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# **Gradual Wage-Price Adjustments, Labor Market Frictions and Monetary Policy Rules**

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## Gradual Wage-Price Adjustments, Labor Market Frictions and Monetary Policy Rules

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#### Abstract

In this paper the role of different types of labor market frictions in the dynamics of output and inflation is investigated. For this purpose, the Keynes-Goodwin model discussed in Chen, Chiarella, Flaschel and Semmler (2006) and Franke, Flaschel and Proaño (2006) is extended by a labor search and matching module along the lines of Mortensen and Pissarides (1994). After estimating the resulting model with U.S. aggregate time series and comparing its dynamics with those of a VAR model, the performance of different types of monetary policy rules for inflation, and more generally, for macroeconomic stability is analyzed.

**Keywords:** Labor market frictions, wage and price inflation, (D)AS-AD, monetary policy

JEL CLASSIFICATION SYSTEM: E31, E52

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#### 1 Introduction

It is widely acknowledged that in the real world labor markets are characterized by a variety of frictions such as the asymmetric or incomplete information about the quality of the market participants, the existence of geographical and skill mismatches, as well as of labor searching and trading costs. As pointed out by Pissarides (2000, p.3), trading in labor markets is likely to be – to a greater extent than in other markets – "uncoordinated, time-consuming, and costly for both firms and workers", itself likely to depend on the actual market conditions such as the relative size of unemployed workers and vacancies.

In the New Keynesian models developed in the last two decades, however, the existence of nominal rigidities was considered as the primary source of welfare losses. In those early frameworks these nominal frictions were commonly specified by means of a staggered price (and lately also a wage) setting mechanism e.g. à la Calvo (1983), whereafter only a fraction of firms (and concerning wages, households) could reset their goods prices to the monopolistically optimal level in every period, see e.g. Blanchard and Kiyotaki (1987), Roberts (1995), Goodfriend and King (1997), and more recently Erceg, Henderson and Levin (2000). The labor search and matching process was however still assumed to function in a frictionless manner, so that firms and workers always (and costlessly) were able to find proper counterparts, what in turn ruled out the existence of Non-Walrasian labor market equilibrium situations – where involuntary unemployment and open vacancies might exist in equilibrium due to external factors.

This important shortcoming of the early New Keynesian literature was recently addressed by Walsh (2003, 2005), Christoffel, Kuester and Linzert (2009), Gertler and Trigari (2009) and Trigari (2009), among others, through the incorporation of real labor market frictions into New Keynesian DSGE models with nominal rigidities using the search and matching approach developed by Mortensen and Pissarides (1994) and Pissarides (2000). However, while this new modeling direction seems to add a significant touch of empirical relevance to the DSGE theoretical construct, it does not remedy the lack of realism of its main building block: The representative agent type of microfoundations – which makes central issues of capitalist economics such as the income distribution conflict irrelevant (see e.g. Flaschel (2009, ch.1)) –, and the rational expectations assumption – which knowingly leads to "dynamic inconsistencies" between the predicted model dynamics and the observed empirical stylized facts, as pointed out by Mankiw (2001), Estrella and Fuhrer (2002), and Rudd and Whelan (2005), among others.

In the alternative approach discussed e.g. in Chiarella and Flaschel (1996) and Chiarella,

Flaschel and Franke (2005), in contrast, the dynamics of the economy are not the equilibrium outcome of an intertemporal utility and profit maximization problem of a representative agent with "mathematically rational" expectations. Instead, they are explained by the gradual adjustments of nominal and real variables to disequilibrium situations in the goods and labor markets, and thus by the implicit assumption of heterogeneous and boundedly rational agents which in their aggregate give rise to such rather smooth processes.

The main aim of this paper is to incorporate the main elements of labor search theory used in recent New Keynesian models into this disequilibrium approach to macroeconomic dynamics in order to analyze, among other things, the conduction of monetary policy in such an environment. For this purpose, the (Disequilibrium) Keynes-Goodwin model discussed in Chen et al. (2006) and Franke, Flaschel and Proaño (2006) – where the dynamics of the goods and the labor markets were linked by a dynamic version of Okun's (1970) law – is extended by the incorporation of a labor search and matching module along the lines of Mortensen and Pissarides (1994) and Pissarides (2000).

The remainder of this paper can be summarized as follows. In section 2 the theoretical framework is discussed. In section 3 the empirical plausibility of the resulting model is investigated first by estimating it using aggregate U.S. time series data, and then by comparing the model dynamic adjustments with the ones of an unrestricted VAR model of the U.S. economy. A closer look on the role of labor market frictions for the transmission of monetary policy shocks is taken in section 4, where the performance of alternative monetary policy rules is also investigated. Finally, section 5 draws some concluding remarks from this study.

#### 2 The Model

#### 2.1 The Goods and Labor Markets

The dynamics of the goods markets in this theoretical model are assumed to be of a "Keynesian" type, with aggregate demand driving the level of output  $(Y_t^D = Y_t)$  and the employment level (as well as the labor productivity) being determined accordingly in a second step.

In order to keep the model as simple as possible, let us assume a linear single input factor technology by which output is produced according to

$$Y_t = z_t N_t, \tag{1}$$

where  $N_t$  denotes the actual (realized) level of employment and  $z_t$  represents the average labor productivity level.

Analogously, the full employment output level  $Y_t^f$  is assumed to be determined by

$$Y_t^f = z_t^{\mathrm{T}} L_t \tag{2}$$

where  $L_t$  is total labor supply in the economy and  $z_t^{\mathrm{T}}$  is the trend labor productivity level.

As it is standard in the literature, see e.g. Rudebusch and Svensson (1999) the output gap  $y_t = \ln(Y_t^D/Y_t^f)$  (a measure of the excess aggregate demand in the economy) is assumed to be determined by

$$y_t = \alpha_y y_{t-1} - \alpha_{yr} (i_{t-1} - \hat{p}_t - (i^o - \pi^o)) - \alpha_{yv} \ln(v_{t-1}/v^o)$$
(3)

where  $y_{t-1}$  represents the output gap in the previous period,  $i^o$  denotes the steady state nominal interest rate,  $\hat{p}_t$  the price inflation rate at date t, and  $\pi^o$  the steady state inflation rate. Additional to these standard terms  $\ln(v_t/v^o)$ , the log deviation of the actual labor share  $v_t$  from its steady state level  $v^o$  is also included in the above equation to explicitly incorporate the role of functional income distribution for the dynamics of the output gap. According to eq.(3) aggregate demand is thus assumed to depend (i) positively (with  $0 < \alpha_y < 1$ ) on aggregate income, (ii) negatively on the real interest rate, and (iii) negatively on the labor share.

Let us now assume that the level of output produced by firms – and therefore their labor demand – is determined solely by the level of aggregate demand  $Y_t^{\rm D} = Y_t$ , and that firms, confronted with it, set their labor demand (analogously to eq.(1)) according to

$$L_t^{\mathrm{D}} = Y_t / z_t^{\mathrm{T}}. \tag{4}$$

where however not  $z_t$  (which is still to be determined and thus still not observable for firms at the beginning of period t) but  $z^{T}$ , the trend labor productivity, is used.

Due to the existence of labor market frictions, however, the actual level of employment  $N_t$  is not necessarily consistent with the labor demand by firms  $L_t^D$ , so that  $L_t^D = N_t$ 

Throughout this paper, the growth rate of a variable  $x_t$  will be denoted as  $\hat{x_t}$ .

