs that increase proportionally with productivity. These assumptions, among other things, ensure that, if real wage rigidities are absent, the divine coincidence continues to hold. It can be shown that this would not be true under a more general parametrisation. Our paper is more general in the sense that we do not need to impose these restrictions in order to get our results.

decisions (3.2). The model differs from a standard NK model in two key elements: a) the introduction of hiring costs and of an exogenous separation rate in the labour market; b) the wage determination mechanism - workers and firms bargain over wages and share the positive surplus arising from a successful hiring. These two elements fundamentally change the dynamics of marginal costs and the price-setting behaviour of firms. Interestingly, the model permits to characterise the long-run equilibrium unemployment in terms of the institutional parameters determining the "structure" of the goods and labour markets (subsection 3.3). Subsection 3.4 shows that in an economy with hiring costs *even in the absence of exogenous real wage rigidities*, the gap between the first best and the second best level of output is not constant but it is a variable responding to shocks.

In section 4 the dynamics of an economy with hiring costs and price staggering is studied. Under Calvo pricing a New Keynesian Phillips curve is derived (4.1). It is shown that inflation at time t depends on expected inflation, a distributed lag of welfare relevant output gaps, the expected output gap and on the productivity and wage shocks. As a consequence the "divine coincidence" does not hold. A non trivial trade-off between output and inflation stabilisation emerges. After a brief discussion of the characteristics of the monetary policy rule (4.2), subsection 4.3 presents the simple three equations reduced form of our model, which consists of an IS equation, a Phillips curve and a Taylor monetary policy rule. In section 5 the model is calibrated making use of plausible parameter values - when possible drawn from the relevant literature. Section 6 presents a selection of the simulations runned, which help showing how the model advanced in the present paper is able to overcome the main shortcomings of the standard NK model and allows a relatively simple analysis of the impact of differing degrees of market imperfections on the dynamic behaviour of the economy. Moreover the simulations pursued throw some new light on an old puzzle, showing that the more rigid is the economy the less volatile is its output after any shock. Section 7 briefly concludes.

2 Highlights of the standard NK model

The standard NK models integrate imperfect competition and nominal rigidities into a dynamic general equilibrium framework largely associated with the RBC paradigm (Galí 2002). In particular, the NK model inherits from the RBC literature a neoclassical labour market. This fact leads, in our view, to some of the weaknesses of this model.

In a standard NK model, the utility function depends on consumption and on hours worked:

$$U(C_t, N_t) = \frac{(C_t)^{1-\sigma}}{1-\sigma} - \xi \frac{(N_t)^{1+\upsilon}}{1+\nu} \tag{1}$$

Utility maximization leads to a standard labour supply equation where the real wage equals the marginal rate of substitution: $\frac{W_t}{P_t} = \xi \frac{N_t^{\upsilon}}{C_t^{-\sigma}}$. On the supply side, firms choose prices taking into consideration the marginal cost's dynamics, which simply reflect movements in real wages and productivity:

$$MC_t = \frac{W_t}{A_t P_t} = \xi \frac{N_t^{\upsilon}}{A_t C_t^{-\sigma}} \tag{2}$$

This specification of the labour market is at the heart of some of the criticism around the NK model. First, as the labour supply turns out to be binding in equilibrium, the model is unable to explain involuntary unemployment. Secondly, in the standard NK model a meaningful policy trade-off between output and inflation stabilisation is absent.

To see this, consider the New Keynesian Phillips Curve:

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t \tag{3}$$

where π_t is inflation and x_t is the output gap. Iterating forward, one can express the current inflation rate in terms of current and future output gaps:

$$\pi_t = \lambda \sum_{s=0}^{\infty} \beta^s E_t \left\{ x_{t+s} \right\} \tag{4}$$

Using (3), it is easy to show that a pure inflation targeting strategy, i.e. a strategy where $\pi_t = 0$ at all t, completely stabilises the output gap, i.e. $x_t = 0$ at all t. Viceversa, a strategy that stabilises the output gap in each period, setting $x_t = 0$ at all t, completely stabilises inflation ($\pi_t = 0$ at all t). Hence the monetary authority does not face a policy trade-off between output and inflation stabilisation: this is the essence of "divine coincidence" (Blanchard Galí, 2005). Such a divine coincidence is seen as unsatisfactory by many researcher and central bankers. In the following sections we shall argue that, even without imposing explicitly some form of real wage rigidity, the divine coincidence disappears as soon as a more realistic structure for the labour market is introduced.

3 Flexible price equilibrium

This section presents a simple dynamic stochastic general equilibrium model with labour and product market imperfections. There are three groups of agents: households, firms and a monetary authority. Households maximise lifetime utility derived from consumption of a composite good and from money holdings; furthermore, each agent, as long as wages are above the level of home production b, inelastically supplies one unit of labour. Monopolistically competitive firms maximise profits by choosing prices and employment levels, under the constraint of hiring costs and facing an exogenous separation rate. Workers and employers bargain over wages: the two parties share the positive surplus arising from a successful hiring. Under fully flexible prices and wages the central bank's only role is fixing the inflation rate.

3.1 Households

There is a continuum of households on the unit interval, and each representative household purchases a composite consumption good C, holds money M and supplies labour. Each unit supplies one unit of labour, provided the real wage is at least equal to the value of home production b, with the labour force normalised to 1. This assumption - by entirely freezing the intertemporal substitution mechanism emphasised by the RBC - greatly simplifies the dynamic analysis and is well suited to our focus on changes in employment along the extensive margin[9]. The utility function is separable in consumption and real money balances $\dfrac{M}{P}$.

[9] The same assumption is made in Walsh (2005).

At date t the representative household j maximises its lifetime utility.

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ U^j(C_t), V^j\left(\frac{M}{P}\right) \right\} \tag{5}$$

As in other similar models, where the monetary policy is represented by an interest rate rule, it is not necessary to specify the functional form $V^j\left(\frac{M}{P}\right)$, because the unique role of this function is in determining the monetary stock which is necessary to clear the money market[10].

Under the hypothesis of a *Constant Relative Risk Aversion* utility function and by omitting the superscript j, one gets:

$$E_t \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma} \tag{6}$$

where β is the subjective discount factor and σ is the constant relative risk aversion degree. The decision is subject to a sequence of budget constraints given by the following:

$$C_t + \frac{(M_t - M_{t-1} + B_t - B_{t-1})}{P_t} = \frac{W_t}{P_t} N_t + i_{t-1} \frac{B_{t-1}}{P_t} + bu_t + \Pi_t - T_t \tag{7}$$

This shows that consumption and savings (the expression in brackets) are financed by income accruing from labour services $\left(\frac{W_t}{P_t} N_t\right)$, by income of unemployed members (bu_t), by the share of profits Π_t (net of transfers from the government T_t), and by returns $\left(i_{t-1} \frac{B_{t-1}}{P_t}\right)$ from one-period financial assets acquired at time $t-1$.

It must be noticed that W_t and b denote, respectively the wage rate and the current value of home production received, respectively, by N_t and u_t, the family members employed or unemployed. The representative household hypothesis leads to assume that the fraction of employed or unemployed members is the same across families; moreover, if each household pools the different income sources before choosing per capita consumption, a perfect insurance emerges and it permits to avoid distributional issues.

Following Dixit-Stiglitz (1977), the composite consumption good C_t consists of the differentiated products of the monopolistically competitive firms:

$$C_t = \left(\int_0^t \left(C_t^i\right)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}} \tag{8}$$

where the parameter $\epsilon > 1$ is the elasticity of substitution of the demand for individual goods and C_t^i is the good produced by the i-th firm. The aggregate price index P_t is given by

$$P_t = \left(\int_0^t \left(p_t^i\right)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}}$$

[10] This functional form will not be considered in the following analysis (see for an analogous approach Walsh, 2005).

One thus obtains the household's demand for good i, simply denoted as C_t^i:

$$C_t^i = \left(\frac{p_t^i}{P_t}\right)^{-\epsilon} C_t \tag{9}$$

Solving the intertemporal optimisation problem one gets the following first order condition:

$$C_t^{-\sigma} = \beta(1+i_t)E_t\left(C_{t+1}^{-\sigma}\frac{P_t}{P_{t+1}}\right) \tag{10}$$

Log-linearising equation (10) around the steady state, one gets the *new IS curve* (McCallum and Nelson, 1999):

$$\hat{c}_t = E_t\hat{c}_{t+1} - \frac{1}{\sigma}\left(\hat{\imath}_t - E_t\hat{\pi}_{t+1}\right) \tag{11}$$

where variables with hat denote log-deviations from steady state and $\pi_t = \log\frac{P_t}{P_{t-1}}$ is the inflation rate at time t. In the model economy the intertemporal substitution elasticity is constant and is given by the reciprocal of the relative risk aversion degree σ.

3.2 Firms and the labour market

3.2.1 Hiring decisions

The economy has a continuum of firms, each producing a differentiated good with an identical technology:

$$Y_t^i = A_t N_t^i \tag{12}$$

where productivity A_t follows an $AR(1)$ process.

In such a model, employment dynamics can be defined by assuming a separation rate equal to δ, where $\delta \in (0,1)$, and on the basis of an optimum hiring rate equal to h_t, endogenously determined as the outcome of optimal choices by the individual firm. The separation rate δ, which is a measure of the probability of job termination, is simply considered as an exogenous parameter in the majority of contributions, even if some studies have tried to provide some endogenous determination (see Trigari, 2005). We shall assume that δ is, to some extent, under control of the policy maker who can impose restrictions on firings as an attempt to influence jobs destructions and thus unemployment levels. Thus, in some sense, δ measures the inverse of the degree of labour protection.

