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A non-Walrasian labor market in a monetary model of the business cycle☆

Francesco Zanetti*

Bank of England and EABCN, Threadneedle Street, London EC2R 8AH, UK

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Abstract

This paper investigates to what extent a new Keynesian, monetary model with the addition of a microfounded, non-Walrasian labor market solely based on union bargaining is able to replicate key aspects of the business cycle. The presence of a representative union offers an explanation for two features of the cycle. First, it generates an endogenous mechanism which produces persistent responses to both supply and demand shocks. Second, labor unionization reduces the elasticity of marginal costs to output. This leads to lower inflation volatility. Model simulations show that the unionized framework can better reproduce European business cycle data than can a model with a competitive labor market.

JEL classification: E24; E31; E32

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1. Introduction

New Keynesian macroeconomics is based on two core beliefs. The first is that fluctuations in aggregate demand are a central source of short-run changes in

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*Tel.: + 44 2076015602; fax: +44 2076015650.
E-mail address: francesco.zanetti@bankofengland.co.uk.

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aggregate economic activity such as output and employment. The second is that the economy is characterized by involuntary unemployment: some people are willing to work, but are unable to find a job at the offered wage. The first of these notions has been extensively investigated using nominal imperfections, in other words the idea that nominal frictions that appear small at the level of individual households and firms may have a large effect on the macroeconomy. The economic literature has also made progress in understanding the microeconomics of unemployment, but has only recently started to use labor market frictions to study the business cycle and its interaction with demand shocks and monetary policy.

If there are no departures from Walrasian assumptions in the labor market, we would expect a decline in labor input associated with a decline in production to lead to a large decline in real wages.[1] As a consequence, the firm's marginal cost falls, increasing the incentive to reduce prices. This is in stark contrast to the empirical evidence, which suggests that output volatility is high and price volatility low.[2] In theory, imperfections in the labor market could account for this. Such imperfections would cause workers to be off their labor supply curves, thereby breaking the tight link between the elasticity of labor supply and the response of real wages to demand disturbances, implying that real wages may not be highly procyclical even if labor supply is quite inelastic. This same mechanism should also amplify and propagate disturbances and, as a consequence, it would be able to generate persistence without implausible assumptions on price adjustment.[3]

These considerations suggest that non-Walrasian labor markets may play a key role in explaining relevant features of the business cycle. In this paper, I incorporate equilibrium unemployment through union bargaining in an otherwise standard new Keynesian monetary model. I then use the model to study the consequences of union bargaining on the business cycle.

The theoretical setup I introduce is characterized by an innovative new Keynesian monetary model which departs from perfect competition in both labor and product markets. The structure of the labor market is non-Walrasian: wages are set by the bargaining process between firms and unions somewhere above the market-clearing level. This generates unemployment as some individual workers are unable to sell as much labor services as they wish to supply, given the established wages. Goods markets are imperfectly competitive due to the presence of monopolistically competitive, intermediate goods-producing firms. The monetary authority conducts policy using a Taylor-type rule to set the interest rate.

This model differs from the typical dynamic stochastic general equilibrium (hereafter, DSGE) model mainly in the presence of equilibrium unemployment, caused by the bargaining power of the union over the wage. To explain the existence of the union, the difference in the supply of labor and capital for the household needs

[1] This is based on the assumption that labor supply is relatively inelastic, as it appears from empirical evidence. For a recent paper on the topic see French (2004).

[2] See, for example, Bernanke and Gertler (1995), Christiano et al. (1997), and Bernanke and Mihov (1998).

[3] Recent works in support of implausible price adjustments are Bils and Klenow (2004), Chari et al. (2000), Dotsey and King (2005), Galì and Gertler (1999), and Sbordone (2002).

to be considered. In fact, for each period, while capital can be sold to a large number of firms, labor is indivisible and can be provided to only one firm. Households realize the possibility of extracting some producer surplus by joining unions that negotiate wages at the firm level while representing their members. The objective of these institutions is to maximize the average labor income of members regardless of capital income. Once a representative union sets the wage rate – higher than the competitive wage – the representative firm chooses the level of employment which maximizes its profit. As a result, some members of the union remain unemployed and are entitled to receive lump-sum transfers from the government. To prevent quits by unemployed members, unions ex post redistribute wages of employed people among all members. In this way, as in Pencavel (1986) and Merz (1995), unions act to completely insure markets so that the marginal utility of consumption between employed and unemployed members is equalized and the simplifying assumption of homogeneous agents is preserved over time.

The setup extends the previous literature in the following ways. First, Hall (2000) stresses that variable persistence in the aftermath of shocks is a critical property of the data that standard neoclassical models fail to reproduce. He suggests that the inclusion of non-Walrasian features may improve the replication of this feature of the business cycle. Along these lines, Maffezzoli (2001) shows that a real business cycle model with a monopoly union can better replicate Italian business cycle data than the Rogerson and Wright (1988) indivisible labor model. Nonetheless, his model does not consider monetary policy shocks and is not able to generate an appropriate level of persistence in response to supply shocks. Alexopoulos (2004) develops a shirking efficiency wage model which improves the replication of labor markets data but again fails to deliver an appropriate degree of persistence. Dotsey and King (2005), building upon Chari et al. (2000), point out that standard sticky price (hereafter, SP) models are not able to account for the persistent response of output to demand shocks and they allow for a number of 'supply side' features to improve the performance of a standard SP model. In this paper, the introduction of labor market bargaining into a standard SP model generates real wage rigidity that acts to magnify the degree of nominal rigidity and, hence, introduces persistence in response to both supply and demand shocks.

Second, Bernanke and Gertler (1995), Christiano et al. (1997), and Bernanke and Mihov (1998) offer evidence that inflation varies only moderately in response to monetary policy shocks. Standard new Keynesian SP models do not capture this feature of the business cycle. In this setup, a unionized labor market generates a lower elasticity of marginal costs with respect to output, and this translates into moderate price adjustment. The presence of union bargaining leads to lower variability of wages over the cycle. This is the key mechanism by which the model delivers lower inflation variability. When choosing its optimal price, a firm bases its decision on the expected present value of marginal costs that fluctuate according to wages and rental rates of capital. As the introduction of union bargaining does not vary significantly the dynamics of the rental rates of capital, the variation of wages is the driving force of marginal costs. Hence, lower volatility of wages translates into lower volatility of marginal costs and, ultimately, reduces inflation volatility.

The search and matching framework of the labor market, where unemployment arises endogenously because workers and employers encounter frictions in their flows of meetings, also makes marginal costs less volatile over the cycle. But while in this paper lower wage volatility due to wage bargaining is the sole reason for the lower cyclicality of marginal costs, in the search framework, as Krause and Lubik (2005) point out, other variables arising from the presence of labor market frictions drive the dynamic of marginal costs. Specifically, marginal costs turn out to depend on wages as well as the value of the average worker and the cost of posting a new vacancy. The cyclical behavior of these last two terms can differ substantially from that of wages in a frictional labor market.

The theoretical model is evaluated against the euro area, which is characterized by a higher degree of labor market unionization than in the United States. Table 1 shows that the union density – the percentage of union membership in a workforce – in the euro area is at least twice as high as in the United States, and the bargaining coverage rates – the proportion of employees covered by a collective agreement – are about 80% in Europe, but four times lower in the United States over the last two decades. Numerical simulations show that including a non-Walrasian labor market improves the ability of a standard SP model to replicate the euro area business cycle. The paper compares selected second moments of the two models to the same statistics of the actual euro area data.