<sup>&</sup>lt;sup>2</sup>In the heterodox macroeconomics literature, the case where economic activity depends negatively on wage share is referred to as a "profit-led regime", in contrast to the "wage-led" case where the economy depends positively on the wage share, see e.g. Barbosa-Filho and Taylor (2006). On the basis of this study, as well as of the empirical findings by Chen et al. (2006), Franke, Flaschel and Proaño (2006), Proaño, Flaschel, Ernst and Semmler (2006), and Proaño (2009), aggregate demand will be assumed in this paper to be profit-led.

does not hold in the normal case. Instead, the actual number of employed workers at t is determined by the level of remaining jobs from the previous period and by the "matches" occurred at the beginning of the actual period. At t, the number of employees is determined by

$$N_t = (1 - \rho)N_{t-1} + m(U_t, V_t) \tag{5}$$

where  $\rho$  represents an exogenous job separation rate<sup>3</sup> and  $m(U_t, V_t)$  is a matching function of a standard Cobb-Douglas type

$$m(U_t, V_t) = \mu U_t^{\xi} V_t^{1-\xi},$$
 (6)

with  $\mu \in (0,1)$  representing the matching technology level,  $U_t = L_t - (1-\rho)N_{t-1}$  the number of unemployed,  $V_t = L_t^D - (1-\rho)N_{t-1}$  the number of vacancies at the beginning of period t, and  $\xi \in (0,1)$  the parameter in the Cobb-Douglas matching function.<sup>4</sup>

By defining  $u_t = U_t/L_t$  and  $v_t = V_t/L_t$  as the unemployment and vacancy rates, respectively, gathering eqs. (2) and (4) to

$$L_t^{\mathrm{D}}/L_t = Y_t/Y_t^f = \exp(y_t),\tag{7}$$

and normalizing the total labor supply to  $L_t = \bar{L}$ , we can reformulate eq.(5) in terms of the employment rate  $e_t = N_t/\bar{L}$  as

$$e_t = (1 - \rho)e_{t-1} + m(u_t, v_t). \tag{8}$$

Using eqs. (6) and (7), we can rewrite eq.(8) as

$$e_t = (1 - \rho)e_{t-1} + \mu[1 - (1 - \rho)e_{t-1}]^{\xi} \left[\exp(y_t) - (1 - \rho)e_{t-1}\right]^{1-\xi}$$
(9)

This quite simple specification allows us to incorporate in the theoretical framework discussed in Chen et al. (2006) and Franke, Flaschel and Proaño (2006) the dependency

<sup>&</sup>lt;sup>3</sup>The assumption of an exogenous job separation rate is consistent with Hall (2005) and Shimer (2005), who find that the rise in unemployment during economic slowdowns is caused not by a higher rate of job destruction (at least in the U.S. employed workers do not get fired more frequently than in economic booms), but by a lower rate of job creation. While this assumption is also met by Gertler and Trigari (2009), Trigari (2009) and Christoffel, Kuester and Linzert (2009), Campolmi and Faia (2006), in contrast, assume that the job separation rate depends partly on the position of the economy within the business cycle, making the separation rate of employment partly endogenous.

<sup>&</sup>lt;sup>4</sup>In Section 4 an economic interpretation of this last parameter will be put forward.

of employment on the actual labor market situation.<sup>5</sup> As this labor market module is formulated, the state of the market influences in a direct way the capability of firms to serve aggregate demand: Indeed, due to the existence of labor market frictions, firms usually do not obtain their desired level of labor demand  $L_t^{\rm D}$ , but obtain only  $N_t$  instead. Furthermore, as it will be discussed below, the magnitude of the discrepancy between  $L_t^{\rm D}$  and  $N_t$  depends in a non-linear manner on all three labor market parameters comprised in eq.(9), namely  $\mu$ ,  $\rho$  and  $\xi$ .

By assuming goods market equilibrium (that is,  $i = i^o$ ,  $\hat{p} = \pi^o$ ,  $v = v^o$  and y = 0), we can calculate from eq.(9) the steady state employment rate  $e^o$ 

$$e^o = \frac{\mu}{(1-\rho)\mu + \rho}.\tag{10}$$

As it can be easily observed, the steady state rate of employment is determined purely by structural factors concerning the labor markets, namely the labor separation rate  $\rho$  and the matching technology  $\mu$ , which influence thus not only the speed and persistence of dynamic responses of the labor markets to exogenous shocks, but also the *level* of the steady state employment rate, as it can be easily confirmed:

$$\begin{array}{lcl} \frac{\partial e^o}{\partial \rho} & = & \frac{-\mu(1-\mu)}{(1-\rho)\mu+\rho^2} < 0 & \text{and} \\ \frac{\partial e^o}{\partial \mu} & = & \frac{\rho}{[(1-\rho)\mu+\rho]^2} > 0, \text{ with } e^o \to 1 \text{ as } \mu \to 1. \end{array}$$

As shown in Figure 1 through a ceteris paribus simulation of the employment rate equation (i.e. holding all other variables in the model constant), the larger the value of the matching technology parameter  $\mu$ , the stronger is the response of the employment rate to an exogenous labor demand shock, and the faster is the return of the employment rate to its steady state level (which in turn also depends on the value of  $\mu$ ). Ceteris paribus, a low matching technology leads thus to a weak response of the actual employment to labor demand shocks that is also more persistent – a result which is in line with other studies featuring aggregate matching functions in the labor markets such as Walsh (2003, 2005).

<sup>&</sup>lt;sup>5</sup>Note that our formulation of the employment rate dynamics differs significantly from traditional search and matching labor market models, because here the vacancies are determined basically by the goods aggregate demand pendant on the labor market (since  $L^{\rm D}/\bar{L}=Y/Y^f$ ) and not, as usual, through a forward-looking decision process including Bellman equations and therein the cost-benefit considerations of both workers and firms. However, as discussed later on in this paper, the present formulation of the employment rate dynamics delivers similar dynamics as do models featuring rational forward-looking agents and nominal as well as real rigidities such as Walsh (2005).

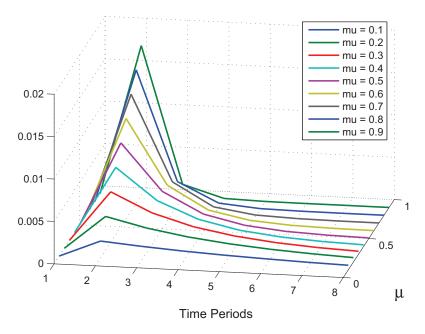


Figure 1: Employment rate response to an exogenous 1% labor demand shock in t=2 for different values of the matching technology  $\mu$ 

Concerning the average labor productivity level  $z_t$ , it is easy to show that its growth rate  $\hat{z}_t = \ln(z_t/z_{t-1})$  is given by

$$\hat{z}_t = g_z + \Delta y_t - \ln(e_t/e_{t-1}), \qquad g_z = \ln(z_t^{\text{T}}/z_{t-1}^{\text{T}}) = \text{const.} \, \forall \, t$$
 (11)

(with 
$$\Delta y_t = y_t - y_{t-1}$$
), since

$$z_t = z_t^{\mathrm{T}} \exp(y_t) / e_t \tag{12}$$

according to eqs. (1) and (2).

