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Welfare-Theoretic Criterion and Labour Market Search*

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Abstract

This paper extends the utility-based welfare criterion developed by Woodford (2003) to a model with labour market search. We show how the central banker's concern for inflation stabilization depends on the average steady-state durations of unemployment and job vacancy.

Keywords: Welfare, labour market search, sticky price, second-order approximation techniques

JEL Classifications: D60, E24, E52

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1 Introduction

The consequences of labour market rigidities on employment, output and inflation constitute an issue of importance for both economists and policymakers. This is the reason why several recent papers have considered search and matching in a microfounded monetary policy model and showed that introducing these features improves the empirical performance of the standard sticky-price model in several directions (Moyen and Sahuc, 2005a, Trigari, 2004, Walsh, 2005). First, the existence of unemployed in equilibrium allows to reproduce the labour market stylized facts characterized by the Beveridge and Phillips curves. Second, labour market frictions act as a necessary complement to nominal rigidities. Third, monetary policy shocks can explain important features of labour market fluctuations.

To date, however, no work has been done to study the implications of a frictional labour market for the optimal monetary policy in a New Neoclassical Synthesis framework.[1] Despite the development of increasingly sophisticated microfounded models, optimal monetary policy analysis remains based on *ad hoc* criterions. Loss functions are often assumed to depend on the variance of some key macroeconomic variables most often output and inflation with no obvious link to household utility.

In this paper, we derive a utility-based welfare criterion in a simple sticky-price model with labour market search. The loss function is then derived directly from the representative household's utility function. This allowed policy to be evaluated with the same degree of rigor that was being used to model the economy. We are then able to consider how labour market frictions influence the criterion.

2 A simple sticky-price model with labour market search

The set-up is a model with nominal price rigidities and search, and matching in the labour market. The details can be found in Moyen and Sahuc (2005a). The main purpose of this section, therefore, is to give the notation for the particular specification we assume.

[1] A notable exception is Cooley and Quadrini (2004) who study optimal monetary policy in a model that integrates the theory of unemployment with a liquidity model of monetary transmission. However, their analysis ignores nominal rigidities.

2.1 Preferences

There is a continuum of households uniformly distributed on the unit interval. In equilibrium, some members will be unemployed while some others will be working for firms. The presence of equilibrium unemployment introduces heterogeneity in the model: each individual's labour income differs based on his employment status. In this case, the individuals' saving decision would become dependent on their entire employment history. To the purpose of this paper, we avoid these distributional issues by assuming that individuals may insure one another against risk of being unemployed such that a representative household have preferences defined over a composite consumption good (C_t), the employment's rate (N_t) and hours worked (H_t) and derive utility according to the following utility function:

$$\mathbb{E}_0 \sum_{j=0}^{\infty} \beta^j \left[\frac{C_t^{1-\sigma}}{1-\sigma} - N_t \frac{H_t^{1+\varphi}}{1+\varphi} \right] \tag{1}$$

where $\beta \in (0,1)$ is the intertemporal discount factor, σ is the inverse of the intertemporal elasticity of substitution, and φ denotes the labour-supply elasticity. The composite consumption basket C_t is a Dixit-Stiglitz aggregate of a multiplicity of differentiated goods indexed by $z \in [0,1]$,

$$C_t = \left[\int_0^1 C_t(z)^{\frac{\theta-1}{\theta}} \, \mathrm{d}z \right]^{\frac{\theta}{\theta-1}} \tag{2}$$

where θ, which is assumed to be greater than one, is the elasticity of substitution across the differentiated retail goods.

The household's demand for a good z is thus given by:

$$C_t(z) = \left(\frac{P_t(z)}{P_t} \right)^{-\theta} C_t \tag{3}$$

where,

$$P_t = \left[\int_0^1 P_t(z)^{1-\theta} \, \mathrm{d}z \right]^{\frac{1}{1-\theta}} \tag{4}$$

is the aggregate price index.