The evolution of employment at firm i is determined by the following:

$$N_t^i = (1-\delta)N_{t-1}^i + h_t^i \tag{13}$$

At the aggregate level, employment $N_t \equiv \int_0^1 N_t^i di$ evolves according to the following:

$$N_t = (1-\delta)N_{t-1} + H_t \tag{14}$$

Where $H_t \equiv \int_0^1 h_t^i di$ denotes the aggregate hiring level.

We denote by U_t the pool of jobless individuals who are available for new jobs. Since labour is inelastically supplied and the labour force is normalised to 1, U_t is defined as follows:

$$U_t = 1 - (1-\delta)N_{t-1} \tag{15}$$

After hiring decisions are undertaken, unemployment is defined as $u_t = 1 - N_t$.

The optimal hiring decisions are adopted under the hypothesis, suggested in Howitt (1988), that firms face a cost of searching and recruiting new workers. Hiring costs for firm i are given as follows:

$$\Psi_t = \frac{GH_t}{U_t} h_t^i \tag{16}$$

where G is a scaling parameter that may be influenced by matching and turnover costs. Firms may bear advertising, screening, and training costs and may incur in firing costs when protection legislation imposes legal restrictions. In this context, search and labour market frictions, explored along the lines suggested by Mortensen and Pissarides (1994), are accompanied by turnover costs.

Furthermore, the marginal cost of hiring is increasing in the aggregate level of hiring H_t: this captures the idea that a high rate of hiring may force firms to increase their search intensity. It means that with an increase in employment due to hiring (H_t) a "congestion" effect occurs: the recruitment process becomes more difficult and the matching less favourable. Viceversa, with an increase in U_t, it is easier for the firm to recruit workers, and the matching between the skills required by the firm and those offered by the available work force improves.

We assume that matches are provided (without bearing any cost) by a specialised firm endowed with superior information. Hence Ψ_t is a cost for production units and a pure rent for the specialised firm. Such a rent enters aggregate profits and is spent according to (9). As a consequence we can write $C_t^i = Y_t^i$ and $C_t = Y_t$. In the following sections we shall assume that the government is able to affect the level of this rent, and by so doing the degree of labour market imperfection.

3.2.2 Price determination

Each firm operates in a product market featuring monopolistic competition under the constraint given by the demand function. Each firm's optimal price is chosen by maximising real profits, given the prices set by other firms:

$$\underset{p_t^i}{Max} E_t \sum_{s=0}^{\infty} Q_{t,t+s} \left\{ p_{t+s}^i Y_{t+s}^i - P_{t+s} \frac{GH_{t+s}}{U_{t+s}} h_{t+s}^i - W_{t+s} N_{t+s}^i \right\} \tag{17}$$

where $Q_{t,t+s} = \beta^s \dfrac{C_{t+s}^{-\sigma}}{C_t^{-\sigma}} \dfrac{P_t}{P_{t+s}}$ is the relevant stochastic discount factor for nominal payoffs. The demand function that constrains the maximisation problem can be written as:

$$Y_t^i = \left(\frac{p_t^i}{P_t} \right)^{-\epsilon} Y_t \tag{18}$$

The optimal price setting rule for firm i, obtained by taking into account the production function and the employment evolution equation, is:

$$\frac{p_t^i}{P_t} = \mu \left\{ MC_t \right\} \tag{19}$$

where the term $\mu = \frac{\epsilon}{\epsilon-1}$ is the mark up.

With flexible prices, in a symmetric equilibrium, all firms will charge the same price ($p_t^i = P_t$). This implies that the real marginal cost will be constant and equal to the inverse of the markup:

$$MC_t = \frac{\epsilon - 1}{\epsilon} = \frac{1}{\mu} \tag{20}$$

The current expected value of the marginal cost MC_t will be affected by the presence of hiring costs as follows:

$$MC_t = \frac{1}{A_t}\frac{W_t}{P_t} + \frac{GH_t}{A_t U_t} - \beta(1-\delta)E_t\left\{\frac{C_t^\sigma}{C_{t+1}^\sigma}\frac{GH_{t+1}}{A_t U_{t+1}}\right\} \tag{21}$$

By inspection of (21) one can see that hiring new workers at time t has two effects: i) it increases the recruitment costs at time t - an effect represented by the term $\frac{GH_t}{A_t U_t}$; ii) it reduces the costs of hiring new workers in period $t+1$, since higher levels of recruiting efforts undertaken in the first period decrease the needs for firms to hire in the following period. The second effect is captured by the term $-\beta(1-\delta)E_t\left\{\frac{C_t^\sigma}{C_{t+1}^\sigma}\frac{GH_{t+1}}{A_t U_{t+1}}\right\}$. In our model the presence of hiring costs creates a wedge between the real wage and the marginal cost relevant for the firm, which in turn are essential to explain inflation dynamics. Such a wedge leads the cyclical behaviour of marginal costs in a model with labour market imperfections to substantially deviate from that of real wages (compare 21 with 2). As Krause and Lubik (2005, p. 11) notice, "hiring frictions generate a surplus for existing matches which give rise to long-term employment relationships. These, in turn, reduce the allocative role of current real wages. As a consequence, the effective real marginal cost can change even if the wage does not change".

3.2.3 Wage Determination

The present wage W_t^R is determined by a component W_t^{Nash}, set in a bargaining process, and by ε_t, which is an exogenous wage shock, assumed to be 1 in steady state. This last term captures the role of institutional factors that may lead to a temporary departure from the Nash wage rule:

$$W_t^R = W_t^{Nash}\varepsilon_t \tag{22}$$

The negotiated wage is the outcome of a bargaining process that maximises the weighted product of the parties' surpluses from hiring and employment. One can assume the following Nash bargaining problem:

$$\max \Omega_W = (V_t^E - V_t^U)^s S_t^{(1-s)}$$

where V_t^E is the value a worker associates with being employed, and where V_t^U is the value a worker assignes to be unemployed, with V_t^E and V_t^U expressed in consumption units. The process is conditioned by the worker's and firm's bargaining powers (respectively s and $1-s$), and gives rise to a distribution of the joint surplus from an established relationship. Firms and workers obtain from the match a return which is lost if they separate, since in this case they have to undertake a search activity and bear additional recruiting costs. The firm will hire up to the value that equals the marginal benefits and marginal costs from hiring; it follows that the firm's (marginal) surplus from a given relationship is simply given by its unit hiring cost:

$$S_t = \frac{GH_t}{U_t} \tag{23}$$

The marginal value of an employment relationship V_t^E depends not only on the bargained wage W_t^{Nash}, but also on the probability that the worker will remain employed in the following period. In period $t+1$ he will have a likelihood to be employed equal to $[(1-\delta)+(\delta\frac{H_{t+1}}{U_{t+1}})]$, where the first term in squared brackets captures the chance to hold the present job, while the second term is the probability to be hired in the subsequent period, conditional on the probability that separation takes place in the present period. It must be noticed that $\frac{H_{t+1}}{U_{t+1}}$, which is a measure of tightness of the labour market, represents for each individual unemployed the probability of finding a job in period $t+1$.

In both situations the worker will get a value V_{t+1}^E. Moreover, the worker faces a probability equal to $\delta(1-\frac{H_{t+1}}{U_{t+1}})$ to be fired and to remain unemployed in the following period. In this case he will obtain a value V_{t+1}^U.

The subjective evaluation, given in terms of utility obtained from consumption, is therefore given by:

$$V_t^E = W_t^{Nash} + \beta E_t \left\{ \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left[\left(1-\delta\left(1-\frac{H_{t+1}}{U_{t+1}}\right)\right) V_{t+1}^E + \delta\left(1-\frac{H_{t+1}}{U_{t+1}}\right) V_{t+1}^U \right] \right\} \tag{24}$$

The value for a worker of being unemployed is dependent on the current value b (that is the current value assigned to home production) and the likelihood of being employed $\frac{H_{t+1}}{U_{t+1}}$ or unemployed $(1-\frac{H_{t+1}}{U_{t+1}})$ in the following period. In those two different scenarios the worker will obtain the different values V_{t+1}^Eor V_{t+1}^U:

$$V_t^U = b + \beta E_t \left\{ \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left[\frac{H_{t+1}}{U_{t+1}} V_{t+1}^E + \left(1-\frac{H_{t+1}}{U_{t+1}}\right) V_{t+1}^U \right] \right\} \tag{25}$$

Combining both conditions we obtain the net value of being employed:

$$V_t^E - V_t^U = W_t^{Nash} - b + \beta(1-\delta) E_t \left\{ \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} \left[\left(1-\frac{H_{t+1}}{U_{t+1}}\right) (V_{t+1}^E - V_{t+1}^U) \right] \right\}$$

Letting η denote the worker's relative bargaining power $[\eta \equiv (s/(1-s))]$, the Nash solution gives:

$$V_t^E - V_t^U = \eta S_t \tag{26}$$

Imposing this condition into the expression for the households' surplus, we get the Nash wage schedule:

$$W_t^{Nash} = b + \eta S_t - \beta(1-\delta)E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \left[\left(1 - \frac{H_{t+1}}{U_{t+1}} \right) \eta S_{t+1} \right] \right\}$$

which in steady state yields:

$$W^{Nash} = b + \eta S \left[1 - \beta(1-\delta) \left(1 - \frac{H}{U} \right) \right] \tag{27}$$

3.3 The long run equilibrium

Taking into account the definition of S_t and substituting the wage schedule into the equilibrium condition (20), one obtains:

$$\frac{1}{\mu} = \frac{b\varepsilon_t}{A_t} + (1+\eta\varepsilon_t)\frac{S_t}{A_t} - \beta(1-\delta)E_t \left\{ \frac{C_t^{\sigma}}{C_{t+1}^{\sigma}} \frac{S_{t+1}}{A_t} \left[1 + \eta\varepsilon_t \left(1 - \frac{H_{t+1}}{U_{t+1}} \right) \right] \right\} \tag{28}$$

This condition determines the equilibrium level of hiring, employment and unemployment.