Recent literature has employed new Keynesian, SP models to study business cycle dynamics and shock propagation. The majority of contributions assume a Walrasian labor market and just few exceptions consider the case of equilibrium unemployment in the economy. Alexopoulos (2002) introduces equilibrium unemployment through imperfectly observed efforts into a standard monetary model, and finds that this improves the model's ability to replicate labor market fluctuations. Danthine and Kurmann (2004) model efficiency wages in a standard new Keynesian framework and find substantial improvements on the labor market front, and also a stronger internal propagation of real and monetary shocks. The search and matching approach to labor market equilibrium, first developed by Mortensen and Pissarides (1994), provides a framework used by Cheron and Langot (2000), Christoffel and Linzert (2005), Krause and Lubik (2005), Trigari (2005) and Walsh (2005) to model a non-Walrasian labor market in a monetary economy. These studies find that search frictions improve the ability of the standard new Keynesian framework to replicate the dynamics of unemployment and inflation. Walsh (2005) shows that search and

Table 1
Union density and bargaining coverage rates

Country	Union density			Bargaining coverage		
	1980	1990	1994	1980	1990	1994
United States	22	16	16	26	18	18
Euro area	49.7	42.9	44.3	82.6	81.3	82.3

Source: OECD (1997) Employment Outlook and computations from the author.

matching frictions improve the response of inflation and labor market activities to monetary shocks. Trigari (2005) estimates a new Keynesian model characterized by search frictions and shows that it accounts well for the actual response of employment and hours per workers to monetary shocks. Search frictions also help to explain the sluggishness of inflation and the persistence of output. Krause and Lubik (2005) use a standard search and matching framework that accounts for both monetary and productivity shocks to investigate the effect of real wage rigidity, and conclude that it has an irrelevant effect on the dynamics of marginal costs and inflation. My approach differs from previous studies in two key ways. First, it uses a different labor market structure: these papers draw their conclusions on the basis of efficiency wages, or on the idea that workers and firms look for a convenient match that cannot always be realized. In contrast, this paper relies on union bargaining as the source of unemployment. Similar to this paper, Christoffel and Linzert (2005) and Trigari (2006) use a bargaining structure where firms and workers bargain over the real wage, and firms then unilaterally choose the hours of work for a given bargained wage. This paper shares the same rationale for the wage bargain – in fact, unions set wages unilaterally – but, as detailed below, it has some key differences: the labor market is frictionless, and the employment decisions of the firm are on the extensive margin. Second, I account for both demand and supply disturbances, while previous research, with the exception of Krause and Lubik (2005), focused mainly on demand disturbances. Such an enriched environment permits an extensive and more realistic testing ground of the model's properties.

The remainder of the paper is organized as follows: Section 2 sets up the model, Section 3 describes the calibration, Section 4 discusses the results and performs numerical simulations, and, finally, Section 5 concludes.

2. Economic environment

2.1. Overview

The model resembles those used by Maffezzoli (2001), Ireland (2000), and King and Rebelo (2000). The model describes the behavior of a representative household, a representative finished goods-producing firm, a continuum of intermediate goods-producing firms indexed by $i \in [0, 1]$, a representative union indexed by $j \in [0, 1]$, and a monetary authority.

This economy is populated by a continuum of ex ante identical, infinitely lived worker–households with names in the closed interval $[0, 1]$. During each period, $t = 0, 1, 2, \ldots$, the representative household purchases output from the representative finished goods-producing firm and supplies capital and labor to the intermediate goods-producing firms in imperfectly competitive markets. It purchases riskless bonds and uses money provided by the government and profits by the firms. The household faces adjustment costs related to investment in physical capital.

For each period, each intermediate goods-producing firm produces a distinct, perishable intermediate good indexed by $i \in [0, 1]$; for convenience firm i produces good i. In addition, the representative intermediate goods-producing firm faces a cost of adjusting its nominal price, as in Rotemberg (1982). This cost of price adjustment allows the monetary authority to influence the behavior of real variables in the short run.

Each representative union indexed by $j \in [0,1]$ unilaterally maximizes its objective function during each period $t = 0, 1, 2, \ldots$, taking as given the labor demand function as determined by the representative goods-producing firm.

The government is the authority in charge of distributing the monetary aggregate to the agents during each period $t = 0, 1, 2, \ldots$. It also provides the household with lump-sum transfers, and riskless bonds.

Finally, the monetary authority sets the nominal interest rate in response to deviations of output and inflation from their steady-state levels, and accounting for monetary policy inertia.

2.2. The representative household

A comparison between the Walrasian and the non-Walrasian model is possible if the dynamics of the labor market takes place on the extensive margin. For this reason, I employ the Rogerson and Wright (1988) indivisible labor model. In this setting, each member of the household chooses between working a fixed number of hours and not working at all. The choice set is not convex, but it may be convexified by introducing employment lotteries. By entering a lottery a household member can choose to work a fraction of n days and to remain unemployed for the remaining $1 - n$ days. With the assumption of perfect risk sharing, the representative household maximizes the following expected utility function[4]:

$$\mathrm{E}\sum_{t=0}^{\infty} \beta^t u\left(C_t, n_t, \frac{M_t}{P_t}\right) = \mathrm{E}\sum_{t=0}^{\infty} \beta^t \left\{\frac{1}{1-\mu}[C_t^{1-\mu} v(n_t)^{1-\mu} - 1] + \kappa_m \log\frac{M_t}{P_t}\right\}, \tag{1}$$

where $v(n_t) = [n_t v_{\mathrm{e}}^{(1-\mu)/\mu} + (1-n_t) v_{\mathrm{u}}^{(1-\mu)/\mu}]^{\mu/(1-\mu)}$, and $0 < \beta < 1$. Variables v_{e} and v_{u} represent the utility of leisure for the employed and unemployed representative households, respectively. Consumption and real money holdings are represented by C_t and M_t/P_t, respectively. The coefficient n_t is the probability for the representative household of being employed, whereas $1 - n_t$ is her probability of being unemployed during each period $t = 0, 1, 2, \ldots$. Note that aggregating individuals into a representative household allows us to interpret n_t as the employment rate. Both variables v_{e} and v_{u} are strictly positive, and, since more labor reduces utility, $v_{\mathrm{u}} > v_{\mathrm{e}}$. In this framework, as in King and Rebelo (2000), agents have an incentive to work if the parameter for the relative risk aversion in consumption, μ, is higher than one. This calibration guarantees that the consumption of the employed agents is higher than that of the unemployed agents, and, as shown below, that the actual wage is

[4]See King and Rebelo (2000) for further details.

higher than the reservation wage.[5] This calibration, together with the assumption that unions act to completely insure markets, guarantees that all agents have an incentive to work. Cheron and Langot (2004) use similar hypotheses in the context of a search model.

The representative household enters period t with bonds B_{t-1} and money M_{t-1}. At the beginning of the period, the household receives a lump-sum nominal transfer T_t from the monetary authority and nominal profits F_t from each intermediate goods-producing firm. The household supplies n_t units of labor to the representative union at the wage rate W_t, and K_t units of capital at the rental rate Q_t to each intermediate goods-producing firm $i \in [0,1]$ during period t. While unemployed, the household receives a reservation wage $\overline{W}_t$ in the form of lump-sum transfers from the government which incorporates unemployment subsidies and her value of leisure. Then, her bonds mature, providing B_{t-1} additional units of money. The household uses part of this additional money to purchase B_t new bonds at nominal cost B_t/r_t, where r_t represents the gross nominal interest rate between t and $t+1$. The household may also use her income for consumption, C_t, or investment, I_t.