2.2 The production technology

The wholesale sector. We consider a representative wholesaler which acts on a perfect competition market and makes hiring decisions. Each period, this firm uses labour (total hours, $N_t H_t$) as input in order to produce a homogeneous wholesale good ($Y_{w,t}$). The production technology is given by

$$Y_{w,t} = A_t N_t H_t \tag{5}$$

where A_t is an exogenous stationary stochastic productivity shock.

The retail sector. There is a continuum of monopolistic competitive retailers indexed by z on the unit interval. Retailers do nothing other than buy wholesale goods, differentiate them with a technology that transforms one unit of wholesale goods into one unit of retail goods, then re-sell them to the households.

Given that vacancy posting costs (ςV_t) are expressed in terms of differentiated goods and that wholesalers demand for each retail goods is given by (3), the demand curve facing each retailer is:

$$Y_t(z) = \left(\frac{P_t(z)}{P_t}\right)^{-\theta} (C_t + \varsigma V_t) \tag{6}$$

In addition, we follow Calvo in assuming that in any given period each retailer can reset its price with a fixed probability $1-\alpha$ that is independent of the time elapsed since the last price adjustment. This assumption implies that prices are fixed on average for $\frac{1}{1-\alpha}$ periods.

Finally, the economy wide resource constraint is given by:

$$Y_t = C_t + \varsigma V_t = \frac{Y_{w,t}}{D_t} \tag{7}$$

where $D_t = \int_0^1 \left(\frac{P_t(z)}{P_t}\right)^{-\theta} \mathrm{d}z$ is the price dispersion expression.

2.3 Labour market matching

Wholesalers meet workers on a matching market and cannot hire them instantaneously. Rather, workers must be hired from the unemployment pool through a costly and time-consuming job creation process.

At the macroeconomic level, the law of motion of aggregate employment (N_t) is

$$N_{t+1} = (1-s)N_t + M_t \tag{8}$$

where $s \in [0,1]$ is a given exogenous job separation rate, constant over time, that ensures that a proportion s of all filled jobs disappears at each instant, and M_t is the mass of recruitings at period t.

The matching function is a very convenient hypothetical concept whose basic idea is that the recruiting effort of employers (the number of vacancies, V_t) and the number of searching workers ($U_t = 1 - N_t$) serve as inputs in a market matching function that generates new hires. The aggregate flow of job matches are deterministic and thus given by the following matching technology:

$$M_t = \tilde{m} U_t^{\varepsilon} V_t^{1-\varepsilon} \tag{9}$$

where $\varepsilon \in (0, 1)$ and $\tilde{m} > 0$ is a scale parameter.

The probabilities of a vacancy being filled (τ_t) and a worker's job-finding rate (ϱ_t) are defined by

$$\tau_t = \frac{M_t}{V_t} \quad \text{and} \quad \varrho_t = \frac{M_t}{U_t} \tag{10}$$

Finally, wage and hours worked are determined by the generalized *Nash*-bargaining solution. Indeed, the matching between an unemployed person and a firm who coordinate each other gives rise to a surplus which must be shared between the meeting pair. This sharing takes place at the match level through a bilateral and decentralized wage/hours negociation.

3 The utility-based welfare criterion

We construct the second-order approximation to the overall utility function (equation 1) by deriving a second-order approximation to the within-period utility function,

$$\mathbb{W}_t = \mathbb{U}(C_t) - \mathbb{V}(N_t, H_t) \tag{11}$$

with $\mathbb{U}(C_t) = \dfrac{C_t^{1-\sigma}}{1-\sigma}$ and $\mathbb{V}(N_t, H_t) = N_t \dfrac{H_t^{1+\varphi}}{1+\varphi}$.