In our model economy, the steady state equilibrium may be inefficient for several reasons. Firstly, the presence of a fixed cost of hiring, equal to G, constitutes a departure from the competitive paradigm. Even if there are no severance costs, those firms that intend to reduce their labour demand in the following periods bear the cost of previous labour employment, which reveals as a *sunk* cost.

Secondly, two different externalities are at work to produce sub-optimal results. There is a *thick market* externality, an external economy of scale as that present in the Diamond trade model: each single unemployed worker faces a higher job finding rate, the higher is the recruiting effort of employees. There is also a *thin market* externality at work: each firm does not internalise the impacts of increased hiring in terms of lower unemployment levels and their negative feedbacks on higher recruiting costs. Therefore the individual firm "fails to take into account the effect of its current recruiting activities in depleting the stock of unemployed workers and hence in raising future costs of hiring" (Howitt, 1988, p. 157).

Furthermore, the two mentioned externalities may interact with other distortions arising from wage bargaining. The presence of searching and turnover costs is the premise for economic rents and bargaining: workers and employers negotiate over wages and thus split the marginal surplus accruing from a successful hiring decision. In this context, each single firm is unable to capture all the rents generated by a successful matching, and the individual marginal hiring decision is set at a suboptimal level.

In our economy, each unemployed worker is involuntarily unemployed and a structural Keynesian unemployment emerges. As Howitt suggests "the model exhibits persistent involuntary unemployment, even though expectations are rational, no nominal wage or price rigidity exists, and no privately attainable gains from trade are left unexploited" (Howitt, 1988, p. 148). Compared to the basic standard NK framework, the long run equilibrium employment obtained in our economy is affected by additional imperfections, as the following analysis shows.

We denote the long run job finding rate, i.e. the steady state ratio of new hired workers over searching individuals, as $z = \frac{H}{U}$. The value of z is implicitly determined as a solution of the equilibrium condition (28). It can be shown that[11]:

$$z = \frac{-\left\{(1+\eta)\left(1-\beta\left(1-\delta\right)\right)\right\}}{2\beta\left(1-\delta\right)\eta} + \Gamma \tag{29}$$

where:

$$\Gamma = \sqrt{\frac{\left(\frac{1}{\mu}-\frac{b}{A}\right)}{\beta\left(1-\delta\right)\eta\frac{G}{A}} + \left[\frac{\left\{(1+\eta)\left(1-\beta\left(1-\delta\right)\right)\right\}}{2\beta\left(1-\delta\right)\eta}\right]^2}$$

Once z is known, the steady state employment rate is determined by solving the following:

$$N = \frac{z}{\delta + (1-\delta)z} \tag{30}$$

The results obtained so far allow us to evaluate the impact of different imperfections and labour market institutions on the steady state level of employment, as shown by the following partial derivatives, where $\beta' \equiv (1-\beta(1-\delta))$.

$$\begin{aligned}
\frac{\partial N}{\partial G} &= -\frac{A-b\mu}{\beta'\eta G^2\mu 2\Gamma}\cdot\frac{\delta}{(\delta(1-z)+z)^2} < 0\\
\frac{\partial N}{\partial \mu} &= -\frac{A}{\beta'\eta G 2\Gamma\mu^2}\cdot\frac{\delta}{(\delta(1-z)+z)^2} < 0\\
\frac{\partial N}{\partial b} &= -\frac{1}{\beta'\eta G 2\Gamma}\cdot\frac{\delta}{(\delta(1-z)+z)^2} < 0\\
\frac{\partial N}{\partial \eta} &= \left[+\frac{1-\beta'}{2\beta'\eta^2} - \frac{1}{2\Gamma}\left(\frac{(1-\beta')^2(1+\eta)}{2\beta'^2\eta^3} + \frac{A(-\frac{b}{A}+\frac{1}{m})}{\beta'\eta^2 G}\right)\right]\cdot\frac{\delta}{(\delta(1-z)+z)^2}\\
\frac{\partial N}{\partial \delta} &= \left[-\frac{1+\eta}{2\beta(1-\delta)^2\eta} + \frac{1}{2\Gamma}\left(\frac{(1-\beta')(1+\eta)^2}{2\beta'^2(1-\delta)\eta^2} + \frac{A\left(\frac{1}{\mu}-\frac{b}{A}\right)}{\beta'(1-\delta)\eta G}\right)\right]\cdot\frac{\delta}{(\delta(1-z)+z)^2}
\end{aligned}$$

It is easy to check the role of different imperfections in lowering the equilibrium employment level N. Some of them, as b and η, increase the value of the 'threat point' and the worker' s bargaining power; they thus exert an indirect negative effect on labour demand, as a consequence of higher values of the Nash-bargained wage. On the other hand, the hiring cost G exerts a direct impact since it is conducive to a lower intention to open

[11] The steady state equilibrium condition can be written as:

$$\frac{1}{\mu} = \frac{b}{A} + \frac{S}{A}\left\{(1+\eta) - \beta(1-\delta)\left[1+\eta\left(1-\frac{H}{U}\right)\right]\right\}$$

Solving for $z = \frac{H}{U}$, one can get:

$$\beta(1-\delta)\eta\frac{G}{A}\left(z\right)^2 + \frac{G}{A}\left\{(1+\eta)\left(1-\beta(1-\delta)\right)\right\}z - \left(\frac{1}{\mu}-\frac{b}{A}\right) = 0$$

i.e. an equation of the form

$$\alpha z^2 + \beta z - \gamma = 0$$

Notice that this is a second order equation in z; it will in general have two solutions, one positive and one negative. To consider the economically meaningful solution, we will consider only the positive root, which leads to (29).

			Unemploy. Rate	Job Finding Rate (H/U)	Recruit. costs as % of GDP
Baseline	δ=0.08, η=0.5, μ=1.1, G=0.26, b=0.865		0.080	0.481	0.010
The Role of:	Employment Protection	δ=0.04	0.036	0.524	0.005
		δ=0.12	0.132	0.440	0.014
	Trade Unions' Power	η=0.3	0.050	0.604	0.013
		η=0.7	0.103	0.410	0.009
	Reservation Wage	b=0.84	0.045	0.631	0.013
		b=0.88	0.12	0.370	0.008
	Recruitment Costs	G=0.15	0.038	0.670	0.008
		G=0.4	0.121	0.367	0.012
	Mark-up	μ=1.05	0.049	0.610	0.013
		μ=1.125	0.142	0.326	0.007

Figure 1: *The impact of varying degrees of imperfection on the long run equilibrium employment*

vacancies and to undertake recruiting efforts. An increase in the firm's monopoly power (μ) which, as well known, shifts downward the labour demand curve, reduces the number of workers that firms are willing to hire for any given bargained wage. For values of the parameters in the acceptability range it can be shown that generally both an increase in η (i.e. the relative bargaining power of workers) and an increase in the separation rate δ, reduce the equilibrium level of employment, as shown in Figure 1[12].

These results can also be used to show the interesting interactions between different imperfections and institutions. Here we explore just one such interaction. The following Table shows that a lower ability of a firm to capture the rents generated by successful hiring decisions (i.e. a higher value of η) amplifies the negative impact of hiring costs (G) on employment. In other words, the combined effects of a higher workers' bargaining

[12] It must be recalled that in our model economy, where the inflows into employment are obstacled by hiring costs, the outflows from employment due to the destruction of jobs cause an increase of the unemployment rate. In this scenario, an increasing labour protection seems to have a positive impact on the equilibrium level of employment, as it preserves the job tenure of incumbent employees. However, a lower employment protection and therefore a higher δ, should exert some positive effect on employment, since it should induce a higher incentive to open vacancies or should be accompanied by a parallel contraction of hiring cost G. The exploration of this potential impact, that cannot be captured in our model, as well as in the standard New Keynesian Model, calls for additional research.

power (η) and of a greater level of hiring costs (G) produce a reinforced negative impact on employment:

$\frac{\partial N}{\partial G}$	η
-0.224	0.1
-0.290	0.3
-0.335	0.5
-0.365	0.7
-0.398	0.9

3.4 The welfare-relevant output gap

It is possible to compare the steady state value of the long run "natural" equilibrium obtained in our model economy with a benchmark solution, represented by a *welfare relevant* concept, i.e the first best solution.

Let N^* denotes the first best outcome and N the "natural" outcome of our model economy. The steady state first best level of employment is simply given by the full employment condition[13]:

$$N^* = 1 \tag{31}$$

The steady state "natural" solution is obtained by solving the equilibrium condition (28) for the steady state. Thus imposing $\varepsilon_t = 1$, $A_t = A$, as seen before, one gets the employment solution (30), here reported for an easier comparison:

$$N = \frac{z}{\delta + (1-\delta)z}$$

The crucial question now is whether the distance between the actual level of output and the first best level of output is a *constant* or is it a variable responding to shocks. The question has been raised by Blanchard and Galí (2005) in an influential recent paper, where the authors show that in the standard NK model the distance between the efficient level of output and the natural level of output (i.e. the one that would prevail if prices were flexible) is constant. They also show how under real wage rigidity this property disappears.