By investing I_t units of the finished good during each period t, the representative household increases the capital stock over time according to

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\phi_k}{2}\left(\frac{K_{t+1}}{gK_t} - 1\right)^2 K_t, \tag{2}$$

where $1<\delta<0$ is the depreciation rate, the parameter $\phi_k \geqslant 0$ represents the magnitude of capital adjustment costs, and g is the gross steady-state growth rate of the capital stock. For all $t = 0, 1, 2, \ldots$, the fraction of aggregate employment and capital supplied by the representative household must satisfy

$$n_t = \int_0^1 n_t(i)\,\mathrm{d}i, \quad K_t = \int_0^1 K_t(i)\,\mathrm{d}i,$$

and the total profits received by each household are

$$F_t = \int_0^1 F_t(i)\,\mathrm{d}i$$

during each period $t = 0, 1, 2, \ldots$. The household carries M_t units of money, B_t bonds, and K_{t+1} units of capital into period $t+1$, subject to the budget constraint

$$\begin{aligned} &P_tC_t + P_tI_t + B_t/r_t + M_t \\ &\quad = B_{t-1} + n_tW_t + F_t + T_t + Q_tK_t + M_{t-1} + (1-n_t)\overline{W}_t, \end{aligned} \tag{3}$$

for all $t = 0, 1, 2, \ldots$.

Thus, the household chooses $\{C_t, n_t, K_{t+1}, I_t, B_t, M_t\}_{t=0}^{\infty}$ to maximize its utility subject to the budget constraint (3) for all $t = 0, 1, 2, \ldots$. Letting $m_t = M_t/P_t$ to denote real money balances, $\pi_t = P_t/P_{t-1}$ the gross inflation rate, and Λ_t the

[5] Formally, equating the marginal utility of consumption across employed and unemployed agents, the consumption of the employed agents, C_e, is $C_\mathrm{e} = C_\mathrm{u}(v_\mathrm{e}/v_\mathrm{u})^{(1-\mu)/\mu}$, where C_u represents the consumption of the unemployed agents. Since $v_\mathrm{e} > v_\mathrm{u}$ and $\mu > 1$, then $C_\mathrm{e} > C_\mathrm{u}$.

non-negative Lagrange multiplier on the budget constraint (3), the first order conditions for this problem are

$$C_t^{-\mu} v(n_t)^{1-\mu} = \Lambda_t, \tag{4}$$

$$\frac{\mu}{1-\mu}(C_t^{1-\mu} v(n_t)^{-(1-\mu)^2/\mu})(v_{\mathrm{e}}^{(1-\mu)/\mu} - v_{\mathrm{u}}^{(1-\mu)/\mu}) + \frac{\Lambda_t}{P_t}\overline{W}_t = \frac{\Lambda_t}{P_t} W_t, \tag{5}$$

$$\begin{aligned} &\Lambda_t\left[1 + \frac{\phi_k}{g}\left(\frac{K_{t+1}}{gK_t} - 1\right)\right] \\ &\quad = \beta \mathrm{E}_t \Lambda_{t+1}\left[(1-\delta) + \frac{Q_{t+1}}{P_{t+1}} - \frac{\phi_k}{2}\left(\frac{K_{t+2}}{gK_{t+1}} - 1\right)^2 + \phi_k\left(\frac{K_{t+2}}{gK_{t+1}} - 1\right)\frac{K_{t+2}}{gK_{t+1}}\right], \end{aligned} \tag{6}$$

$$\beta r_t \mathrm{E}_t \frac{\Lambda_{t+1}}{\pi_{t+1}} = \Lambda_t, \tag{7}$$

and

$$\frac{\kappa_m}{m_t} + \beta \mathrm{E}_t \frac{\Lambda_{t+1}}{\pi_{t+1}} = \Lambda_t. \tag{8}$$

Eqs. (4)–(8), together with the household budget constraint (3), and the evolution of capital stock (2), provide the necessary and sufficient conditions to solve the household maximization problem.

According to Eq. (4), the Lagrange multiplier must equal the household's marginal utility of consumption. According to Eq. (5), the utility of the wage equals the marginal disutility of working plus the utility from the reservation wage.[6] This equation represents the labor supply equation in the Walrasian setting of the model. For the non-Walrasian setting, it is replaced by the equation from the union bargaining process described below. Eq. (6) dictates that the current utility cost of a unit of capital equals the present discounted value of the future product of capital, accounting for the cost of adjusting capital. Note that the future product of capital is given by the value of a depreciated unit of capital, $1-\delta$, and the revenue from future capital rental rate, Q_{t+1}. This last term, as shown below, is determined by the optimal capital decisions of the representative firm. Eqs. (7)–(8) are the Euler equations that describe the optimal path for bonds and real money holdings, respectively.[7]

[6]As pointed out above, since $\mu > 1$, Eq. (5) implies that the actual wage is higher than the reservation wage.

[7]Note that in the presence of an interest rate rule, which is assumed below, the money demand equation simply determines the nominal level of money balances. For this reason, it can be safely ignored in the computation of the equilibrium.

2.3. The representative finished goods-producing firm

During each period $t = 0, 1, 2, \ldots$, the representative finished goods-producing firm uses $Y_t(i)$ units of each intermediate good $i \in [0, 1]$, purchased at nominal price $P_t(i)$, to produce Y_t units of the finished product at constant returns to scale technology

$$\left[\int_0^1 Y_t(i)^{(\theta-1)/\theta}\,\mathrm{d}i\right]^{\theta/(\theta-1)} \geqslant Y_t,$$

where $\theta > 1$. Hence, the finished goods-producing firm chooses $Y_t(i)$ for all $i \in [0, 1]$ to maximize its profits

$$P_t\left[\int_0^1 Y_t(i)^{(\theta-1)/\theta}\,\mathrm{d}i\right]^{\theta/(\theta-1)} - \int_0^1 P_t(i)Y_t(i)\,\mathrm{d}i,$$

for all $t = 0, 1, 2, \ldots$. The first order conditions for this problem are

$$Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\theta} Y_t, \tag{9}$$

for all $i \in [0, 1]$ and $t = 0, 1, 2, \ldots$.

Competition drives the finished goods-producing firm's profit to zero at the equilibrium. This zero profit condition implies that

$$P_t = \left[\int_0^1 P_t(i)^{1-\theta}\,\mathrm{d}i\right]^{1/(1-\theta)},$$

for all $t = 0, 1, 2, \ldots$.

2.4. The representative intermediate goods-producing firm

During each period $t = 0, 1, 2, \ldots$, the representative intermediate goods-producing firm hires n_t units of labor and $K_t(i)$ units of capital from the representative household, in order to produce $Y_t(i)$ units of intermediate good i according to the constant return to scale technology

$$Y_t(i) = a_t\{\alpha K_t(i)^\eta + [n_t(i)g^t]^\eta\}^{1/\eta}, \tag{10}$$

where $\eta < 1$, $\alpha > 0$, and $g \geqslant 1$, where g denotes the gross rate of labor-augmenting technological progress. The aggregate technology shock, a_t, follows the autoregressive process

$$\ln(a_t) = \rho_a \ln(a_{t-1}) + \varepsilon_{at}, \tag{11}$$

where $\rho_a < 1$. The zero-mean, serially uncorrelated innovation ε_{at} is normally distributed with standard deviation σ_a.