Since within-period utility is additively separable between consumption, $\mathbb{U}(C_t)$, and employment and hours, $\mathbb{V}(N_t, H_t)$, we can consider the second-order approximations to each term in (11) separately. The second-order approximation of $\mathbb{U}(C_t)$ is given by:

$$\mathbb{U}(C_t) = \bar{\mathbb{U}}_{\bar{C}} \bar{C} \left[\hat{c}_t + \frac{1-\sigma}{2} \hat{c}_t^2 \right] + \mathcal{O}\left(\|\zeta\|^3 \right) \tag{12}$$

where $\bar{X}$ is the steady-state value of the variable X_t, $\hat{x}_t = \ln X_t - \ln \bar{X}$ and $\mathcal{O}\left(\|\zeta\|^3 \right)$ denotes the order of residual and $\|\zeta\|$ is a bound on the amplitude of exogenous disturbances.

Likewise, the second-order approximation of $\mathbb{V}(N_t, H_t)$ is given by:

$$\begin{aligned}\mathbb{V}(N_t, H_t) &= \bar{\mathbb{V}}_{\bar{H}}\bar{H}\left[\hat{y}_t - \hat{a}_t - \frac{\varphi}{1+\varphi}\hat{n}_t + \frac{\varphi^2}{2(1+\varphi)}\hat{n}_t^2 + \frac{1+\varphi}{2}\hat{y}_t^2\right. \\ &\left. -(1+\varphi)\hat{y}_t\hat{a}_t - \varphi\hat{y}_t\hat{n}_t + \varphi\hat{n}_t\hat{a}_t + \frac{\theta\alpha}{2(1-\alpha)(1-\beta\alpha)}\hat{\pi}_t^2\right] \\ &+\mathcal{O}\left(\|\zeta\|^3\right). \qquad (13)\end{aligned}$$

We then take the present discounted sum of equations (12) and (13), subtract the second expression to the first one, and finally take expectations of the overall utility to obtain the welfare expression:[2]

$$\begin{aligned}\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\mathbb{W}_t &= -\frac{\bar{\mathbb{U}}_{\bar{C}}\bar{C}}{2}\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\left\{\frac{\theta\alpha}{(1-\alpha)(1-\beta\alpha)}\frac{\bar{Y}}{\bar{C}\bar{N}}\hat{\pi}_t^2\right. \\ &+\left[(1-\sigma)\left(1-\bar{N}\right)+\left(\varphi+\sigma\frac{\bar{Y}}{\bar{C}}\right)\right]\frac{\bar{Y}}{\bar{C}\bar{N}}\left(\hat{y}_t-\delta_y\hat{y}_t^n-y^*\right)^2 \\ &+\frac{\varphi(\sigma+\varphi-1)}{1+\varphi}\frac{\bar{Y}}{\bar{C}\bar{N}}\left(\hat{n}_t-\delta_n\hat{n}_t^n-n^*\right)^2 \\ &+(1-\sigma)\varsigma\frac{\bar{V}}{\bar{C}}\left(\hat{v}_t-v^*\right)^2+\frac{\varphi\bar{Y}}{\bar{C}\bar{N}}\left[\left(\hat{y}_t-\hat{n}_t\right)^2-\left(\hat{y}_t-\hat{n}_t^n\right)^2\right] \\ &-\frac{(1-\sigma)\varsigma\bar{V}\bar{Y}}{\bar{C}^2}\left(\hat{y}_t-\hat{v}_t\right)^2-\frac{\sigma\varsigma\bar{Y}\bar{V}}{\bar{C}^2\bar{N}}\left(\hat{y}_t-\hat{v}_t^n\right)^2 \\ &-\varphi\left(\frac{\varphi+\sigma\frac{\bar{Y}}{\bar{C}}}{1+\varphi}\right)\frac{\bar{Y}}{\bar{C}\bar{N}}\left(\hat{n}_t-\hat{y}_t^n\right)^2 \\ &\left.+\frac{\varphi\sigma\varsigma}{1+\varphi}\frac{\bar{Y}\bar{V}}{\bar{C}^2\bar{N}}\left(\hat{n}_t-\hat{v}_t^n\right)^2\right\}+t.i.p.+\mathcal{O}\left(\|\zeta\|^3\right), \qquad (14)\end{aligned}$$