For comparison, in Franke, Flaschel and Proaño (2006) the link between the goods and the labor market dynamics was established by the following specification for the dynamics of the employment rate based on Okun's (1970) law:

$$\hat{e}_t = \alpha_{ey1} \Delta y_{t-1} + \alpha_{ey2} \Delta y_{t-2} + \alpha_{ey3} \Delta y_{t-3} - \alpha_{ev} \ln(v_{t-1}/v^o). \tag{13}$$

In section 3 the performance between the labor search & matching (LSM) specification given by eq.(9) and the above dynamic Okun's Law (DOL) will be analyzed.

#### 2.2 The Wage-Price Dynamics

As previously mentioned, in contrast to the recent DSGE macroeconometric models such as Erceg, Henderson and Levin (2000) and Christiano, Eichenbaum and Evans (2005) – where the dynamics of wages and prices are driven by the rational, forward-looking, profit and utility maximizing behavior of firms and households – the theoretical approach by Chiarella and Flaschel (1996) and Chiarella, Flaschel and Franke (2005) assumes that the dynamics of the two variables are influenced in a direct manner by the current respective excess demand pressures in the labor and goods markets, and that they are also likely to be influence each other in a cross-over manner.

More specifically, the main driving forces of wage inflation in this alternative approach are the deviation of the actual employment rate from its NAIRU equivalent  $e^o$ , and the log deviation of the wage share from its steady state level  $v^o$ . The negative influence of the wage share in this Wage Phillips Curve (WPC) can be interpreted as arising from a wage bargaining process where the parties involved also have an eye on the general distribution of total income. At relatively low values of the wage share, workers seek in the wage bargaining process to catch up to what is considered a normal, or "fair", level. By the same token, workers are somewhat restrained in their wage claims if v is currently above normal. Another theoretical (and perhaps more fashionable) underpinning could be borrowed from Blanchard and Katz (1999). They specify a wage curve argument in which the tighter the labor market, the higher the level of the real wage, given the workers' reservation wage. The wage share enters this scenario in a logarithmic form by assuming that the reservation wage depends on labor productivity and lagged wages.<sup>6</sup>

The structural wage Phillips curve is thus given by

$$\hat{w}_t = f_w(e, v) + [\kappa_{wp}\hat{p}_t + (1 - \kappa_{wp})\pi_t^c + \kappa_{wz}\hat{z}_t],$$

$$f_w(e, v) = \beta_{we}(e_{t-1} - e^o) - \beta_{wv}\ln(v_{t-1}/v^o)$$
(14)

where  $\pi_t^c$  represents the inflationary climate in the economy (to be described in detail below) and the term  $\kappa_{wz}\hat{z}_t$  provides an additional benchmark in the sense that wages increase proportionally with productivity and current (and expected) prices. The functional expression  $f_w$  summarizes the two driving variables, employment and the wage share. As already mentioned,  $e^o$  is assumed to be an exogenously given "natural" rate of employment, the counterpart of the usual NAIRU specification.

<sup>&</sup>lt;sup>6</sup>A detailed translation of this approach into eq.(14) is given in Chiarella, Flaschel and Franke (2005, pp.170ff).

With respect to the price Phillips curve (PPC), besides the output gap as the main driving variable, again the wage share takes effect in this relationship, in a positive manner though. Cost push terms are contemporaneous wage inflation and the inflation climate, whereas productivity growth affects price inflation in a negative manner.

The price Phillips curve is thus formulated as

$$\hat{p}_t = f_p(y, v) + \kappa_{pw}(\hat{w}_t - \hat{z}_t) + (1 - \kappa_{pw})\pi_t^c.$$

$$f_p(y, v) = \beta_{py} y_{t-1} + \beta_{pv} \ln(v_{t-1}/v^o).$$
(15)

The positive influence of the wage share in the equation can be explained by a target markup rate  $\gamma$  that firms may wish to realize. Besides the other arguments in eq.(15), firms raise prices if labor costs are currently so high that  $pY < (1 + \gamma)wN$ , which is equivalent to  $(1 + \gamma)wN/pY - 1 = (1 + \gamma)v - 1 > 0$ . The wage share deviations specified in eq.(15) are thus obtained if  $1 + \gamma = 1/v^o$ , i.e. if the target markup is consistent with equilibrium income distribution.

As already mentioned, the excess demand pressure terms  $e - e^o$  and y and the wage share terms in the wage and price Phillips Curves are additionally augmented by a weighted average of respective contemporaneous cross rates of inflation (which reflect the idea of myopic perfect foresight in the nominal variables), and a backward looking measure of the prevailing inertial inflation in the economy (the "inflationary climate", so to say) symbolized by  $\pi^c$ , as well as by the actual labor productivity growth rate  $\hat{z}$  (which is expected to directly influence wages in a positive and prices in a negative manner, due to the associated easing in production cost pressure).

From the corresponding across-markets or reduced-form Phillips curves (with  $\kappa = 1/(1 - \kappa_{wp} \kappa_{pw})$ )

$$\hat{w}_t = \kappa \left[ f_w(e, v) + \kappa_{wp} f_p(y, v) + (\kappa_{wz} - \kappa_{wp} \kappa_{pw}) \hat{z}_t \right] + \pi^c, \tag{16}$$

$$\hat{p}_t = \kappa \left[ f_p(y, v) + \kappa_{pw} f_w(y, v) + \kappa_{pw} (\kappa_{wz} - 1) \hat{z}_t \right] + \pi^c, \tag{17}$$

we obtain the following discrete-time approximation of the law of motion of the labor share v = w/(pz):

$$\hat{v_t} = \hat{w_t} - \hat{p_t} - \hat{z_t} 
= \kappa \left[ (1 - \kappa_{pw}) f_w(e, v) - (1 - \kappa_{wp}) f_p(y, v) + (\kappa_{wz} - 1) (1 - \kappa_{pw}) \hat{z_t} \right].$$
(18)

<sup>&</sup>lt;sup>7</sup>See Chiarella, Flaschel and Franke (2005, pp.111f), where also an empirical study by Brayton, Roberts and Williams (1999) is discussed. In fact, the wage share expression in eq.(15) can be related to a significant influence of an actual markup variable in the latter work.

with

$$f_w(e, v) = \beta_{we}(e_{t-1} - e^o) - \beta_{wv} \ln(v_{t-1}/v^o),$$
  
$$f_p(y, v) = \beta_{py} y_{t-1} + \beta_{pv} \ln(v_{t-1}/v^o).$$

and  $\hat{z}_t$  given by eq.(11).

Concerning the evolution of the overall inflationary expectations among the economic agents in the model economy, as in Franke, Flaschel and Proaño (2006) let us assume that the dynamic behavior of the inflationary climate is described by

$$\pi_t^c = \pi_{t-1}^c + \beta_{\pi^c} [\kappa_{\pi^c} (\hat{p}_t - \pi_{t-1}^c) + (1 - \kappa_{\pi^c}) (\pi^o - \pi_{t-1}^c)], \tag{19}$$

where  $\beta_{\pi^c}$  is an adjustment speed parameter and  $\pi^o$  the steady state inflation rate, which is assumed to be known by the public and targeted by the central bank. The weight parameter  $\kappa_{\pi^c} \in [0,1]$  is associated with the central bank's credibility, with  $(1 - \kappa_{\pi^c})$  representing the influence of the trend-chasing adaptive expectations component in the inflationary climate in the economy.