Since the intermediate goods are not perfect substitutes in the production of the final goods, the intermediate goods-producing firm faces an imperfectly competitive market. During each period $t = 0, 1, 2, \ldots$, it sets the nominal price $P_t(i)$ for its output, subject to satisfying the representative finished goods-producing firm's demand. The intermediate goods-producing firm faces a quadratic cost of adjusting nominal prices, measured in terms of the finished goods and given by

$$\frac{\phi_{\mathrm{p}}}{2}\left[\frac{P_t(i)}{\pi P_{t-1}(i)}-1\right]^2 Y_t,$$

where $\phi_{\mathrm{p}}>0$ is the degree of adjustment cost and π is the steady-state gross inflation rate. This relationship, as stressed in Rotemberg (1982), looks to account for the negative effects of price changes on customer–firm relationships. These negative effects increase in magnitude with the size of the price change and with the overall scale of economic activity, Y_t.

The problem for the firm is to choose $\{P_t(i), n_t(i), K_t(i)\}_{t=0}^{\infty}$ to maximize its total market value given by

$$\mathrm{E}\sum_{t=0}^{\infty}\beta^t \Lambda_t\left[\frac{F_t(i)}{P_t}\right], \tag{12}$$

subject to the constraints imposed by (9)–(11). In Eq. (12), $\beta^t \Lambda_t/P_t$ measures the marginal utility value to the representative household of an additional dollar in profits received during period t and

$$\frac{F_t(i)}{P_t}=\frac{P_t(i)Y_t(i)}{P_t}-\frac{n_t(i)W_t}{P_t}-\frac{K_t(i)Q_t}{P_t}-\frac{\phi_{\mathrm{p}}}{2}\left[\frac{P_t(i)}{\pi P_{t-1}(i)}-1\right]^2\frac{Y_t}{P_t},$$

for all $t=0,1,2,\ldots$. Letting Ξ_t the Lagrange multiplier on (10), the first order conditions for this problem are

$$\begin{aligned}\phi_{\mathrm{p}}\Lambda_t\left[\frac{\pi_t(i)}{\pi}-1\right]\frac{\pi_t(i)}{\pi}&=(1-\theta)\Lambda_t\left[\frac{P_t(i)}{P_t}\right]^{-\theta}+\theta\Xi_t\left[\frac{P_t(i)}{P_t}\right]^{-(1+\theta)}\\&\quad+\beta\phi_{\mathrm{p}}\mathrm{E}_t\left\{\Lambda_{t+1}\left[\frac{\pi_{t+1}(i)}{\pi}-1\right]\left[\frac{\pi_{t+1}(i)}{\pi}\frac{Y_{t+1}}{Y_t}\right]\right\},\end{aligned} \tag{13}$$

$$\frac{\Lambda_t}{P_t}W_t=\Xi_t a_t\{\alpha K_t(i)^{\eta}+[n_t(i)g^t]^{\eta}\}^{1/\eta-1}[n_t(i)]_t^{\eta-1}g^{\eta t}, \tag{14}$$

$$\frac{\Lambda_t}{P_t}Q_t=\Xi_t a_t\{\alpha K_t(i)^{\eta}+[n_t(i)g^t]^{\eta}\}^{1/\eta-1}\alpha K_t(i)^{\eta-1}, \tag{15}$$

where $\pi_t(i)=P_t(i)/P_{t-1}(i)$ for all $t=0,1,2,\ldots$. In particular, (14) and (15) show that firm maximizes its profits when marginal cost of labor and capital equates the marginal revenues of these factors. Eq. (13) is the new Keynesian Phillips curve in its non-linearized form and it highlights that the firm sets prices as a markup on marginal cost, accounting for price adjustment costs. This equation relates the price level to the real variables of the economy.

2.5. The representative union

In the economy there are decentralized unions, named on $j \in [0, 1]$. Each intermediate goods-producing firm negotiates with a single union, which is too small to influence the outcome of the market. Each household can supply its labor to only one firm and is a price taker in the capital market. By organizing in unions, the households can extract some producer surplus.

The representative union negotiates the wage rate on behalf of its members. The bargaining process is modelled as a static Stackelberg game in which the representative union (leader) chooses the wage rate and the representative intermediate goods-producing firm (follower) decides how much labor to employ given the established wage rate. This modelling strategy belongs to the same family of the commonly used right to manage models introduced by Nickell (1982). The employment decisions are unilateral decisions of management so that the wage setting can be established through the bargaining process between unions and firms. The choice of this formulation may be justified by transaction costs, and it also fits with the empirical observation that firms set labor demand unilaterally. Christoffel and Linzert (2005) and Trigari (2006) introduce a right to manage bargain into a new Keynesian model with search frictions and show that this improves the link between real wages, real marginal costs, and inflation. Their notion of right to manage differs from the one used here because firms set hours of work. Therefore, in their framework, marginal costs depend on the intensive margin of labor input, as opposed to the extensive margin in this paper. Since in their model most of the adjustment of the labor input occurs at the extensive margin, together with the lower volatility of wages due to the wage bargain, this works to make marginal costs less volatile. In this paper, on the other hand, marginal costs depend on the extensive margin and what decreases their volatility is solely the wage bargain that acts to reduce the variability of wages. Therefore, although in both models marginal costs are less volatile, the mechanism that generates the results is different.

In the literature, there is no consensus about the objective function of a union, as noted by Farber (1986) and empirically assessed by Gahan (2002). For this reason, I assume, as in Maffezzoli (2001) and Pissarides (1998), that the representative union maximizes the average members' wage bill in the form of the following objective function:

$$n_t(i)W_t(j) + (1 - n_t(i))\overline{W}_t(j),$$

taking the conditional labor demand of the intermediate goods-producing representative firm and the representative household reservation wage as given. To keep the setup simple, the reservation wage $\{\overline{W}_t(j)\}_{t=0}^{\infty}$ is assumed to be exogenous in the form of a lump-sum transfer from the government. It encompasses the disutility of employment perceived by the representative union and any unemployment subsidies paid by the government.

During each period $t = 0, 1, 2, \ldots$, the representative union maximizes the real discounted labor income of its members,

$$\mathrm{E}\sum_{t=0}^{\infty}\frac{\beta^t}{P_t}[n_t(i)W_t(j) + (1 - n_t(i))\overline{W}_t(j)],$$

with respect to the wage rate $\{W(j)\}_{t=0}^{\infty}$, subject to the conditional labor demand (14). It is true that the assumption that the representative union bargains with the representative firm in each period is different from the evidence on actual bargaining frequencies in Europe. Possibly a more plausible option would be to introduce a staggered wage bargaining that follows a Calvo scheme, in the spirit of Erceg et al. (2000). Here, in order to keep as simple a theoretical framework as possible, I leave the investigation of this issue open for future research. The first order conditions for the union problem are

$$\left(\frac{a_t n_t(i) g^t}{Y_t(i)}\right)^{\eta}\left[(1-\eta)\left(\frac{a_t n_t(i) g^t}{Y_t(i)}\right)^{\eta} + \eta\right] = \frac{\Lambda_t}{\Xi_t}\frac{n_t(i)}{P_t Y_t(i)}\overline{W}_t(j). \tag{16}$$

This non-linear equation defines the wage setting rule for the economy after the union bargaining process has been carried out.[8] The representative union faces a trade-off between claiming a higher wage for its members and having a higher employment. Unlike the representative household labor supply (5), this equation accounts for optimal demand side decisions in the labor market. Eq. (16), together with the labor demand (14), determines the equilibrium wage.