In this section we show how in our model, *even in the absence of exogenous real wage rigidities*, the gap between the first best and the second best level of output is not constant but it is a variable responding to shocks. To explore this issue, the first step is the determination of the natural level of output, which can be obtained by maintaining the assumption of full flexibility of nominal variables. The short run equilibrium, which

[13] Blanchard-Galí (2006) consider as the benchmark solution the "constrained efficient allocation". Implicitely, they assume that the social planner cannot eliminate the frictions in the labour market. In the present work, we consider hiring costs as labour market imperfections that, at least to a certain extent, can be alleviated by appropriate policies. This choice, in our view, is more appropriate to describe European unemployment. Notice however that the results of this paper are attainable also if one takes the constrained efficient allocation as a reference point.

can be affected by the exogenous shocks, can be derived by the log-linearization of the marginal costs; this permits to obtain:

$$\frac{1}{\mu}\widehat{mc}_t = \frac{W}{A}\left\{\hat{w}_t^{Nash} + \hat{\varepsilon}_t\right\} + \frac{S}{A}\left\{\hat{s}_t\right\} - \beta(1-\delta)\frac{S}{A}E_t\left\{\sigma\left(\hat{c}_t - \hat{c}_{t+1}\right) + \hat{s}_{t+1}\right\} - \frac{1}{\mu}\hat{a}_t \tag{32}$$

where $S = \dfrac{GH}{U}$ is the hiring cost's value of steady state and $\hat{s}_t = \hat{h}_t - \hat{u}_t$. In the following we assume the steady state level of productivity $A = 1$.

Log-linearising the Nash wage rule, it is possible to obtain:

$$W\hat{w}_t^{Nash} = \eta S\hat{s}_t - \beta(1-\delta)\eta S\left(1 - \frac{H}{U}\right)E_t\left\{\sigma\left(\hat{c}_t - \hat{c}_{t+1}\right) + \left(1 - \frac{\frac{H}{U}}{1-\frac{H}{U}}\right)\hat{s}_{t+1}\right\} \tag{33}$$

Using these two expressions, after some algebra, we can rewrite the marginal cost as follows:

$$\frac{1}{\mu}\widehat{mc}_t = F_1\hat{n}_t - F_2\hat{n}_{t-1} - F_3E_t\hat{n}_{t+1} - F_4\hat{a}_t + W\hat{\varepsilon}_t \tag{34}$$

where:

$$F_1 = (1+\eta)\,Sb_0 + \beta(1-\delta)S\left\{\left(1+\eta H'\right)(b_1 - \sigma) - \frac{H}{U}b_1\eta\right\} \tag{35}$$

$$F_2 = S\,(1+\eta)\,b_1 \tag{36}$$

$$F_3 = \beta(1-\delta)S\left\{\left(1+\eta H'\right)(b_0 - \sigma) - \frac{H}{U}b_0\eta\right\} \tag{37}$$

$$F_4 = \frac{1}{\mu} + \beta(1-\delta)S\sigma\left(1+\eta H'\right)(1-\rho_a) \tag{38}$$

$$b_0 = \frac{1}{\delta} \tag{39}$$

$$b_1 = \frac{(1-\delta)}{\delta}H' \tag{40}$$

$$H' = \left(1 - \frac{H}{U}\right) \tag{41}$$

Since under the symmetrical equilibrium condition (20) one has $\dfrac{1}{\mu} = MC_t$ and the mark up μ is a constant, the log-deviations of the marginal cost must be $\widehat{mc}_t = 0$. From the (34) the natural employment (associated to the natural output) evolves according to the following:

$$F_1\hat{n}_t = F_2\hat{n}_{t-1} + F_3E_t\hat{n}_{t+1} + F_4\hat{a}_t - W\hat{\varepsilon}_t \tag{42}$$

from which it can be seen that time t natural employment thus depends on employment at time $t-1$, on the expectations of employment at time $t+1$, on the productivity shock and on the wage shock.

To finally evaluate whether the distance between the natural (second best) employment $\hat{n}_t$ and the first best is constant, it is sufficient to compare (42) with the corresponding efficient employment, which is simply $\hat{n}_t^* = 0$ (remember that employment is constant at the full employment level under the first best). Equation (42) immediately shows that aggregate shocks cause an *endogenous* dynamic in the welfare relevant output gap: when productivity shocks $\hat{a}_t$ and wage shocks $\hat{\varepsilon}_t$ hit the economy, the natural employment equilibrium changes and thus the gap with respect to the first best ($\hat{n}_t^* = 0$) changes[14].

4 Sticky prices

The further question is to examine the *welfare-relevant output gap* in a model affected by price stickiness. In this context, where nominal rigidities give rise to non neutral effects of monetary policy, a new 'policy design' problem arises.

The non neutrality of nominal shocks may be obtained by introducing nominal inertia, as shown in the basic sticky price model widely adopted in the New Keynesian Economics. In this section, this basic framework is reformulated to take into account the presence of hiring costs. An additional inertia in the interest rate adjustment qualifies the Taylor rule, which is assumed to be the monetary policy rule adopted by the central bank.

4.1 Calvo pricing and the New Keynesian Phillips curve

Let us now assume the staggered price setting model proposed by Calvo (1983). In each period t, a fraction $(1-\theta)$ of firms (randomly selected) reset their optimal price, while the remaining fraction θ keeps it unchanged. The optimal price for an adjusting firm is set so as to maximise the discounted sum of current and expected future profits. It can be shown that the following condition is obtained[15]:

$$E_t \sum_{s=0}^{\infty} \theta^s Q_{t,t+s} Y_{t+s/t} \left(\tilde{P}_t - \frac{\epsilon}{\epsilon - 1} P_{t+s} MC_{t+s} \right) = 0 \tag{43}$$

where, as seen before, $Q_{t,t+s}$ is the discount factor with which agents value profits obtained at date $t+s$, while $\tilde{P}_t$ denotes the optimal price chosen in period t and $Y_{t+s/t}$ is the future level of output in period $t+s$ for a firm re-setting prices at time t. The real marginal cost is as in (21) above:

$$MC_t = \frac{1}{A_t}\frac{W_t}{P_t} + \frac{GH_t}{A_t U_t} - \beta(1-\delta) E_t \left\{ \frac{C_t^\sigma}{C_{t+1}^\sigma} \frac{GH_{t+1}}{A_t U_{t+1}} \right\} \tag{44}$$

[14] Interestingly, this result contrasts - at least at a first sight - with the finding of Blanchard-Galí (2006). In their paper, in fact, the divine coincidence still holds after the introduction of hiring costs. They thus need to assume real wage rigidities to create a non-trivial policy trade-off. In our model, instead, the introduction of hiring costs *does* introduce such a trade-off. What can explain this apparent inconsistency? The answer is simple, and lies in the fact that Blanchard-Galí (2006) focus on a particular, very convenient parametrisation. Specifically, they assume that the utility function is log in consumption and that hiring costs increase proportionally with productivity. These two assumptions imply that the first best and the second best level of output are constant and invariant to productivity shocks. As both are constant, the distance among the two is also constant and the divine coincidence continues to hold. As soon as one deviates from these two assumptions, the first best and the second best level of output will vary with shocks and, more importantly, they will not evolve in the same way: the divine coincidence disappears. Intuitively, the main reason why the first best and the second best level of output will have different dynamics lies in the presence of the two mentioned externalities in the hiring process (the first entering through aggregate hirings H_t and the second through unemployment U_t).

[15] See Blanchard-Galì (2006) for a detailed discussion of the derivation in a similar setting.

In our model, hiring costs affect profits and therefore pricing decisions. Furthermore, since the lagged values of employment influence the present level of hiring and therefore recruiting costs, one should have that profits are conditioned by past employment decisions. However, it must be noticed that it is the *marginal* value of hirings ($\frac{GH_t}{U_t}$) that matters and that in the specification for hiring costs adopted (16) such a marginal value is independent of the individual hiring level h_t^i. One can thus obtain again the standard result that lagged values do not exert any influence on current choices, and each optimising firm chooses the same strategy since the pricing history does not affect the individual choice. This allows one to aggregate prices and to obtain, as in the standard Calvo model, the index $P_t = \left[(1-\theta)(P_t^*)^{1-\epsilon} + \theta(P_{t-1})^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}$.

Log-linearising around a zero inflation steady state the optimal price setting rule and the price index equation one can get the standard *New Keynesian Phillips Curve*:

$$\hat{\pi}_t = \beta E_t \left\{\hat{\pi}_{t+1}\right\} + \lambda \widehat{mc}_t \tag{45}$$

Where $\widehat{mc}_t$ represents the log deviation of real marginal cost from its steady state value and $\lambda = (1-\beta\theta)(1-\theta)/\theta$.

Apparently the Phillips curve in (45) is identical to the standard NK Phillips curve. However, the term $\widehat{mc}_t$ is now influenced by the presence of hiring costs. Equation (32) leads to rewrite the NKPC (45) in terms of employment as follows:

$$\hat{\pi}_t = \beta E_t \left\{\hat{\pi}_{t+1}\right\} + \lambda\mu \left\{F_1 \widehat{\overline{n}}_t - F_2 \widehat{\overline{n}}_{t-1} - F_3 E_t \widehat{\overline{n}}_{t+1} - F_4 \hat{a}_t + W\hat{\varepsilon}_t\right\} \tag{46}$$

where the upper bar denotes the solutions for the real variables in a sticky price equilibrium. Expression (46) can be written in terms of the welfare relevant output gap. By denoting $\hat{x}_t$ the welfare relevant output gap and recalling that in our model the output gap is equal to the employment gap, $\hat{x}_t = \widehat{\overline{y}}_t - y_t^* = \widehat{\overline{n}}_t$, one has [16]:

$$\hat{\pi}_t = \beta E_t \left\{\hat{\pi}_{t+1}\right\} + \lambda\mu \left\{F_1 \hat{x}_t - F_2 \hat{x}_{t-1} - F_3 E_t \hat{x}_{t+1} - F_4 \hat{a}_t + W\hat{\varepsilon}_t\right\} \tag{47}$$

Interestingly, equation (47) implies that the "divine coincidence" does not hold, and this result is obtained without introducing any unexplained real wage rigidity. Inflation at time t depends on expected inflation, a distributed lag of welfare relevant output gaps, the expected output gap and on the productivity and wage shocks. This implies that there is no way to stabilise at once inflation and the welfare relevant output gap. A new policy trade off arises which is absent in the standard NK model.