#### 2.3 Monetary Policy

As standard in the actual theoretical literature, not the level of money supply but the nominal interest rate is modeled as the policy instrument of the monetary authorities. Accordingly, the short-term nominal interest rate set by the monetary authorities is defined by

$$i_t = i^o + \phi_{\hat{p}}(\hat{p}_{t-1} - \pi^o) + \phi_{y_t} y_{t-1} \tag{20}$$

where  $i^o$  is the steady state nominal interest rate, and  $\phi_{\hat{p}}$  and  $\phi_y$  are coefficients representing the reaction of the central bank to deviations of the price inflation rate from its target level (the inflation gap), and to non-zero output gaps, respectively.<sup>8</sup>

As Figure 2 illustrates, the market hierarchy of the described theoretical economy is clearly defined: aggregate demand (determined by the real interest rate, the labor share and the output gap in the previous period) determines the level of output (and thus the

<sup>&</sup>lt;sup>8</sup>Note that an interest rate smoothing term is not incorporated as e.g. in Walsh (2005), following the empirical and theoretical arguments of e.g. Rudebusch and Wu (2003), whereafter monetary policy impulses should be specified as autoregressive processes due, for example, the uncertainty of the monetary authorities at time t concerning the actual state of the economy.

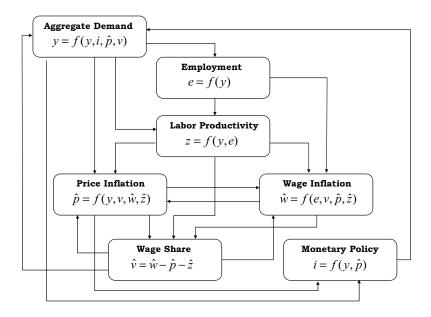


Figure 2: The structure of the model

output gap) in the actual period. Due to the existence of labor search and matching frictions, not  $L_t^{\rm D} = Y_t/z_t^{\rm T}$ , but  $N_t$  is realized instead. Labor productivity is determined residually from  $z_t = Y_t/N_t$ . Wage- and price inflation are determined not only by the goods-, but also by the labor markets, as well as by the weighting coefficients of both wage and price Phillips curves equations concerning the cross-over inflation expectation scheme. Concerning the dynamics of the labor share, while the influence of the (log) wage share on its rate of growth is unambiguously negative (see eq.(18)), the joint, net effect of the goods and labor market dynamics depends on the respective slopes of the two structural Phillips curves, as well as, again, on the cross-over inflation expectations formation of the economic agents.

It should be pointed out that the destabilizing Mundell inflationary expectations channel (discussed extensively in Chiarella, Flaschel and Franke (2005)), which affects positively the dynamics of all other dynamic variables of the system through its positive influence on price inflation, as well as on wage inflation, also operates in this model, being more destabilizing the larger is  $\beta_{\pi^c}$  in eq.(19). However, as long as the nominal interest rate

reacts – along the lines of the so-called Taylor principle – over-proportionally  $(\phi_{\hat{p}} > 1)$  in eq.(20)) to price inflation increases, the interaction between price inflation and output is intrinsically stable, since  $\partial y/\partial \hat{p} < 0$ ,  $\partial y/\partial y < 0$ ,  $\partial \hat{p}/\partial y > 0$  and  $\partial \hat{p}/\partial \hat{p} = 0$ . Accordingly, for  $\phi_{\hat{p}} > 1$  an exogenous increase in  $\hat{p}$ , leads to a larger increase in i, to a decrease in y and thus to a decrease in  $\hat{p}$ . As a consequence, the positive effect of a higher  $\hat{p}$  on the inflationary climate  $\pi^c$  is short-lived and is thus not likely to destabilize the interaction between  $\hat{p}$  and y.

Because the local stability conditions of the original theoretical model have been investigated extensively by Chen et al. (2006) and Franke, Flaschel and Proaño (2006) both numerically and analytically, and because the introduction of the labor search module does not imply per se the occurrence of instability (as it in fact incorporates more frictions into the model), the remainder of this paper does not focus on the local stability analysis of this model variant but investigates instead the empirical plausibility of this modified theoretical model, and analyzes the performance of alternative monetary policy rules.

#### 3 Empirical Evidence

Let us now assess the empirical plausibility of the theoretical framework discussed in the previous section by comparing the model's dynamic adjustment to an exogenous one-time monetary policy shock (modeled as an AR(1) process with an autoregressive coefficient of 0.7 as in Walsh (2005)) with the impulse response functions resulting from an unrestricted VAR model estimated with aggregate time series of the U.S. economy. Accordingly, the parameters underlying the following simulations assume a quarterly frequency and are chosen so that nominal interest rates as well as wage and price inflation rates are presented as annualized values. In the following simulations the wage- and price inflation adjustment equations, as well as the output gap and the inflationary climate equations are calibrated with parameter values along the lines of those obtained for the U.S. economy by Franke, Flaschel and Proaño (2006) and Proaño et al. (2006).<sup>10</sup>

<sup>&</sup>lt;sup>9</sup>This stability property of the real interest rate channel (first analyzed by formal methods in Tobin (1975), see also Groth (1992)), operates in models with a conventional LM equation through the well known Keynes effect.

<sup>&</sup>lt;sup>10</sup>The following estimations were computed using the original time series of all variables except of the wage share, which was detrended using a quadratic trend given the downward but not exactly linear evolution of that series over the last 30 years in the United States. The inflationary climate parameters are chosen so that this variable does not exert a significant influence on the dynamics of the system.

Table 1: Baseline calibration parameters

Goods Markets	$\alpha_y$	$\alpha_{yr}$	$\alpha_{yv}$	
	0.7	0.05	0.1	
Wage Phillips Curve	$\beta_{we}$	$\beta_{wv}$	$\kappa_{wp}$	$1 - \kappa_{wp}$
	0.510	0.230	0.420	0.580
Price Phillips Curve	$\beta_{py}$	$\beta_{pv}$	$\kappa_{pw}$	$1 - \kappa_{pw}$
	0.210	0.270	0.550	0.450
Monetary Policy Rule	$\phi_{\hat{p}}$	$\phi_y$	$\beta_{\pi^c}$	$\kappa_{\pi^c}$
& Inflationary Climate	1.5	0.5	1	0.5

In those and other related studies such as Chen and Flaschel (2006), Flaschel and Krolzig (2006) and Proaño (2009) similar models to the one discussed here have been estimated with aggregate data of the U.S. and major European countries using different econometric methods. These empirical studies do not only support the theoretical formulation of the model, but also suggest that wage flexibility is larger than price flexibility towards their demand pressure terms in the labor and goods markets, respectively. Furthermore, the term  $\ln(v/v^o)$  has been found to be by and large statistically significant and to have numerically similar coefficients in both wage and price adjustment equations. The same is true for the cross-over inflation expectation terms, with the wage inflation entering in the price Phillips curve and the price inflation entering in the wage Phillips Curve. The inclusion of lagged price inflation (as a proxy for the inflationary climate term) in both equations seems also to be supported by the data.

The empirical estimates for the parameter values of the labor search employment rate specification given by eq.(9) was estimated using U.S. aggregate time series stemming from the Federal Reserve Bank of St. Louis data set. The data is quarterly, seasonally adjusted and concerns the period from 1970:1 to 2005:4. The real interest rate was computed as  $r_t = i_{t-1} - \hat{p}_t$  with  $i_t$  as the three-month T-bill and  $\hat{p}_t$  as the annualized GDP deflator inflation rate.