with

$$\begin{aligned}\delta_y &= \frac{\left(\varphi+\sigma\frac{\bar{Y}}{\bar{C}}\right)}{\left[(1-\sigma)\left(1-\bar{N}\right)+\left(\varphi+\sigma\frac{\bar{Y}}{\bar{C}}\right)\right]}, \\ y^* &= -\frac{\left(1-\Phi_y-\bar{N}\right)}{\left[(1-\sigma)\left(1-\bar{N}\right)+\left(\varphi+\sigma\frac{\bar{Y}}{\bar{C}}\right)\right]}, \\ \delta_n &= \frac{\varphi}{(\sigma+\varphi-1)},\ n^*=\frac{1}{(\sigma+\varphi-1)},\ \text{and } v^*=\frac{1}{(\sigma-1)}.\end{aligned}$$

[2]Notice that, in using equations (8) and (9), it is also possible to express vacancies ($\hat{v}_t$) in function of current employment ($\hat{n}_t$) and next period's employment ($\hat{n}_{t+1}$). But we prefer to keep only current variables. Steps of calculation are detailed in a technical appendix, available upon demand.

Φ_y is a measure of inefficiency in the economy at steady state related to monopolistic competition and "*t.i.p.*" denotes terms independent of the actual policy. We also use the fact that the productivity shock may be expressed in terms of natural variables (defined as the level of variables that would prevail under fully flexible prices):

$$\hat{a}_t = \left(\frac{\varphi + \sigma\frac{\bar{Y}}{\bar{C}}}{1+\varphi}\right)\hat{y}_t^n - \frac{\varphi}{1+\varphi}\hat{n}_t^n - \left(\frac{\sigma\varsigma}{1+\varphi}\frac{\bar{V}}{\bar{C}}\right)\hat{v}_t^n. \tag{15}$$

Notice that when the labour market is Walrasian, (14) reduces to the well-known form:

$$\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\mathbb{W}_t = -\frac{\bar{\mathbb{U}}_{\bar{C}}\bar{C}}{2}\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\left\{(y_t - \hat{y}_t^n - y^*)^2 + \frac{\theta\alpha}{(1-\alpha)(1-\beta\alpha)}\hat{\pi}_t^2\right\} + t.i.p. + \mathcal{O}\left(\|\zeta\|^3\right).$$

4 Discussion

We now seek to understand the role of labour market frictions on the expression of the social welfare. For that, after normalizing by $\Omega = \frac{\theta\alpha}{(1-\alpha)(1-\beta\alpha)}\frac{\bar{C}\bar{N}}{\bar{Y}}$ and replacing $\bar{N}$ by $\bar{\varrho}/(\bar{\varrho}+s)$ and $\bar{V}$ by $s\bar{\varrho}/[\bar{\tau}(\bar{\varrho}+s)]$, one remarks that (14) can be written in a compact way:

$$\begin{aligned}\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\mathbb{W}_t = & -\Omega\frac{\bar{\mathbb{U}}_{\bar{C}}\bar{C}}{2}\mathbb{E}_0\sum_{t=0}^{\infty}\beta^t\Big\{\hat{\pi}_t^2 + \lambda_{yy^*}\left(\hat{y}_t - \delta_y\hat{y}_t^n - y^*\right)^2 \\ & +\lambda_{nn^*}\left(\hat{n}_t - \delta_n\hat{n}_t^n - n^*\right)^2 + \lambda_{vv^*}\left(\hat{v}_t - v^*\right)^2 + \lambda_{yv}\left(\hat{y}_t - \hat{v}_t\right)^2 \\ & +\lambda_{yn}\left[\left(\hat{y}_t - \hat{n}_t\right)^2 - \left(\hat{y}_t - \hat{n}_t^n\right)^2\right] + \lambda_{yv^n}\left(\hat{y}_t - \hat{v}_t^n\right)^2 \\ & +\lambda_{ny^n}\left(\hat{n}_t - \hat{y}_t^n\right)^2 + \lambda_{nv^n}\left(\hat{n}_t - \hat{v}_t^n\right)^2\Big\} + t.i.p. + \mathcal{O}\left(\|\zeta\|^3\right),\end{aligned} \tag{16}$$

where

$\lambda_{yy^*} = \left[\frac{(1-\sigma)s}{\bar{\varrho}+s} + \left(\varphi + \sigma + \frac{\sigma\varsigma\bar{\varrho}s}{\bar{\tau}(\bar{\varrho}+s)\bar{C}}\right)\right]\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$;