Consider at first a "pure inflation targeting" strategy, i.e. a strategy aimed at stabilising inflation at all horizons ($\hat{\pi}_t = 0$ for all t). From (47) it follows that the output gap evolves according to the following:

$$F_1 \hat{x}_t = F_2 \hat{x}_{t-1} + F_3 E_t \hat{x}_{t+1} + F_4 \hat{a}_t - W\hat{\varepsilon}_t \tag{48}$$

Thus, we see that a pure inflation targeting strategy is unable to stabilise the output gap in face of productivity or wage shocks: output deviations from the benchmark will be

[16] More precisely, as the actual steady state level of output differs from the first best one, the output gap $\hat{x}_t$ denotes the *percentage change in the distance* between actual output and the first best.

large and display a high degree of inertia. Notice that under the pure inflation targeting strategy, firms have no incentive to change their prices[17]; accordingly, the dynamics of the output gap replicate exactly the dynamics under flexible prices, as can easily be seen by comparing (48) with (42).

Secondly, consider a "pure output targeting" policy, a strategy aimed at stabilising the output gap in each period, i.e. $\widehat{n}_t = 0$ and $\hat{x}_t = 0$ for all t. Iterating forward (45), one gets:

$$\hat{\pi}_t = \lambda \sum_{s=0}^{\infty} \beta^s E_t \left\{ \widehat{mc}_{t+s} \right\}$$

$$\begin{aligned} \hat{\pi}_t &= \lambda\mu \sum_{s=0}^{\infty} \beta^s E_t \left\{ F_1 \hat{x}_{t+s} - F_2 \hat{x}_{t+s-1} - F_3 E_t \hat{x}_{t+s+1} - F_4 \hat{a}_{t+s} + W \hat{\varepsilon}_{t+s} \right\} \\ &= \lambda\mu \sum_{s=0}^{\infty} \beta^s \left\{ W E_t \hat{\varepsilon}_{t+s} - F_4 E_t \hat{a}_{t+s} \right\} \end{aligned}$$

A "Pure Output Targeting" strategy is thus unable to stabilise inflation. Therefore, adverse realisations of wage or productivity shocks necessarily lead to a rise in inflation and/or a negative output gap. The presence of hiring costs, by affecting the distance between the first best and the natural level of output, creates a non trivial trade-off between output and inflation stabilisation. This calls into question the role of the monetary authority.

4.2 The monetary policy rule

The specific rule for the monetary policy proposed by Taylor (1993), expresses a direct relationship between the interest rate and two target variables, inflation and output gap. The appropriate definition of these two variables and their assigned relative weights reflect central bank's preferences[18]. These choices should be implemented to offset distorsions that may exists in the economy (Galí, 2002). However, when some model uncertainty is present, for instance when the central bank knows the distribution of some parameters of the model economy but does not know their actual realisations, some caution in policy responses may be desirable (Clarida, Galí, Gertler, 1999). This implies the adoption of an optimal rule, under some constraints on the volatility of the interest rate. The sluggishness

[17] See e.g. Galí (2002) for a discussion of this point.

[18] In a class of models where individual preferences are expressed in terms of consumption and leisure, and where each family elastically supplies his labour services, the choice of the optimal policy rule may be undertaken adopting a welfare criterium as the expected utility of the representative household. This welfare approach has been suggested by Woodford (2003, ch. 6); the author derives a quadratic loss policy function that represents a quadratic (second-order Taylor series) approximation to the level of expected utility of the single household. This utility-based welfare approach is however not attainable in our model economy, as in Walsh (2005), where each family inelastically supplies a fixed amount of labour. It must be recalled that other issues, as the possibility of "hybrid" targeting rules and discretionary policies or the role of imperfect knowledge may condition the actual choice of central banks. A wide excursus of the several themes and critical perspectives related to targeting policy rules is offered by the group of contributions collected in Bernanke, Woodford (2005).

in the policy reaction function, which provides a more realistic picture of the historical patterns of interest rates, may be captured by the following rule:

$$(1+i_t) = \beta^{1-\rho_m}(1+i_{t-1})^{\rho_m} E_t(\pi_{t+1})^{\phi_\pi(1-\rho_m)}(x_t)^{\phi_x(1-\rho_m)} e^{\varepsilon_t^m} \tag{49}$$

Log-linearising it around the steady state, one can get:

$$\hat{\imath}_t = i_t - \rho = \rho_m \hat{\imath}_{t-1} + \phi_\pi (1-\rho_m) E_t(\hat{\pi}_{t+1}) + \phi_x (1-\rho_m) \hat{x}_t + \varepsilon_t^m \tag{50}$$

The "interest rate smoothing" is captured by ρ_m, the coefficient associated with the lagged value of the interest rate: the higher is ρ_m, the more partial is the adjustment of the policy instrument and therefore the more cautious is the response of the central bank to exogenous disturbances. Furthermore, the extent of the adjustment of the policy instrument is conditioned by ϕ_π and ϕ_x: the higher are the values of ϕ_π and ϕ_x, the coefficients associated to the target variables, the faster the economy returns to its equilibrium values when some shocks occurr. Finally it is assumed that ε_t^m is an *i.i.d* shock term.

4.3 Dynamics with hiring costs and sticky prices

The model presented so far, although featuring several market imperfections and institutional parameters, can be reduced to a relatively simple three equations macro-model as can be done with the standard NK model. The equilibrium in our economy with hiring costs, Nash bargaining and equilibrium unemployment is fully characterised by the Euler equation (the *IS* curve), the New Keynesian Phillips Curve (NKPC), the monetary policy rule and the processes for the exogenous shocks:

$$\textbf{IS: } \hat{x}_t = -\frac{1}{\sigma}(i_t - E_t\pi_{t+1} - \bar{r}_t) + E_t\hat{x}_{t+1} \tag{51}$$

$$\textbf{NKPC: } \hat{\pi}_t = \beta E_t\{\hat{\pi}_{t+1}\} + \lambda\mu\{F_1\hat{x}_t - F_2\hat{x}_{t-1} - F_3E_t\hat{x}_{t+1} - F_4\hat{a}_t + W\hat{\varepsilon}_t\} \tag{52}$$

$$\textbf{Taylor rule: } \hat{\imath}_t = \rho_m \hat{\imath}_{t-1} + \phi_\pi (1-\rho_m) E_t(\hat{\pi}_{t+1}) + \phi_x (1-\rho_m) \hat{x}_t + \varepsilon_t^m \tag{53}$$

Exogenous processes:
Productivity shock: $a_t = \rho_a a_{t-1} + u_t^a$
Wage Shock: $\varepsilon_t = \rho_w \varepsilon_{t-1} + u_t^\varepsilon$
Monetary Policy Shock: $\varepsilon_t^m = u_t^m$

The model here presented may be compared with a standard New Keynesian model where structural imperfections in the labour market are absent. We also perform a sensitivity analysis in order to explore how the economy responds to shocks as some fundamental parameters change. The model presented allows one to pursue the analysis of the differences in dynamic performance between two economies, characterised by different degrees of market imperfection and labour protection. All such exercises are performed in section 6.

5 Calibration

In this section we describe the parameter values used in our baseline calibration. These parameters are chosen to be largely consistent with those standard in the *New Keynesian* literature. The following table summarises the baseline values for the key parameters of our model with hiring costs:

Preferences and Technology	β	σ	ϵ	μ	A
	0.99	2	11	1.1	1
Labour market	u	G	δ	η	b
	0.08	0.26	0.08	0.5	0.865
Price nominal rigidity	θ				
	0.75				
Interest Rate rule	ρ_m	ϕ_π	ϕ_x		
	0.9	1.1	0		
Shocks' Persistence	ρ_w	ρ_a	ρ_ε		
	0.75	0.9	0		

Preferences and technology: β is set equal to 0.99, which implies a riskless annual return of about 4 percent (The time period is taken to correspond to a quarter). We assume $\sigma = 2$, which implies a greater degree of risk aversion than that implied by a log utility function. The elasticity of substitution between differentiated goods ϵ is set equal to 11, corresponding to a markup $\mu = 1.1$[19]. The steady state level of productivity A is set equal to 1 only for simplicity.

The labour market: In the baseline calibration, we set $u = 0.08$, which is roughly consistent with the average unemployment rate in Europe (EU15). Following Trigari (2005), we assume a separation rate δ equal to 0.08. This value is consistent with the findings in Hall (1995), that is a separation rate between 8 and 10 percent. The relative bargaining power η is set to 0.5, which implies that the bargaining power of workers is 1/2 of the bargaining power of firms. The scaling parameter G is chosen such that hiring costs are 1% of steady state output[20]. The remaining labour market parameters are determined by using steady state relationships. In particular, the job-finding rate $\frac{H}{U} = 0.481$. Finally, the steady state equilibrium condition allows us to pin down the value of home production b.

The degree of price rigidity θ is set equal to 0.75, as in Galí (2002), implying an average duration of a price contract of one year (a higher level than suggested in Galí and Gertler, 1999 for the U.S. economy).