In order to test for stationarity, Phillips-Perron unit root tests were carried out for each series in order to account, not only for residual autocorrelation as is done by the standard ADF Tests, but also for possible residual heteroskedasticity when testing for stationarity. The Phillips-Perron test specifications and results are shown in Table 2. As it can be observed there, the applied unit root tests confirm the stationarity of all series with the exception of the short term real interest rate r at the 5% level. Nevertheless, due to the general low power of the unit root tests, this result can be interpreted as a reflection of the

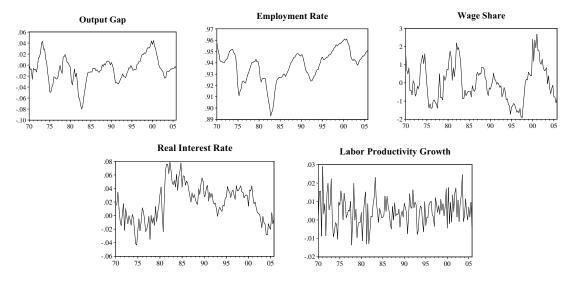


Figure 3: U.S. aggregate time series. The detrended wage share is depicted using a normalized scale. Source: US FRED Database.

strong autocorrelation present in the short term real interest rate.

Table 2: Phillips-Perron Unit Root Test Results. Sample: 1970:1 - 2005:4

Variable	Lag Length	Determ.	Adj. Test Stat.	Prob.*
$\Delta y_t$	-	-	-9.296	0.000
$\Delta e_t$	-	-	-5.430	0.000
$\Delta \ln(v_t/v^o)$	-	-	-13.557	0.000
$\Delta \ln(z_t)$	-	-	-10.092	0.000
$r_t$	-	-	-2.383	0.017

<sup>\*</sup>MacKinnon (1996) one-sided p-values.

Before analyzing the empirical evidence for the joint dynamics of the main variables of the theoretical model, let us first focus on the empirical estimates of the LSM specification put forward in this paper. Eq.(9) was estimated by means of nonlinear GMM in order to account for a possible correlation between the disturbance term and the right-hand side variables, since this is an instrumental variables method which accounts for this eventual problem, and, being a minimum distance estimator, does not rely on a specific assumption with respect to the distribution of the residuals. Indeed, as stated in Wooldridge (2001,

p.92), a GMM estimation possesses several advantages in comparison to more traditional estimation methods such as OLS and 2SLS especially in time series models, where heteroskedasticity in the residuals is a common feature: "The optimal GMM estimator is asymptotically no less efficient than two-stage least squares under homoskedasticity, and GMM is generally better under heteroskedasticity." Accordingly, the Newey and West (1987) HAC weighting matrix was chosen in the GMM objective function to allow the resulting GMM estimates to be robust against possible heteroskedasticity and serial correlation of an unknown form in the error terms. As instrumental variables in the GMM regression the four lags of  $\Delta e_t$ ,  $\Delta \ln(v_t/v^o)$ ,  $r_t$  and  $\Delta \ln(z_t)$  were included. In order to test for the validity of the overidentifying restrictions, the J-statistics as proposed by Hansen (1982) were calculated. The following GMM estimates of eq.(9) were obtained (standard errors in brackets):

$$\Delta e_t = \underset{[0.042]}{0.433} \left[ 1 - \left( 1 - \underset{[0.008]}{0.042} \right) e_{t-1} \right]^{\underset{[0.039]}{0.422}} \left[ \exp(y_t) - \left( 1 - \underset{[0.008]}{0.045} \right) e_{t-1} \right]^{\underset{[0.039]}{1-0.422}} - \underset{[0.008]}{0.045} e_{t-1}$$

$$\mathbf{Adj. \ R-squared} = 0.285 \qquad \mathbf{J-stat \ (p-val)} = 0.963$$

In general terms the GMM regression widely supports the theoretical formulation of the employment rate dynamics, being also consistent with other studies: The estimated value of  $\mu=0.433$  is consistent with the estimates of De Haan, Ramey and Watson (2000) (Christoffel, Kuester and Linzert (2009) calibrate their model with  $\mu=0.42$ ), as well as the Cobb-Douglas parameter estimate  $\xi=0.422$ , which is concordant with the empirical findings of European countries and the U.S. surveyed by Petrongolo and Pissarides (2001) (Walsh (2005) sets this parameter equal to 0.4). In contrast, the estimate of the job separation rate  $\rho=0.045$  is significantly lower than the empirical findings by Hall (1995), Hall (2005), Shimer (2005), who estimate this coefficient to be approximately 0.1. This difference can be however explained by the fact that while in those studies the job separation rate is calculated from the cyclical component of the unemployment rate computed through the Hodrick-Prescott filter, see e.g. Shimer (2005, p.32), in this estimation, in contrast, not such detrending of the employment rate was undertaken.

For comparison the GMM estimates (computed with the same set of instrumental vari-

ables as in the previous regression) of the DOL specification given by eq.(13) are:

$$\hat{e}_t = 0.154 \Delta y_{t-1} + 0.178 \Delta y_{t-2} - 0.059 \Delta y_{t-3} - 0.006 \ln(v_{t-1}/v^o)$$

Adj. R-squared = 
$$0.306$$
 J-stat (p-val) =  $0.482$ 

As the adjusted R-squared statistics show, because the LSM specification given by eq.(9) imposes more structural restrictions on the data, the Okun's Law specification has a slightly better fit. However, the labor search specification has two main advantages in comparison the the OL specification: First, the GMM estimates of eq.(9) imply a fairly reasonable steady state employment rate of about  $e^o = \mu/((1-\rho)\mu + \rho) = 0.433/((1-0.045) \times 0.433 + 0.045) = 0.944$ , what delivers an additional test for the empirical relevance of the above equation, and second, as it will be discussed in the next section, its more elaborated theoretical structure delivers some interesting insights on the role of the labor markets for the dynamics of the economy which could not be obtained from the more empirically based Okun's Law.

Let us now analyze the dynamic adjustments of the theoretical framework with the DOL specification of Franke, Flaschel and Proaño (2006) and the framework variant discussed in this article to a monetary policy shock with the impulse response functions of an unrestricted VAR(1) model<sup>11</sup> of the core model variables i,  $\Delta y$ ,  $\Delta e$ , and  $\hat{v}$  (since the dynamics of the growth rate of the labor share  $\hat{v}$  comprise the dynamics of wage- and price inflation, and of the average labor productivity).<sup>12</sup>

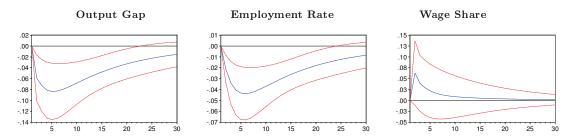


Figure 4: Impulse-response functions of an unrestricted VAR(1) model to a 1% nominal interest rate shock.

Figure 4 illustrates how the output gap, the employment rate and the (detrended) wage share react to a one-time 1% increase in the nominal interest rate. As expected, a higher

<sup>&</sup>lt;sup>11</sup>The lag length was chosen according to the Schwarz and the Hannan-Quinn Information Criteria.

<sup>&</sup>lt;sup>12</sup>As in the previous regression we use the (chance of the) log detrended wage share  $\ln(v/v^o)$  due to the pronounced downwards trend in this variable over the last twenty years.

interest rate affects the output gap negatively, what in turn leads to a decrease in the employment rate and to an increase in the wage share due to the joint reaction of price inflation, wage inflation and labor productivity to such a slowdown in economic activity.