2.6. The monetary authority

During each period $t = 0, 1, 2, \ldots$, the monetary authority conducts policy by changing of the nominal interest rate r_t in response to deviations of lagged output Y_{t-1} and lagged inflation π_{t-1}, from their steady-state levels y and π, following the Taylor-type rule,

$$\ln\left(\frac{r_t}{r}\right) = \rho_r \ln\left(\frac{r_{t-1}}{r}\right) + (1-\rho_r)\left[\rho_y \ln\left(\frac{Y_{t-1}}{Y}\right) + \rho_\pi \ln\left(\frac{\pi_{t-1}}{\pi}\right)\right] + \varepsilon_{rt}, \tag{17}$$

where r is the steady-state value of the nominal interest rate, r_{t-1} is the lagged nominal interest rate, and ε_{rt} is a normally distributed serially uncorrelated innovation with zero mean and standard deviation σ_r. As advocated by Carlstrom and Fuerst (2000), I employ lagged values for output and inflation because it is consistent with the information set of the monetary authority at time t, and it guarantees determinacy.

Parameter ρ_r expresses the degree of interest rate smoothing. If ρ_π is larger than one the monetary authority policy is to stabilize inflation; the same holds for output if ρ_y is larger than zero. As pointed out in Clarida et al. (1998), this modelling

[8] Eq. (16) is derived by substituting Eq. (14) into the union objective function and partially deriving it with respect to $n_t(i)$. Once the labor demand schedule has been taken into account, the choice of the control variable is irrelevant.

strategy for the monetary authority is consistent with that observed empirically in both the United States and European countries.

2.7. Symmetric equilibria

The unionized and non-unionized equilibria differ in the way in which labor supply is derived. In the absence of the representative union, labor supply comes from the household maximization process for $\{n_t\}_{t=0}^{\infty}$, as in Eq. (5). Instead, in the presence of a representative union the labor supply depends upon the wage rate $\{W_t(j)\}_{t=0}^{\infty}$ which comes from the bargaining between the union and the firm, as in Eq. (16). Common to the two settings is the following:

In a symmetric, dynamic equilibrium, all intermediate goods-producing firms and unions make identical decisions, so that $n_t(i) = n_t$, $y_t(i) = y_t$, $P_t(i) = P_t$, $F_t(i) = F_t$, $W_t(j) = W_t$, and $\overline{W}_t(j) = \overline{W}_t$ for all $i \in [0,1]$, $j \in [0,1]$, and $t = 0,1,2,\ldots$. The equilibrium is defined as a sequence of functions for relative prices $\{W_t, Q_t, r_t, P_t\}_{t=0}^{\infty}$, an infinite dimensional allocation for the firm $\{K_t^{\mathrm{d}}, n_t^{\mathrm{d}}, Y_t\}_{t=0}^{\infty}$, an infinite dimensional allocation for the household $\{C_t, I_t, K_t^{\mathrm{s}}, B_t, M_t\}_{t=0}^{\infty}$, and a sequence of government policy $\{B_t, M_t\}_{t=0}^{\infty}$ such that:

- the allocation $\{K_t^{\mathrm{d}}, n_t^{\mathrm{d}}, Y_t, P_t, F_t\}_{t=0}^{\infty}$ solves the firm problem,
- the allocation $\{C_t, I_t, K_{t+1}^{\mathrm{s}}, B_t, M_t\}_{t=0}^{\infty}$ solves the representative household problem,
- market clearing on all markets $K_t^{\mathrm{d}} = K_t^{\mathrm{s}}$, $n_t^{\mathrm{d}} = n_t^{\mathrm{s}}$, $Y_t = C_t + I_t + (\phi_{\mathrm{p}}/2)(P_t(i)/P_{t-1}(i) - \pi)^2 Y_t$, and the human capital accumulation holds,
- the market-clearing conditions $T_t = M_t - M_{t-1} - (1 - n_t)\overline{W}_t$ and $B_t = B_{t-1} = 0$ must hold for all $t = 0,1,2,\ldots,$
- monetary policy rule holds for all $t = 0,1,2,\ldots$.

The system is approximated by log-linearizing its equations around the stationary steady state. In this way, I attain a linear dynamic system that describes the path of the endogenous variables' relative deviations from their steady-state value, accounting for exogenous shocks in the economy. This latter method is referred to as the state-space approach, and the Klein (2000) technique, which builds upon the seminal paper by Blanchard and Kahn (1980), allows us to write the system of linearized difference equations as

$$\mathbf{s}_t = \mathbf{\Psi}\mathbf{s}_{t-1} + \mathbf{\Omega}\boldsymbol{\varepsilon}_t,$$

and

$$\mathbf{f}_t = \mathbf{U}\mathbf{s}_t.$$

The vector $\mathbf{s}_t$ contains the model state variables which includes the current values of the capital stock $k_t = K_t/g^t$, the lagged interest rate r_{t-1}, the lagged values of output $y_{t-1} = Y_{t-1}/g^{t-1}$, lagged inflation π_{t-1}, the lagged values of firms' profit $f_{t-1} = F_{t-1}/P_{t-1}g^{t-1}$. The vector $\mathbf{f}_t$ includes the model flow variables which are current consumption $c_t = C_t/g^t$, employment rate n_t, the multipliers $\lambda_t = \Lambda_t g^{t\mu}$, and

$\xi_t = \Xi_t g^{t\mu}$, investments $i_t = I_t/g^t$, and the real factor prices $w_t = W_t/P_t g^t$, and $q_t = Q_t/P_t$. Finally, the vector $\boldsymbol{\varepsilon}_t$ contains the technology shock, ε_{at}, and the policy shock, ε_{rt}. These shocks are assumed to be serially and mutually uncorrelated. With this formulation, the elements of the matrices $\boldsymbol{\Psi}$, $\boldsymbol{\Omega}$, and $\mathbf{U}$ all depend upon parameters expressing private agents' tastes and technologies and parameters of the monetary authority rule.

3. Model calibration

The variables of the model are calibrated using data from the euro area. The structural parameters used are in line with other studies such as Smets and Wouters (2003) and Galì et al. (2001), which apply DSGE models to the European economy. I calibrate the model on quarterly frequencies and the value for each parameter is described below and reported in Table 2.

The model accounts for a trend in the variables through human capital accumulation which captures the labor augmented technological progress expressed by the term g. This setup implies that the variables grow at the gross rate of g along a balanced growth path. Based on the fact that the annual growth rate for the euro area countries is approximately 2.26%, I set the parameter g equal to 1.0056.

I compute the steady-state values for inflation, π, using the OECD (2002) *Economic Outlook* data set for euro area countries. I calibrate the value for steady-state gross inflation equal to 1.04 on an annual basis so that we can use a quarterly calibration value of 1.01.

As noted, some structural parameters are taken from the literature. I take the calibrated value for the technology shock from Smets and Wouters (2003), who estimate a DSGE model for the euro area using Bayesian techniques. Hence, I set serial correlation and standard deviation for technology shock, ρ_a and σ_a, equal to 0.8674 and 0.0056, respectively. The value for the variance of the policy shock is in line with Clarida et al. (1998), who estimate a similar specification for this shock with the generalized method of moments. Its standard deviation, σ_ε, equals 0.0018.