Following Walsh (2005), we adopt a baseline *interest rate rule* for monetary policy where the central bank is assumed to respond to inflation but not to the output gap ($\phi_x = 0$). Furthermore, we assume that the degree of inertia in the policy rule ρ_m equals 0.9, a value consistent with the empirical evidence on policy rules. In subsection 6.3 we

[19] Notice that a mark-up of 1.1 is definitely lower than the average (1970-1992) mark-up in manifacturing estimated for several OECD countries by Oliveira Martins, Scarpetta, Pilat (1996).

[20] Walsh (2005) makes a similar assumption when he calibrates job posting costs to be 1% of steady-state output.

shall also explore the consequences of variations in the parameters of such a monetary policy rule.

Persistence of shocks: we assume that productivity shocks are more persistent than wage shocks ($\rho_a = 0.9$ while $\rho_w = 0.75$).

In the following, we compare our model with hiring costs with a standard *New Keynesian* model. Notice that, for an easier comparison, we use exactly the same parameter values for the two models. The only parameter that enters into the standard *NK* model, but is absent in our model, is the inverse of the elasticity of labour supply, ν, which we set equal to 1, implying a unit wage elasticity of labour supply (as in Galí, 2002).

6 Simulations

As already mentioned, the standard *NK* model fails in replicating the large and persistent response of output and to reproduce the sticky dynamics of inflation after nominal shocks. Moreover, the standard *NK* model typically implies that the volatility of inflation is much larger than the one of output, a result which again is at odds with empirical evidence. In this section we show that our simple model with hiring costs and equilibrium unemployment helps to solve these shortcomings.

6.1 Comparison with the standard NK model

First of all, it is relevant to evaluate the impact of a monetary shock, which in our simulation takes the form of a 1% decrease in the nominal interest rate. The results obtained are shown in Figure 2.

Several interesting facts emerge. First, inflation in an economy with hiring costs (simply labelled as "h") appears to be less volatile and more persistent than in a standard NK economy (denoted as "s"). Second, the response of output shows higher persistence in a h-economy than in a s-economy. Therefore, the model with hiring costs is able to better replicate a central dynamic feature of real world economies, namely "the sluggish response of inflation together with the large and persistent response of output" (Trigari 2005, p. 2). Third, in the h-model the sensitivity of real marginal costs and of real wages to output changes is much lower than in the standard NK model. Interestingly, the low volatility of real wages is obtained endogenously, without the need to impose an unexplained real wage rigidity. This "endogenous rigidity" of the real wage comes from the fact that, by assuming a constant reservation wage (the home production b), we have de facto closed the traditional intertemporal substitution channel of employment variations. In line with empirical evidence, in our model employment fluctuations are mainly determined by labour demand variations.

Our simple model with hiring costs is thus able to overcome many of the dynamic weaknesses of the standard NK model. Furthermore, it can be shown that these dynamics, obtained with a simple and tractable model, are very similar to the ones obtained in those far more complex NK models which incorporate labour search and exogenous wage rigidities (Trigari, 2005 ; Walsh, 2005).

The intuitive reasons behind the results here obtained are as follows: a positive nominal shock causes an increase in the aggregate demand for goods and labour. Accordingly, in period t recruiting activities and unit hiring costs also increase. However, for each

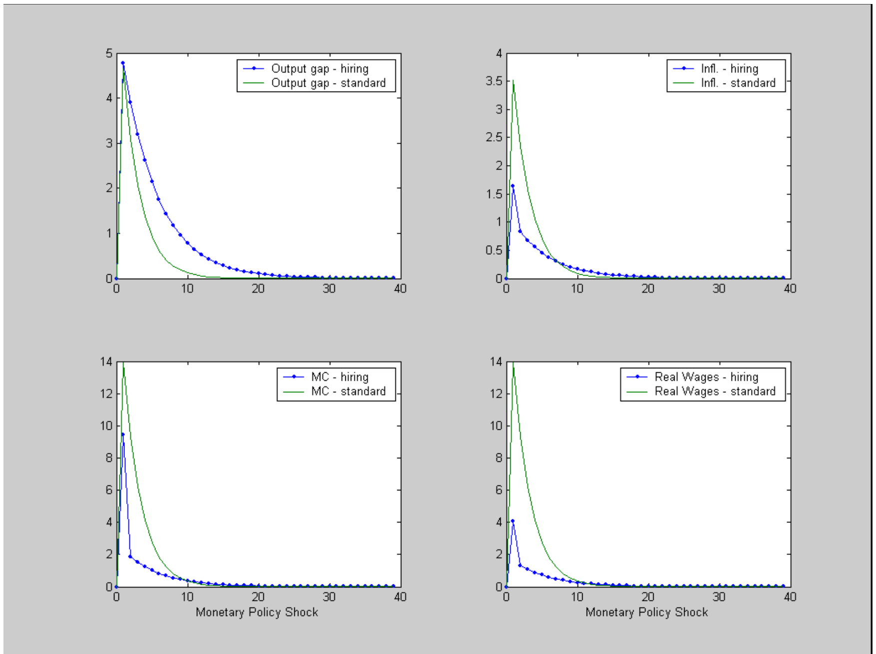

Figure 2: *Comparison with the standard NK model*

additional hiring undertaken in this period, there will be $(1-\delta)$ more employed workers in the next period[21]. In this context, additional current hirings generate, in period $t+1$, two externalities. On the one hand, the increase in the number of employed workers reduces the costs of new hires; on the other hand, a lower level of unemployment has a negative impact since it represents an obstacle to the matching process and thus increases hiring costs. These two forces may counterbalance one another and as a net effect may produce not only a less pronounced responsiveness of marginal costs to output fluctuations, but also a smoother dynamic. Furthermore, the less marked change of the marginal value of an employment relationship (the lower volatility of S), induces, on its turn and for a given bargaining power η, a less pronounced change of the real wage, as shown in Figure 2.

6.2 The Role of Labour Market Institutions

Additional insights may be obtained by comparing the different output and inflation responses to exogenous shocks and associated to different values of the structural imperfections of the labour market. This sensitivity analysis has been performed by varying the value of the separation rate δ (Figure 3), of the workers' bargaining power η (Figure 4), and of the hiring costs G, expressed as a percentage α of aggregate output (Figure 5). We just show the results obtained following a wage shock, i.e. a 1% unexpected increase of the real wage. The same conclusions hold with respect to other shocks.

[21]By simply considering the definition of the marginal hiring costs at time $t+1$ some relevant intertemporal links appear, as $S_{t+1} = G\frac{H_{t+1}}{U_{t+1}} = G\frac{N_{t+1}-(1-\delta)N_t}{1-(1-\delta)N_t}$.