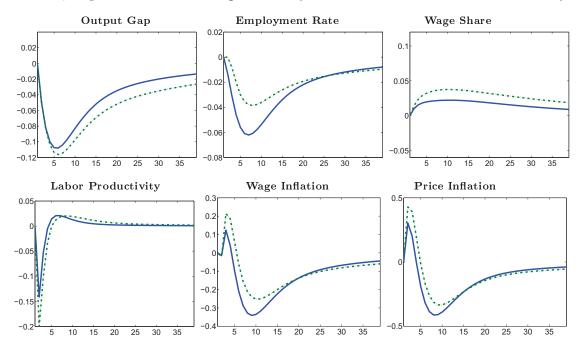


Figure 5: Model dynamic adjustments to a 1% monetary shock for different employment rate dynamic adjustment mechanisms (annualized inflation rates, percent values). The solid line corresponds to the labor search specification, while the dashed line corresponds to the dynamic Okun's law specification

Figure 5 in turn illustrates the dynamic adjustment predicted by the two model variants using the parameter values of Table 1 and the GMM parameter estimates for the DOL formulation and the GMM estimates for the LSM specification. As it can observed, in the two model variants the dynamic adjustments are not only concordant with the estimated VAR(1) model – not only in qualitative, but also in quantitative terms, as they lie within the estimated confidence bands of the just discussed VAR(1) – but are also along the lines of the predicted reactions of other macroeconomic models with labor frictions, such as Walsh (2003, 2005) and Christoffel, Kuester and Linzert (2009) even though the modeling approach of this paper does not rely on intertemporal utility and profit maximizing behavior by households and firms assumed there, nor on the Calvo (1983) staggered wage and price setting scheme. Similarly to the impulse-response functions of the unrestricted

VAR(1) model shown in Figure 4, the initial increase in the nominal interest rate leads to a fall in aggregate demand (and production) which leads to a fall in employment (with a certain delay) and a reduction of the average labor productivity. Despite the fact that the production and employment decrease influence negatively wage and price inflation, due to the sluggish reaction of these variables the immediate reaction of labor productivity leads initially to a (countercyclical) increase in the wage share, which in turn leads to a short-lived positive reaction of wages and prices, which is reversed over time by the negative developments of the output and the employment rate.

Now, even though the dynamic adjustment of both model variants are by and large of the same characteristics, as it will be shown in the next section the LSM specification for the employment rate dynamics discussed in this paper delivers a more structured view of the labor market, allowing a deeper analysis of the effect of different types of labor frictions on the dynamics of the economy.

#### 4 Labor Market Frictions and Macroeconomic Dynamics

As discussed in Section 2, the different labor market parameters  $\mu$  (the matching technology level),  $\rho$  (the exogenous job separation rate) and  $\xi$  (the Cobb-Douglas exponent in the matching function) comprised in eq.(9) affect in a direct manner not only the extent up to which the economy reacts to exogenous shocks, but also the speed with which the economy returns to equilibrium.

In order to analyzed in a differentiated manner the influence of the different labor market parameters in the economy's dynamic adjustments with respect to monetary policy shocks, in each of the following simulations, the model's reaction to a 1% increase in the nominal interest rate is computed using again the parameter estimates of Table 1 and the GMM estimates of the LSM specification, varying however only one of the labor market parameters at a time.

Let us begin with the matching technology parameter  $\mu$ . As it can be clearly observed in Figure 6, a higher efficiency in the matching process between vacancies and unemployed workers (represented by a larger value of  $\mu$ ) diminishes the discrepancy between the firms's labor demand level  $L_t^D$  and the actual employment level  $N_t$ , leading to a relatively stronger reaction of the employment and a weaker reaction of the average labor productivity, as labor productivity is determined residually from the difference between  $Y_t$  and  $N_t$ . Large values of  $\mu$  are thus related with strong reactions of employment and low reaction of the

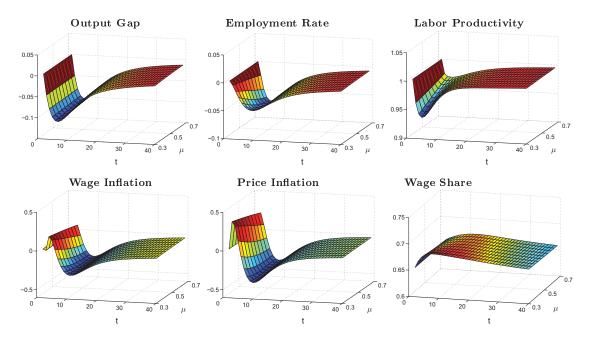


Figure 6: Dynamic adjustments to a 1% monetary shock for varying  $\mu$  values (annualized inflation rates, percent values)

average labor productivity. Furthermore, it should be noted that the actual reaction of the employment rate is much stronger than it is depicted in Figure 6 – where only the deviations of the actual employment rate from its steady state level are illustrated –, as the steady state employment rate depends also positively on  $\mu$  (as well as on the other labor market factors), see eq.(10). Concerning the nominal variables of the model, as it can also be clearly observed, the short-lived positively reaction of price inflation (and with a period delay, of wage inflation) resulting from the increase in the labor share (which results from the decrease in the labor productivity) diminishes for larger values of  $\mu$ , due to the inverse relationship between the employment and the labor productivity level.

Figure 7 in turn illustrates the effect of a larger job separation rate for the dynamic adjustments of our model economy with respect of an analogous monetary policy shock. As in the previous case, due to the increase in the labor share (resulting from the drop in labor productivity), we observe a short-lived increase in price inflation (as well as in wage inflation due to the influence of the former on the latter), which is also reversed due to the decrease in output and inflation after some quarters. Respecting the nominal variables, along the lines of Christoffel, Kuester and Linzert (2009) Figure 7 shows that these do not

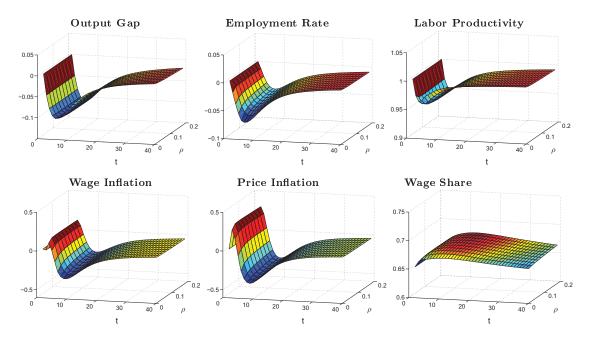


Figure 7: Dynamic adjustments to a 1% monetary shock for varying  $\rho$  values (annualized inflation rates, percent values)

seem to be particularly influenced by variations in the job separation rate. Concerning the employment rate, Figure 7 shows that for lower values of  $\rho$  the reaction – relative to the respective steady state employment rate – is much stronger than for larger values, where the employment rate does not deviate much from its (lower) steady state level.