Table 2
Calibration

Parameter	Value	Parameter	Value
g	1.0056	θ	6
π	1.01	β	0.99
ρ_a	0.8674	μ	2
σ_a	0.0056	ρ_π	1.658
σ_ε	0.0018	ρ_y	0.148
n	0.61	ρ_r	0.9
i/y	0.21	ϕ_{p}	30
k/y	12.73	ϕ_π	40

I choose parameters for the steady-state employment rate, n, investment share of output, i/y, and capital share of output, k/y, in order to match with the euro area data. I assign the following values: $n = 61\%$, $i/y = 21\%$, and $k/y = 12.73$. These values imply a technological parameter, α, equal to 1.15, and a depreciation rate, δ, of 0.02. This calibration for the employment rate implies a value for the unemployment rate, $1 - n$, of 39%, which is higher than that observed in the data. This should be considered more of a non-employment rate. Treating these people as if unemployed can be justified to the extent that they are all to some extent potential workers, even if they are job searching at a low level of intensity. This is similar to the treatment in Cole and Rogerson (1999). Sensitivity analysis suggests that the qualitative results of this paper are not materially affected by different calibrations of this parameter. I fix the parameter θ, which measures the degree of market power possessed by the representative goods-producing firm, equal to 6, following Rotemberg and Woodford (1992). Since the steady-state value of θ determines the markup of prices over marginal costs, this value implies a markup of 20%, which is reasonable for the European economy, as suggested in Galì et al. (2001). I calibrate the discount factor, β, equal to 0.99, which implies an annual steady-state real interest rate of 4% for the euro area as in Smets and Wouters (2003). I fix the elasticity of intertemporal substitution, μ, equal to 2 as it is in King and Rebelo (2000). As in King and Rebelo (2000), the weights in the function $v(n)$, v_{e} and v_{u}, are pinned down by information at the steady state.[9] I set the substitution parameter, η, equal to -0.43, as estimated for the European economy in Pissarides (1998). This value implies an elasticity of substitution between physical and human capital equal to 0.7. On this parameter, an extensive sensitivity analysis suggests that it does not affect the quality of the results. The value for the reservation wage $\overline{W}$ is calibrated using Eq. (16) and matching the value for the employment rate n.

I calibrate the parameters of the monetary policy rule using Smets and Wouters (2003). Values for the interest rate response to inflation, ρ_{π}, interest rate response to output, ρ_{y}, and the degree of interest rate smoothing, ρ_{r}, take values close to the so-called Taylor-type rule for monetary policy. In particular, the interest rate response to inflation, ρ_{π}, equals 1.658, the interest rate response to output, ρ_{y}, equals 0.148, and the degree of interest rate smoothing, ρ_{r}, equals 0.9.

Estimated values for the degrees of price and capital adjustment costs for the euro area are not available in the literature. For this reason, I follow the suggestion of Ireland (2000) and set the price adjustment costs parameter, ϕ_{p}, equal to 30, and the parameter representing the capital adjustment costs, ϕ_{k}, equal to 40. Qualitative differences between the baseline and unionized models hold across different values of ϕ_{p} and ϕ_{k}.

[9]To see this, following King and Rebelo (2000), once we log-linearize Eq. (5) around the steady state, the coefficient of the deviation of employment from its steady state is $((1-\mu)^2/\mu)nv_n(n)/v(n) = ((1-\mu)^2/\mu)nU_n/U_c = ((1-\mu)^2/\mu)nw/c = ((1-\mu)^2/\mu)nw/y/c/y$. The term nw/y is the labor share, and, in steady state, equals one minus the capital share. The value for the capital share can be recovered from Eq. (6).

4. Findings

This section discusses the findings from the model. The analysis compares the union economy model to the baseline SP model. Both demand and supply shocks are considered. This part is divided into two subsections: the first analyzes the predictions of the models and the second simulates the model in order to test its ability to capture some stylized euro area business cycle facts.

4.1. Model predictions

Figs. 1 and 2 show the responses to monetary and productivity shock, respectively. For each variable, I plot its response to a one standard deviation shock in the union model (solid line) and the baseline SP model (dashed line). The qualitative response of the variables in the two models is similar for both supply and demand shocks.

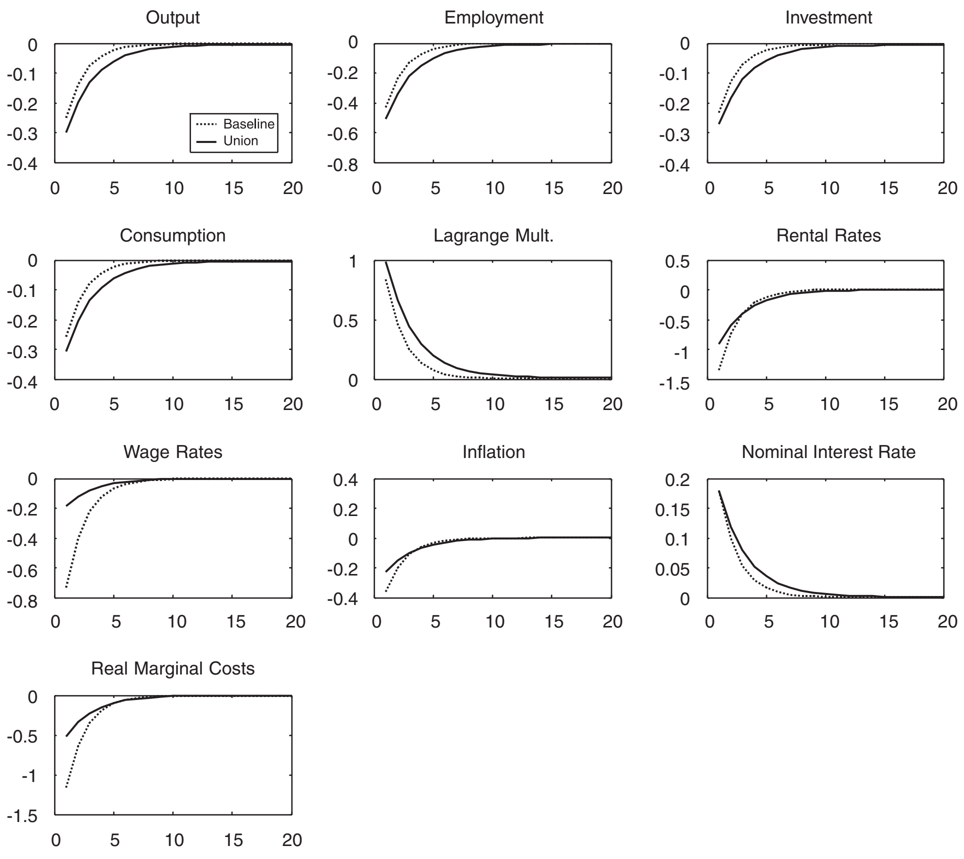

Fig. 1. Impulse response functions to a monetary policy shock. Each panel shows the percentage–point response of the union (solid line) and baseline (dashed line) models' variables to one standard deviation monetary policy shock.