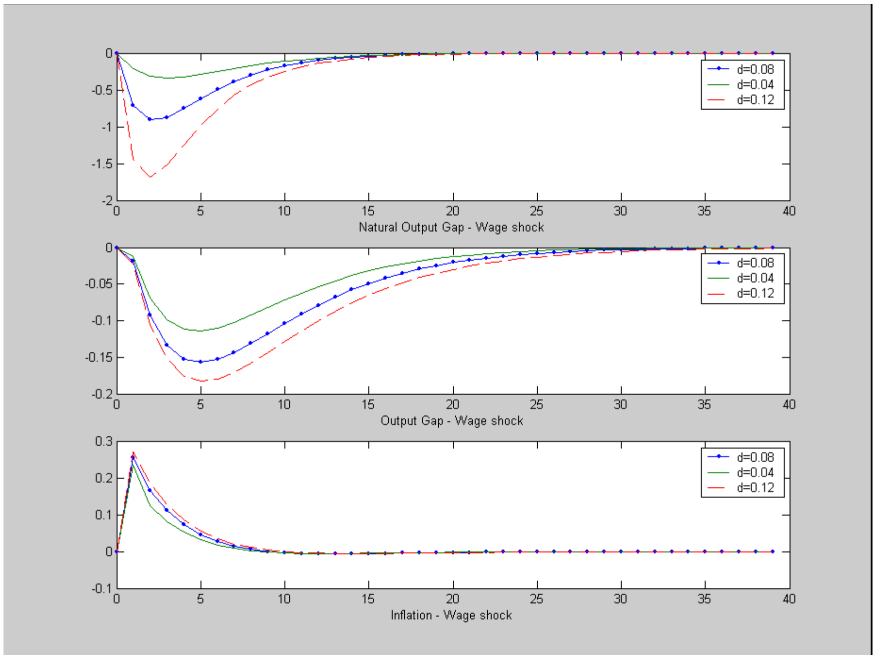

Figure 3: *Sensitivity analysis: changing separation rate (δ)*

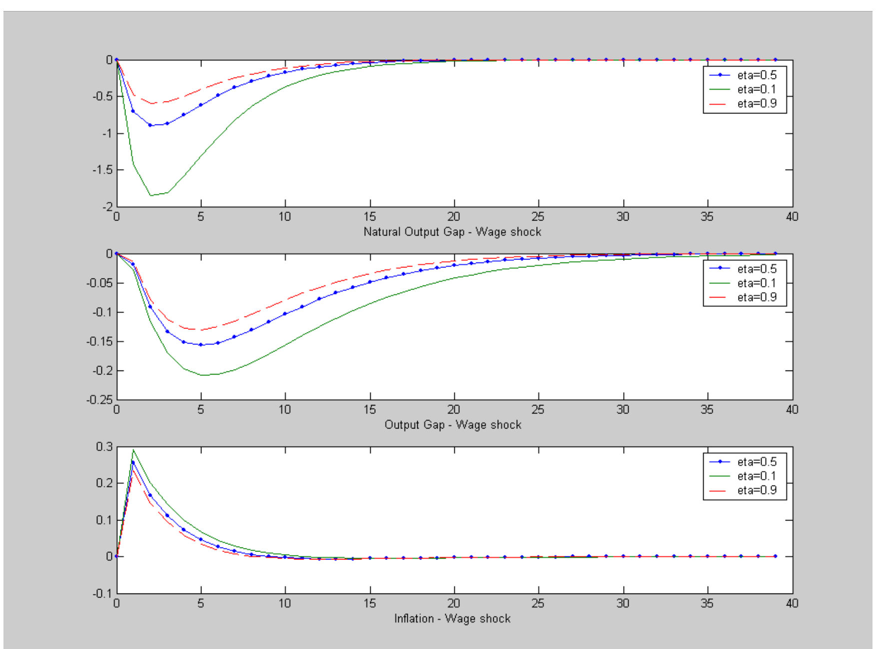

Figure 4: *Sensitivity analysis: changing bargaining power (η)*

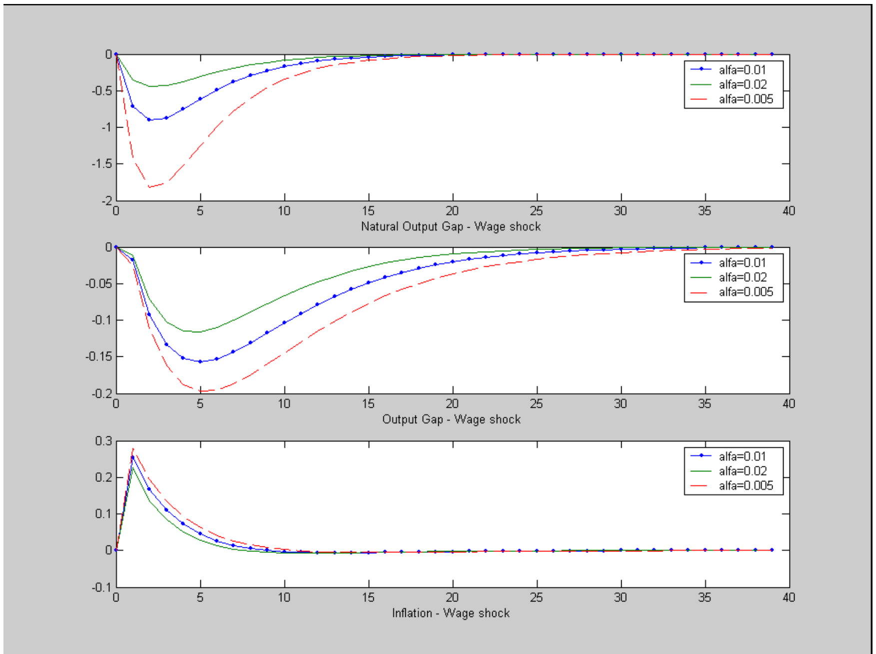

Figure 5: *Sensitivity analysis changing hiring costs as a percentage of aggregate output (α)*

It is interesting to note that the larger the departure of each single key parameter from the value it would assume in a competitive framework, the smaller the response of aggregate real activity to exogenous shocks. The closer the economy is to a competitive ideal the more volatile are output responses.

Notice also that, for any set of parameter values, a wage shock generates, through an increase in marginal costs, higher inflation and lower output levels. However, the magnitude of these effects are significantly conditioned by labour market institutions, since employment and wage adjustments are influenced by the various rules governing labour allocation.

To evaluate the role of these institutions, one can start by considering the impact of a wage shock under different legislation on employment. The shock generates a lower job destruction, the higher is the employment protection, and therefore the lower is the separation rate δ. It means that the contractionary impact on employment and output of an exogenous wage shock are lower when higher firing costs cause a lower employment adjustment.

Furthermore, a higher protection of workers' positions may be obtained in wage agreements. A higher workers' contractual strength η, due for instance to an increase of union membership or a higher coverage of collective agreements, makes that a wage shock feeds into lower contraction of employment and output.

Similar results are obtained when the insiders' position is empowered by the presence of higher rents, due to a higher level of recruitment costs α; in this case the matching rents are increased by recruitment costs, and these costs as well as firing costs, reduce job turnover rates, hence a given wage shock gives rise to lower job destruction.

6.3 Rigid versus flexible economy

To further explore the role played by the several imperfections and by their combined action, it is possible to compare the simulated dynamic behaviour of two different model economies, one featuring significant imperfections in the labour market, and the other one showing a more competitive framework. Let us call the first one the Rigid Economy (RE), and the second one the Flexible Economy (FE). This simplified characterisation is obtained by introducing in the RE high recruitment costs, a lower separation rate and a higher worker' s bargaining power. The following table summarises the main characteristics of the two economies[22]:

	Separation rate	Workers' Bargaining Power	Hiring Costs (as % GDP)	Unemployment Rate
Rigid Economy	0.06	0.7	1.5	0.10
Flexible Economy	0.10	0.3	0.8	0.04

The assumed parametrisation for the two economies has been used to evaluate the impact of exogenous shocks in the two different scenarios. It is natural to observe that the influence of monetary policy, which can be advocated when some disturbance hits the economy, is conditioned by the objective trade off shown by the slope of the Phillips curve. Let us assume, for instance, some exogenous adverse shocks that shift up the Phillips curve. For the same set of central bank's preferences in terms of inflation and output deviations, one obtains that disinflation is costly in terms of output losses, the flatter is the Phillips curve. This comes true for the FE, where the task of bringing down inflation produces a more significant sacrifice in terms of output contraction[23].

The results in terms of responses to a wage shock for the RE and for the FE are obtained under the hypothesis of a standard Taylor rule characterised by a persistence parameter $\rho_m = 0.9$, an inflation weight $\phi_\pi = 1.5$ and an output gap weight $\phi_x = 0.5$. To maintain comparability, the same rule has been assumed for the two economies. The results are shown in Figure 6.

Observe from the patterns shown in Figure 7 that a less pronounced fluctuation of

[22] Others parameters are obtained through the steady state conditions. In particular, under these calibrations we get:

- Job-Finding rate $\frac{H}{U}$: 0.35 for the RE, 0.71 for the FE
- Recruitment costs G: 0.71 for the RE, 0.11 for the FE
- Reservation Wage b: 0.822 for the RE, 0.883 for the FE.

[23] Assume that exogenous shocks are zero and suppose also that the monetary authority tries to permanently rise the employment level by $x\%$. It follows that this policy leads to a steady state level of inflation given by $\hat{\pi} = \frac{1}{1-\beta}\lambda\mu\left(F_1 - F_2 - F_3\right)x$. For the same degree of nominal stickiness, the RE is characterised by a steeper Phillips curve, since high recruitment costs G, strong trade unions (high η), strong employment protection (a small separation rate δ) generate a coefficient $\frac{1}{1-\beta}\lambda\mu\left(F_1 - F_2 - F_3\right)$ higher than that of the FE. For instance, for the parametrisation chosen and presented in this section the slope of the Phillips curve of the RE is nearly three times higher than that of the FE.

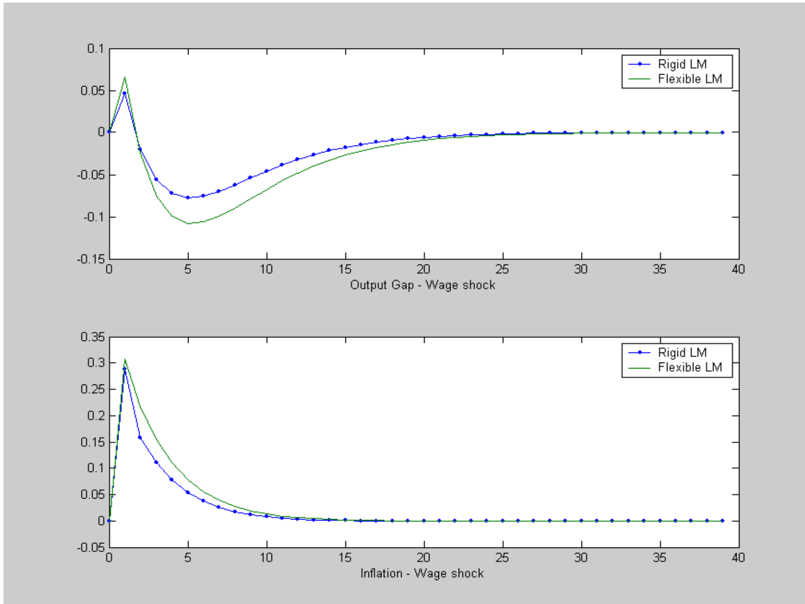

Figure 6: *Rigid vs flexible economy: wage shock with a traditional Taylor rule*

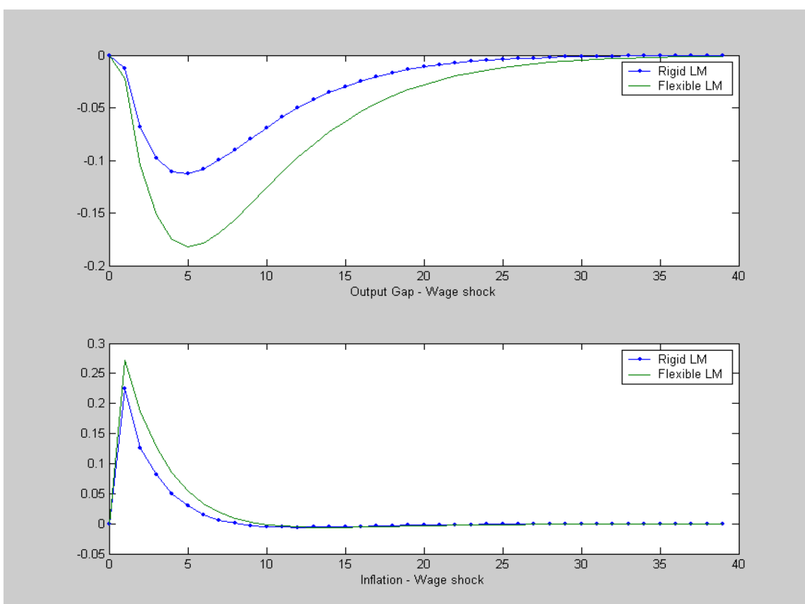

Figure 7: *Rigid vs flexible economy: wage shock with an anti-inflation oriented Taylor rule*