Finally, Figure 8 illustrates the effect of variation in the parameter  $\xi$  of the Cobb-Douglas labor matching function. In this case we can observe that for larger values of  $\xi$  (the parameter representing the relative importance of the unemployment rate in the labor matching process) the reaction of actual employment becomes weaker, and that of labor productivity stronger. In order to understand these reactions it is helpful to think of  $\xi$  as the degree by which aggregate goods demand is served through internal labor productivity adjustment within the firms rather than through an external adjustment through the hiring of new employees. For example, for  $\xi = 0.3$  the employment rate reacts strongly to a variation in aggregate demand, while for  $\xi = 0.7$  it react only weakly, being the labor productivity of the already employed workers which takes over most of the adjustment of production. Additionally, as Figure 8 shows, the larger  $\xi$  is, the larger is also the persistence in the wage share reaction due to the stronger (and more persistent) reaction of the average

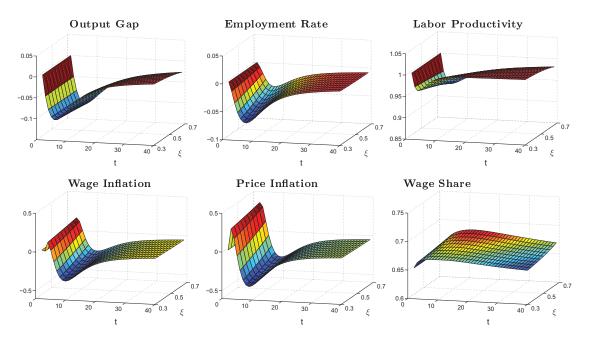


Figure 8: Dynamic adjustments to a 1% monetary shock for varying  $\xi$  values (annualized inflation rates, percent values)

#### labor productivity.

A real world analogy of this interpretation of  $\xi$  which highlights the advantages of the present LSM specification against the use of a simple Okun's law can be found in the differentiated effects of the actual global financial crisis on output and employment in the U.S. and Germany. Indeed, while in the U.S. the large output drop was followed by an unprecedent collapse in employment, in Germany the production sector reacted to the collapse in aggregate demand with the flexible use of time bank hours (Arbeitszeitkonten) and other similar measures which by definition led to a reduction of the average labor productivity, leaving however the employment level practically unchanged (see Möller (2010)). In terms of the model, this differentiated adjustment could be interpreted with the U.S being characterized by a low  $\xi$ , and Germany by a larger one.

#### 5 Monetary Policy Rules and Macroeconomic Stabilization

After the analysis of the role of the different labor market parameters for the dynamic adjustments of the model, let us now investigate the role of monetary policy for macroeconomic stability and more specifically the role of the choice of monetary policy targets for the dynamics of the economy. For this purpose the dynamic reactions of the model to an exogenous one-time 1% aggregate demand and an exogenous one-time 1% cost-push shock under the different monetary policy rules summarized in Table 3 are analyzed.

	I. Standard	II. Taylor Rule	Taylor Rule
Weights	Taylor Rule	with Employment Target	with Wage Inflation Target
$\phi_{\hat{p}}$	1.5	1.5	1.5
$\phi_y$	0.5	0.0	0.0
$\phi_e$	0.0	0.5	0.0
$\phi_{\hat{w}}$	0.0	0.0	0.5

Table 3: Alternative Monetary Policy Rules: Weighting Parameters

Rule I corresponds to the original Taylor (1993) specification, whereafter the nominal interest rate reacts to price inflation (with a coefficient of  $\phi_{\pi} = 1.5$ ) and the output gap (with  $\phi_{y} = 0.5$ ). In the second rule not the output gap, but the employment rate (as the labor markets are the main source of inefficiencies in the present theoretical framework) is targeted (with  $\phi_{e} = 0.5$ ). Finally, in rule III only the nominal variables price and wage inflation – with a joint reaction of  $\phi_{\hat{p}} + \phi_{\hat{w}} = 2$  – are assumed to enter in the the central bank's reaction function.

In order to evaluate the performance of these three monetary policy rules, a standard central bank (CB) loss function comprising the cumulated percent square deviations of the price inflation rates and output gaps in the member economies  $\mathcal{A}$  and  $\mathcal{B}$  from their respective targets, i.e.

$$\mathcal{L}_T = \sum_{t=1}^{T} \left[ (\hat{p}_t - \pi^o)^2 + y_t^2 \right]$$
 (21)

is calculated.  $^{13}$  The values of this CB loss function at different horizons are shown in Tables 4 and 5.

<sup>&</sup>lt;sup>13</sup>Note that this evaluation procedure differs from the approach pursued in the New Keynesian DSGE literature, where the performance of monetary (and fiscal) policy is evaluated in terms of deviations from the flexible-price equilibrium. In the present approach, in contrast, such an equilibrium is not explicitly modeled, nor is considered as the baseline scenario.

Table 4: Welfare Losses at Different Horizons (aggregate demand shock)

Monetary Policy Rule	8 Quarters	16 Quarters	24 Quarters	32 Quarters
I	34.516	43.547	44.046	44.087
II	37.202	45.736	45.969	45.995
III	39.795	47.847	47.856	47.856

As Table 4 clearly shows, given the parameter values used in these simulations, in the case of an aggregate demand shock the monetary policy rule with the price and wage inflation targets has the worst relative performance followed by the policy rule with the employment rate target. The monetary policy rule with the standard price inflation and output gap targets, in contrast, brings about the lowest loss for the central bank at all horizons.

Table 5: Welfare Losses at Different Horizons (cost-push shock)

Monetary Policy Rule	8 Quarters	16 Quarters	24 Quarters	32 Quarters
I	0.5099	0.7231	1.0628	1.3526
II	0.5103	0.7492	1.1752	1.5864
III	0.5420	0.6486	0.9350	1.2138

Table 5, in turn, illustrates the evolution of the CB "losses" resulting from a cost-push shock. As it can be clearly observed, at the 8 quarters horizon rule I is the most effective rule followed by rule II (as in the previous case). This ranking is however reversed over the next quarters. So from the 16th quarter on, rule III delivers the lowest loss for the central bank, followed by rule II and rule I. These simulations suggest that in the case of a cost-push shock a rule with both wage and price inflation targets is the more efficient one over the long term.<sup>14</sup>

<sup>&</sup>lt;sup>14</sup>In a related paper, Faia (2008) performs similar experiments within a New Keynesian DSGE framework with labor market frictions, finding that targeting the output gap is suboptimal towards targeting the unemployment gap. The intuition behind this result is that because because in her framework the evolution of the real marginal costs (the main determinant of price inflation in the New Keynesian DSGE approach) depends solely on unemployment and in that study the existence of labor market frictions are the source of the inefficiency in the economy, a monetary policy rule reacting to the unemployment gap is thus welfare-enhancing. Here, in contrast, the performance of monetary policy is evaluated using a different metric not based on the welfare resulting from the lifetime consumption of a representative agent, as usually done in New Keynesian DSGE models.

Let us now analyze the CB loss function and thus the effect of a variation of the nominal and real target weights values for macroeconomic stabilization. For this the CB loss function is again computed for different combinations of the respective target weights of rules I, II and III in the interval [0.1 - 1.8] for  $\phi_p$  and  $\phi_e$ , and in the interval [0.8 - 1.8] for  $\phi_p$  for both aggregate demand and cost-push shocks.

Figure 9 illustrates the values of the CB loss function resulting from these two exercises at the 30 quarters horizon.

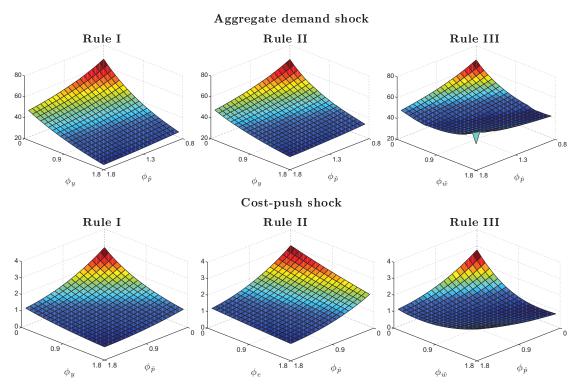


Figure 9: CB Loss for varying real and nominal target weights resulting at 30 quarters horizon.