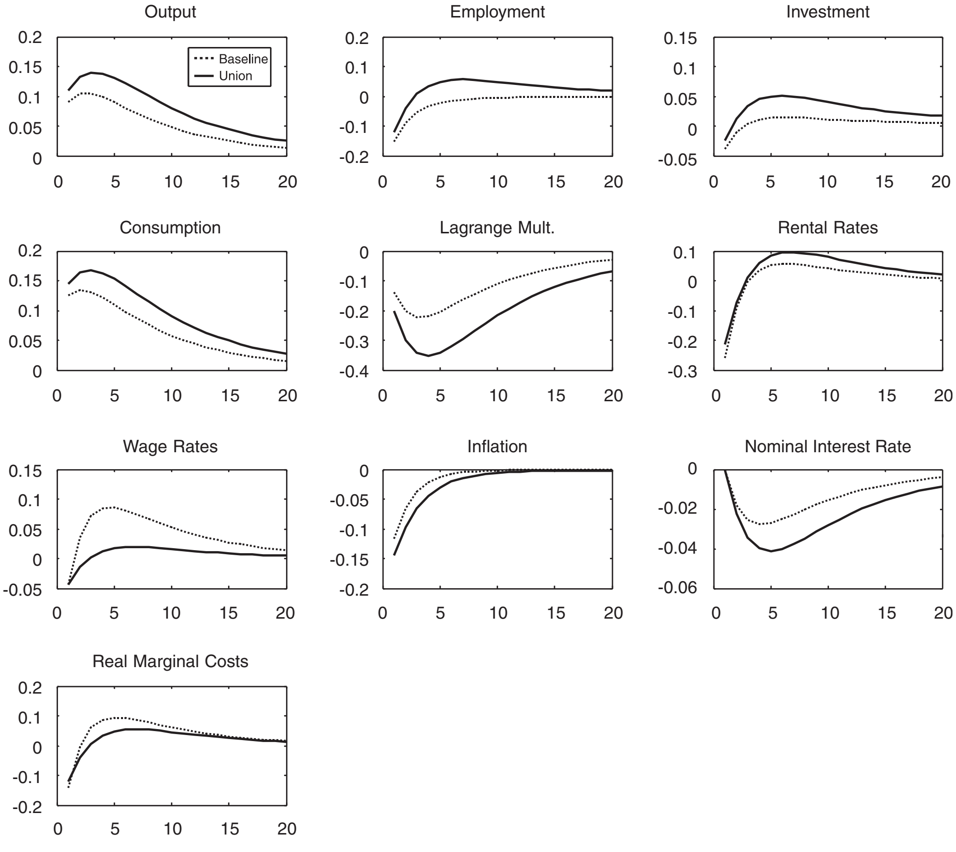

Fig. 2. Impulse response functions to a productivity shock. Each panel shows the percentage–point response of the union (solid line) and baseline (dashed line) models' variables to one standard deviation productivity shock.

Therefore, the introduction of a union bargaining process does not affect the nature of the baseline dynamics. However, from a quantitative perspective, the two models differ in some key aspects.

In both models, when a contractionary monetary shock hits the economy, the nominal interest rate immediately rises, causing real variables and inflation to fall with a higher degree of persistence in the case of an economy with unions. A positive productivity shock causes output and consumption to rise, and the rental rate of capital, the nominal interest rate, employment, and inflation to fall. These reactions are standard in the literature, except for employment, for which the debate is still open.[10] As in Galì (1999), employment falls after a productivity shock because with given aggregate demand due to SPs, higher productivity allows output to be

[10]For more details see recent contributions by Galì (1999), Christiano et al. (2004), and Francis and Ramey (2005).

produced with fewer units of labor. For all the variables, again, the degree of persistence is higher in the union case.

To analyze the predictions of the model, I limit the analysis to the case of monetary shocks, but the analysis applies equally to the case of productivity shocks. A monetary shock is a white noise process so that its effect vanishes after one period. Hence, the dynamics of the variables in later periods are entirely independent of the influences of this exogenous shock. For all the impulses, except for the factors' remuneration, the initial jump in the variables is higher for the unionized economy and the time required to the variable to return to the steady state is longer. The higher initial change may be explained by the different effect that shocks have on the household's Lagrange multiplier. Following King and Rebelo (2000, p. 49), in the perfect competitive labor market, the labor supply may be characterized by combining the log-linearized equations (4)–(5) so that the Lagrange multiplier becomes a function of the wage rates. In the unionized economy, the same expression is obtained combining Eqs. (4)–(16). Therefore, the Lagrange multiplier becomes a function of wage rates as well as productivity shocks and output. Hence, since the Lagrange multiplier reacts to a larger number of variables, its initial reaction to shocks is higher. As already mentioned, the Lagrange multiplier represents both the marginal utility of consumption for the representative household as well as the shadow value of installed physical capital. In this model, as is standard in the literature, both consumption and capital are negatively related to their marginal values. Therefore, the change in consumption and capital is more pronounced in the unionized economy and this leads to a higher initial change in the other variables.

Once shocks occur and the variables react, the speed of convergence along the original steady state is lower for the unionized economy. This feature can be explained by the lower volatility of real wages in the economy with the representative union, as shown in Fig. 1. The lower sensitivity of real wages to disturbances generates real rigidity in the economy. As pointed out in Ball and Romer (1990), the degree of nominal rigidity arising from a given adjustment cost is increasing in the degree of real rigidity. Rigidity of prices after a nominal shock is an equilibrium if the gain to the representative firm from changing its nominal price, ceteris paribus, is less than the cost of changing it. If the representative firm desires only a small change in its real price – that is, if there is large degree of real rigidity – then the gain from making the change is small. Since real rigidity reduces the gain from adjustment, it increases the range of shocks for which a non-adjustment is an equilibrium. Hence, the effect of real rigidity is to magnify the degree of nominal rigidity. In the unionized economy, for the same degree of nominal rigidities as in the baseline SP model, variables adjust slowly along the original balanced growth path.

The inability of SP models to replicate the low elasticity of inflation to monetary shocks has been debated by several papers such as Bernanke and Gertler (1995), Christiano et al. (1997), and Bernanke and Mihov (1998). The union model improves the replication of this feature. It can generate a decrease in the elasticity of inflation to monetary policy compared with the baseline SP model. Responses of real marginal cost to a contractionary monetary policy are shown in Fig. 1. The sensitivity of real marginal cost to output is lower for the unionized economy.

In fact, in the aftermath of a contractionary monetary policy shock, output falls approximately 2.5% in the baseline economy and 3% in the unionized economy; in contrast, the associated variation in real marginal costs is a decline of roughly 11% in the baseline economy and 5% in the unionized economy. The mechanism that generates this result is the reduced sensitivity of marginal costs to variations in aggregate output. This implies that the same shock, which changes output to a small extent in both settings, generates a smaller decrease in the level of marginal costs for the unionized economy. This means that smaller variation in real marginal costs leads firms to adjust prices by a smaller extent. This amplifies the sluggishness of the aggregate price level in response to changes in aggregate demand and, therefore, reduces inflation volatility. Quantitatively, the inflation peak is about 0.2% in the union economy and 0.4% in the baseline model. The magnitude of these findings is in line with the empirical evidence in the euro area as in Smets and Wouters (2003).

4.2. Model simulations

The series for the euro area variables are taken from Fagan et al. (2001), drawn from the European Central Bank database. The data are quarterly, from 1980:1 to 1998:4, and they represent aggregate series for the EU-11 countries. Output is measured by real GDP, consumption is measured by private consumption, investment is measured by gross investment, employment is measured by standard units of labor, inflation is measured by changes in the GDP deflator, and the interest rate is measured by the short-term interest rate. All data, except for the interest rate, are seasonally adjusted. The real variables are expressed in per-capita terms by dividing by the total population aged 15–64. All variables, except inflation and the interest rate, are transformed into logarithms. All the series are HP filtered, so that only the cyclical component remains.

The state-space representation of the model is used to generate realization of the model by simulating a system of difference equations in $\mathbf{s}_t$ and $\mathbf{f}_t$ for T periods by generating a $(T \times 1)$ dimensional series of Gaussian white noise innovations, $\boldsymbol{\varepsilon}_t$, where T is the number of simulated periods that equals the number of periods in the observed time series of the economy. The simulated data are based on a set of 1000 simulations over a 76-quarter horizon, as the size of the sample considered.

Tables 3–5 list business cycle data for the euro area macroeconomic variables output, consumption, investment, employment, inflation, and interest rates and compare them with the simulated series for the union (U) and baseline SP models. The statistics reproduced are the standard deviation, the relative volatility (the ratio of the standard deviation of each variable and the standard deviation of output), and the correlation coefficient with output.

Table 3 shows the standard deviations for the variables under investigation. A comparison of the union and the baseline models shows that the presence of a representative union produces higher volatility for the real variables, and lower volatility for inflation. The union model is better able to replicate the variance of inflation, the interest rate, output, and consumption. The union model underperforms in the replication of the variance of investment and employment.