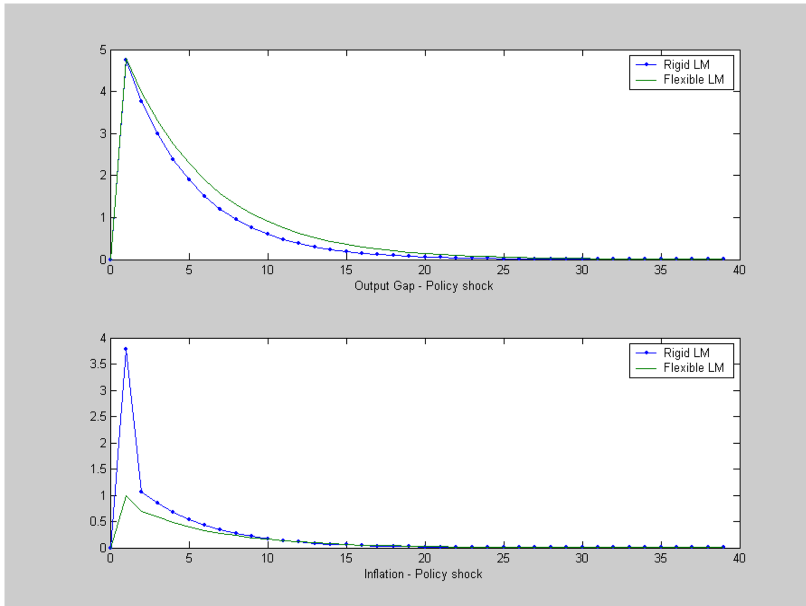

Figure 8: *Rigid vs flexible economy: an unexpected policy shock (anti-inflation Taylor rule)*

output is obtained in a more rigid context, since in this case, the same inflation target calls a lower volatility of output, as predicted by its steeper Phillips curve. The differences are even more significant when the monetary authority is anti-inflation oriented and adopts a policy more oriented to a strict inflation targeting. By imposing $\phi_x = 0.$ and $\phi_\pi = 1.1$, the results obtained are shown in Figure 7.

The comparison seems appropriate to interpret the different scenario observed in the US and the Euro area, where the two central banks adopt similar policy rules to stabilise inflation, but face different side-effects in terms of output stabilisation, as proved by the lower volatility of the output gap prevailing in several European countries.

To further evaluate the different responses of output and inflation to exogenous shocks, let us consider an unexpected policy shock represented by a one percent decrease of the nominal interest rate (Figure 8). As one can see from Figure 8, the impact of the same monetary policy shock is influenced by the several institutions governing the functioning of the labour market. When employment protection, workers bargaining power and matching rents due to recruitment costs are higher, as in the RE, a given policy shock and the consequential aggregate demand expansion exert stronger upward pressures on wages, marginal costs and inflation. However, for a given nominal shock, the higher inflation response in the RE is associated with dampened fluctuations of employment and output, thus showing that the labour market represents a crucial channel for the transmission of monetary policy. This implies that, for given central bank's preferences, the RE shows much lower volatility of output and a higher volatility of inflation, thus suggesting that the same stabilisation target calls for different policy rules in the two economies.

As for productivity shocks, as seen in subsection 4.1, a positive shock causes a reduction of $\widehat{mc}_t$, the log deviation of real marginal cost from its steady state value. This effect in turns generates an initial lower price dynamics $\hat{\pi}_t$. The magnitude of this impact is conditioned, as seen from the Phillips curve, by several parameters that play a role in determining the link between marginal costs and current inflation, and therefore on F_4, where $F_4 = \frac{1}{\mu} + \beta(1-\delta)S\sigma\,(1+\eta H')\,(1-\rho_a)$.

A careful examination of F_4 shows that the labour market imperfections positively affect F_4, and therefore the more relevant the imperfections in the labour market the higher F_4. The intuition behind this result is that a positive productivity shock allows firms to produce a given level of output with less workers and this 'labour saving effect' is higher when recruiting and firing costs are higher and when employees are able to appropriate a larger share of matching rents. These considerations may explain why the initial reduction of inflation is significantly higher in the RE than in the FE. However, this initial impact tends to vanish in the long run, as shown in Figure 9, since in our model the dynamic pattern of marginal costs implies that a lower recruiting effort at time t increases the cost of hiring new workers in period $t+1$ (equation 44). These dynamic effects can easily motivate the reversal patterns that a disinflation have in the two economies, thus justifying why the differentials in price reduction obtained in the first period in the RE, are reabsorbed in a longer perspective.

It must be added that when positive shocks lead to a higher natural output, stickiness in price setting does not produce the same increase of the actual output. In the rigid economy, however, the higher real rigidities featuring this economy are conducive to a lower distance between the actual and the natural output and generate a protracted response of output gap, as shown in Figure 9.

Figure 10 reports some of the volatilities of output and inflation resulting from different kinds of shocks. The interesting result, once again, is that labour market institutions and imperfections deeply affect the constraints faced by the central bank. A country that has more rigid labour markets typically experiences a lower degree of output volatility and higher inflation volatility. Intuitively, when labour markets are rigid, it is more costly for the firm to hire new workers and therefore employment does not vary as much as it would in a more flexible economy. If the rigidity lies in the labour market, in the RE job and output flows are less volatile, as quantities cannot adjust and the shock has to be absorbed through price changes.

7 Conclusions

We have constructed a simple dynamic general equilibrium model to study the interactions between market imperfections and nominal rigidities which is capable of overcoming the main shortcomings of the standard NK model.

In order to get involuntary unemployment and a more sensible dynamics than that obtained by the standard NK model we only need two ingredients: staggered price setting and labour market imperfections. The unexplained real wage rigidity indispensable in Blanchard, Galí (2006) needs not be used in our framework: a certain degree of real wage stickiness turns out endogenously. Nor there is any need to embody a full-fledged search model of the labour market in the dynamic NK framework.

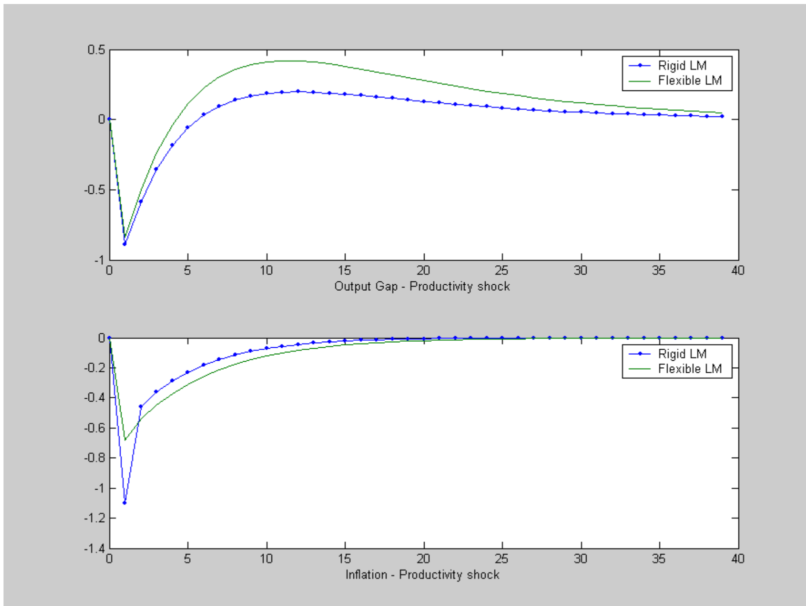

Figure 9: *Rigid vs flexible economy: productivity shock (anti-inflation Taylor rule)*

	Shocks			
	Wage	**Productivity**	**Mon. Policy**	**All**
Rigid Economy				
Inflation volatility	0,27	1,31	0,82	1,57
Output volatility	0,28	1,33	1,48	2,01
Flexible Economy				
Inflation volatility	0,36	1,12	0,30	1,23
Output volatility	0,45	1,70	1,61	2,39
NB: Standard Deviations Shocks:				
Monetary Policy	0,002	As in Walsh (2005)		
Productivity	0,010	As in Walsh (2005)		
Wage	0,010	No reference value		
Interest Rate Rule:	Baseline Calibration			

Figure 10: *Output and inflation volatility in a RE and in a FE*

The introduction of a very simple model of hiring costs, drawn from Howitt (1988), is sufficient to make the divine coincidence to disappear and to create a significant trade-off between output and inflation stabilisation, showing that the structure of the labour and goods markets deeply affects the transmission mechanism of monetary policy. Hence our model is more parsimonious than those developed so far.

Moreover, with respect to the standard NK model, our model allows to better replicate the observed sluggish response of inflation and large and persistent output fluctuations after a monetary policy shock. The model is also consistent with the observed low volatility of real wages (as already said, without imposing real wage rigidity) and with a volatility of output larger than that of inflation. The careful reader may realise that the simulated dynamics of our model are very similar to the ones obtained by using far more complex models incorporating labour search. We regard the ability of reaching an equally realistic result with a simpler model as an advantage of our approach.

The model also allows to compare the dynamic behaviour of a "rigid" and a "flexible" economy. It turns out that output is less volatile in a rigid economy (i.e. an economy with a high degree of labour market imperfections) than in a flexible economy, whilst the opposite holds as far as inflation is concerned.

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