There are several insights which should be highlighted: In the first place, these 3D graphs corroborate the well-known notion that a more aggressive monetary policy (represented by larger values of the target weights in the monetary policy rule) contributes significantly to macroeconomic stabilization. There is however a certain heterogeneity in the extent by which the economy is stabilized by a higher responsiveness to the different target weights. In the case of rule I, for example, as the slope of the area illustrated in the

first graph in Figure 9 shows, an increase in  $\phi_y$  leads to a stronger reduction in the CB loss function than an increase in  $\phi_{\hat{p}}$  in the case of an aggregate demand shock. This is not necessarily true for the cost-push shock case. Also worth to be highlighted is that while an increase in rule II's target weight  $\phi_e$  leads to a larger reduction in the CB loss than an increase in  $\phi_{\hat{p}}$  in the case of an aggregate demand shock, in the cost-push shock case such a loss reduction is more pronounced for larger values of  $\phi_{\hat{p}}$ . Furthermore, concerning rule III, it is worth noting that in both aggregate demand and cost-push cases the effect of higher values of  $\phi_{\hat{w}}$  and  $\phi_{\hat{p}}$  on the CB loss is not monotonically negative. Indeed, for certain threshold values, higher values of  $\phi_{\hat{w}}$  and  $\phi_{\hat{p}}$  do not reduce, but rather increase the CB losses. This is due to the resulting higher volatility of the output gap under rule III, which is exacerbated by larger values of  $\phi_{\hat{w}}$  and  $\phi_{\hat{p}}$ .

Finally, let us analyze the performance of some of the monetary policy rules just discussed for different values of the labor market parameters.

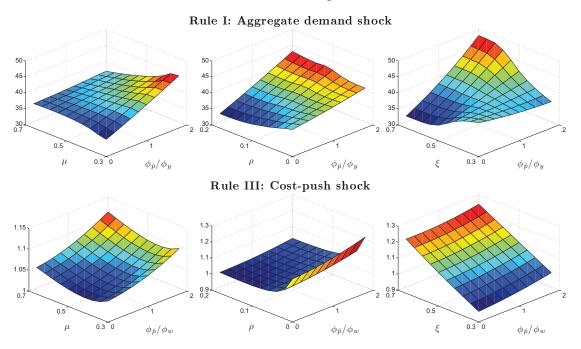


Figure 10: CB Loss for varying target weights and labor market parameters at 30 quarters horizon.

Figure 10 shows again the CB losses at 30 quarters horizon, this time however for different values of the parameters  $\mu$ ,  $\rho$  and  $\xi$ , and for different values of the target weight

 $\phi_{\hat{p}}$  in the best performing rules – rule I in the aggregate demand shock scenario and rule III in the cost-push case – with  $\phi_y = 2 - \phi_{\hat{p}}$  in the first case and  $\phi_{\hat{w}} = 2 - \phi_{\hat{p}}$  in the second case. In Figure 10, thus, while the same total reaction of the monetary authorities to aggregate demand and cost-push shocks is assumed, <sup>15</sup> with  $\phi_y + \phi_{\hat{p}} = 2$  and  $\phi_{\hat{w}} + \phi_{\hat{p}} = 2$ , respectively, the relative weight of the price (wage) inflation and the output gap in the monetary policy rules I and III varies: For low values of  $\phi_{\hat{p}}/\phi_y$  ( $\phi_{\hat{p}}/\phi_{\hat{w}}$ ) the monetary authorities react more strongly to output gap (wage inflation) than to price inflation developments, and viceversa.

As it can be clearly observed in Figure 10, the relationship between the labor market parameters and the relative reaction of the monetary authorities to y ( $\hat{w}$ ) and  $\hat{p}$  given by the ratios  $\phi_{\hat{p}}/\phi_y$  and  $\phi_{\hat{p}}/\phi_{\hat{w}}$ , respectively, is highly nonlinear due to the fact that the loss function  $\mathcal{L}$  comprises the reaction of both output and inflation deviations from their respective target levels which, as we have seen, can significantly differ from each other in their extent and persistence. Nonetheless, Figure 10 delivers a variety of important insights. Concerning the aggregate demand shock case, this simulation exercise shows that a relatively larger value of  $\phi_y$  results in lower CB losses for all values of  $\mu$  and  $\mu$ , as well as for larger values of  $\mu$ . For low values of  $\mu$ , in contrast, a relatively larger value of  $\mu$  are from  $\mu$  and  $\mu$  as e.g. illustrated in Figure 8. Furthermore, while the relative gains of a larger  $\mu$  seem to be larger for large values of  $\mu$ , for  $\mu$ , in contrast, they diminish along with larger values of this parameter. In the case of an aggregate demand shock there is thus a higher substitutability between  $\mu$  and  $\mu$  when there is a higher matching efficiency, as well as when separation rate is low.

Concerning the cost-push shocks, on the other hand, it is more difficult to deliver a straightforward interpretation of the relationship between the labor market parameters and  $\phi_{\hat{p}}/\phi_{\hat{w}}$  due to the much more complex interplay between the wage- and price inflation rate determination specified in this paper. Indeed, in a on a first sight counterintuitive manner, this simulation exercise suggests that a relatively larger  $\phi_{\hat{w}}$  enhances rule III's performance in terms of CB losses. Additionally, in contrast to the effects of larger  $\mu$  and  $\rho$  in the aggregate demand shock scenario, in this case larger values of  $\mu$  and  $\xi$  are related – in a nonlinear manner – with larger CB losses by and large irrespectively of the specific values of  $\phi_{\hat{p}}/\phi_{\hat{w}}$ , what, at least respecting  $\xi$ , can be explained by the looser link between the economic activity and the employment (and thus, to a certain extent, wage inflation) for larger values of  $\xi$ .

<sup>&</sup>lt;sup>15</sup>Note that in her evaluation of different monetary policy rules, Faia (2008) implicitly assumes different total reaction of the monetary policies, making an appropriate comparison difficult to achieve.

#### 6 Concluding Remarks

In this paper the (Disequilibrium) Keynes-Goodwin model discussed in Chen et al. (2006) and Franke, Flaschel and Proaño (2006) was extended and enhanced by the incorporation of a labor market module containing basic search and matching elements along the lines of Mortensen and Pissarides (1994) and Pissarides (2000).

The particular specification not only of the employment rate dynamics but also of the general theoretical approach pursued in this paper was not only supported by empirical data, but it could be shown by means of numerical simulations that it can be a useful framework for the analysis of the macroeconomic effects of different types of labor market frictions.

Concerning the role of monetary policy in such a framework, the discussed dynamic simulations allowed us not only to evaluate the performance of alternative monetary policy rules for given labor market parameters, but they also delivered interesting insights on the relationship between different degrees of labor market rigidities (in different senses) and the performance of alternative monetary policy rules to aggregate demand and cost-push shocks.

On more real-world related grounds, if one takes into account the significant differences in the characteristics of the labor markets for example across the countries of the European Monetary Union, the findings of this paper might deliver some interesting insights on the recent developments of output, employment, inflation and income distribution in those countries.

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