Table 3
Standard deviation

Variable	EU-11	Union	Sticky price
Output	1.31	1.28	1.05
Consumption	1.15	0.80	0.65
Investment	2.76	3.61	3.06
Employment	1.16	1.84	1.53
Inflation	0.56	0.84	0.97
Interest rate	0.98	0.43	0.40

Notes: Observed (EU-11) and simulated (from union and sticky price models) standard deviations. The observed statistics are based on seasonally adjusted quarterly data from Fagan et al. (2001) from 1980:1 to 1998:4. The real variables are expressed in per-capita terms by dividing by the total population, age between 15 and 64. Variables, except inflation and interest rate, are transformed in logarithms. All the series are HP filtered so that only the cyclical component remains. The simulated business cycle statistics are based on 1000 simulations over 76 quarter horizon and are HP filtered for comparison purposes. Simulated figures are averages across simulations.

Table 4
Relative standard deviation

Variable	EU-11	Union	Sticky price
Output	1.00	1.00	1.00
Consumption	0.88	0.63	0.62
Investment	2.11	2.84	2.92
Employment	0.55	1.45	1.48
Inflation	0.43	0.67	0.94
Interest rate	0.75	0.34	0.38

Notes: Observed (EU-11) and simulated (from union and sticky price models) relative standard deviations with respect to output. For further information, see notes to Table 2.

Table 5
Correlation with output

Variable	EU-11	Union	Sticky price
Output	1.00	1.00	1.00
Consumption	0.91	0.89	0.88
Investment	0.85	0.93	0.93
Employment	0.92	0.74	0.61
Inflation	0.26	0.31	0.52
Interest rate	0.17	−0.44	−0.36

Notes: Observed (EU-11) and simulated (from union and sticky price models) correlation with output. For further information, see notes to Table 2.

Table 4 compares the relative standard deviation of the variables with respect to output, so that these statistics can be interpreted as the volatility of the variables. In the union model the volatility of the nominal variables is lower, and the volatility of the real variables, except for consumption, is higher. A comparison with the data shows that the union model matches the euro area economy better overall. The only mismatch is given for the interest rate figure for which the actual data is 0.75, whereas the union model produces a value of 0.34.

Table 5 presents the correlations of the variables with output. The statistics for the union model are closer to the one for the euro area economy. The correlations with output of the nominal interest rate and inflation are both lower in the union than in the baseline model. A shortcoming of both models is their inability to replicate the correlation of the interest rate with output. There are two interpretations for this drawback. First, it is the outcome of the two specific shocks we embedded into the model; enriching the model with additional shocks may solve this shortcoming. Second, as Boivin and Giannoni (2005) point out, it may be due to the time span considered for the monetary policy rule which covers both pre- and post-European Economic and Monetary Union.

As a further exercise, I explore whether the union model simulations produce more persistence, as the theoretical analysis suggests. I compare the correlations of supply and demand shocks with leads of the simulated series for both union and baseline models. The higher the correlation of shocks with leads of the simulated series, the longer lasting is the effect of shocks on the dynamics of the variables. Tables 6 and 7

Table 6
Correlations of simulated series with supply shocks

	Output		Consumption		Investment		Employment		Inflation		Interest rate	
	U	SP	U	SP	U	SP	U	SP	U	SP	U	SP
$t+3$	0.30	0.23	0.26	0.22	0.28	0.20	0.24	0.13	0.11	0.10	−0.33	−0.26
$t+2$	0.42	0.37	0.44	0.41	0.34	0.28	0.22	0.09	0.00	0.04	−0.32	−0.28
$t+1$	0.53	0.50	0.65	0.64	0.34	0.31	0.12	−0.02	−0.22	−0.09	−0.16	−0.16
t	0.54	0.56	0.85	0.88	0.20	0.22	−0.16	−0.30	−0.62	−0.40	−0.06	−0.07

Notes: Correlations of different leads of simulated series from union (U) and sticky price (SP) models with supply shocks. All series have been HP filtered; all figures are averaged across simulations.

Table 7
Correlations of simulated series with demand shocks

	Output		Consumption		Investment		Employment		Inflation		Interest rate	
	U	SP	U	SP	U	SP	U	SP	U	SP	U	SP
$t+3$	−0.03	0.01	−0.03	−0.01	−0.02	0.02	−0.03	0.02	−0.01	0.02	0.15	0.08
$t+2$	−0.13	−0.07	−0.09	−0.05	−0.14	−0.08	−0.15	−0.08	−0.11	−0.07	0.36	0.32
$t+1$	−0.30	−0.27	−0.18	−0.15	−0.36	−0.31	−0.36	−0.31	−0.29	−0.30	0.74	0.83
t	−0.62	−0.68	−0.35	−0.37	−0.75	−0.82	−0.75	−0.81	−0.62	−0.78	−0.18	−0.15

Notes: Correlations of different leads of simulated series from union (U) and sticky price (SP) models with demand shocks. All series have been HP filtered; all figures are averaged across simulations.

reproduce these statistics for the productivity and policy shocks, respectively. For both shocks, the correlation in lead periods is higher in the union model, which suggests that, in the non-Walrasian setting, shocks have longer-lived effects on the variables.

The overall lesson from the simulation of the model is that, in general, the union model is better able to replicate the observed business cycle properties of the euro area than the standard SP model.

5. Conclusions

This paper introduces equilibrium unemployment generated through a simple union bargaining process into an otherwise standard new Keynesian monetary model. The combination of a non-Walrasian labor market with general equilibrium models has been used recently in the new Keynesian literature through efficiency wage and search models to study business cycle dynamics and shock propagation. The novelty of this paper is that it introduces a simple union bargaining process, as means to study interactions between both supply and demand shocks and the business cycle in a monetary SP model.

The introduction of union bargaining produces two main results. First, the persistence of macroeconomic variables in the aftermath of supply and demand shocks increases. The presence of the representative union in the economy generates real rigidity because of the lower wage volatility relative to a perfectly competitive labor market. This feature produces an endogenous mechanism which increases variable persistence. Second, inflation becomes less volatile. The sensitivity of real marginal costs to output is lower in the unionized economy so that firms adjust prices to a smaller extent than in the competitive labor market. Model simulations show that the union model is superior to a standard SP model in replicating the pattern of euro area business cycles.

These findings are similar to those produced using a standard search and matching framework of the labor market. Trigari (2005) and Walsh (2005) point out that search frictions improve the ability of a standard new Keynesian model to replicate the response of the economy to monetary shocks. Their results are driven by the different nature of real marginal costs in the search framework. Krause and Lubik (2005) show that, in a search framework, real marginal costs differ from the real wage. Search frictions generate long-run attachment between workers and firms, such that the value of the average worker to the firm and the cost of posting a new vacancy become part of the firm's real marginal costs. These factors, together with real wages, become the drivers of real marginal costs. In this paper instead, real marginal costs fluctuate according to wages and the decline of wage fluctuation is entirely responsible for the decline of the volatility of marginal costs.

Christoffel and Linzert (2005) and Trigari (2006) use a search model characterized by a right to manage bargaining framework similar to the one in this paper, but where firms set hours of work instead of employment, and show that this improves the performance of a search model. What drives their results is the lower volatility of wages due to the wage bargain as well as the fact that most of the adjustment of labor input occurs on the extensive margin, which, in their modified framework, does not affect marginal costs. In this paper, instead, the extensive margin affects real marginal costs and what generates the results is, solely, the lower volatility of real wages.

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