$\lambda_{nn^*} = \frac{\varphi(\sigma+\varphi-1)}{1+\varphi}\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$; $\lambda_{vv^*} = \frac{(1-\sigma)\varsigma s\bar{\varrho}^2}{\bar{\tau}(\bar{\varrho}+s)^2\bar{Y}}\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$;

$\lambda_{yn} = \varphi\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$; $\lambda_{yv} = -\frac{(1-\sigma)\varsigma s\bar{\varrho}^2}{\bar{\tau}(\bar{\varrho}+s)^2\bar{C}}\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$; $\lambda_{yv^n} = -\frac{\sigma\varsigma\bar{\varrho}s}{\bar{\tau}(\bar{\varrho}+s)\bar{C}}\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$;

$\lambda_{ny^n} = -\varphi\left(\frac{\varphi+\sigma+\frac{\sigma\varsigma s\bar{\varrho}}{\bar{\tau}(\bar{\varrho}+s)\bar{C}}}{1+\varphi}\right)\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$; $\lambda_{nv^n} = \frac{\varphi\sigma\varsigma s\bar{\varrho}}{(1+\varphi)\bar{\tau}(\bar{\varrho}+s)\bar{C}}\frac{(1-\alpha)(1-\beta\alpha)}{\theta\alpha}$.

The introduction of labour market search completely alters the structure of the welfare function. First, in addition to the standard variables (inflation and pseudo output-gap), the welfare now includes the employment, vacancies and their respective flexible-price counterparts. Second, the weights are function of the steady-state values of each variable, apart from λ_{nn^*} and λ_{yn} that are independent of conditions on the labour market.[3]

To assess the qualitative effects of search frictions (summarized by $\bar{\varrho}$ and $\bar{\tau}$) on the welfare criterion, we first look at the first-derivatives of the relative weights with respect to the two steady-state probabilities.[4] As revealed in Table 1, these two probabilities imply an opposite variation of the weights. Indeed, the absolute value of the relative weights always decrease in the steady-state value of the probability that an unemployed worker finds a vacant position. By contrast, they always increase in the steady-state value of the probability of a vacancy being filled.

Second, with the help of a standard numerical example (Table 2), we may examine quantitatively the sensitivity of the relative weights to the steady-state probabilities ($0.25 \leq \bar{\varrho} < 1$ and $0.25 \leq \bar{\tau} < 1$). As displayed in Figure 1, the central banker's incentive to stabilize inflation crucially depends on the degree of labour market rigidities: λ_{yy^*} (mainly driven by $\bar{\varrho}$) can be larger or weaker whereas the other weights (mainly driven by $\bar{\tau}$) are always larger.

Finally, Table 3 reports the values of the weights, obtained from our set of parameters and for three values of the degree of price stickiness ($\alpha = 0.6, 0.75, 0.9$). As it is standard with a pricing specification *à la* Calvo, all the relative weights are at least 100 time weaker than those on inflation, such that inflation stabilization is clearly the main objective of the central bank. However, the less price stickiness the higher the relative size of the weights of the different terms.

These results also indicates that it will be wrong to consider the same loss function when comparing models with and without labour market rigidities or ranking alternative monetary policy rules. The policy objectives pursued by the central bank crucially depend on the properties of the labour market.

5 Conclusion

This paper extends the utility-based welfare criterion developed by Woodford (2003) to a model with labour market frictions. By deriving an explicit analytical solution, it is possible to compare the welfare expression that results in this model to the one that is obtained in

[3] Unfortunately, it is difficult to place an intuitive interpretation on most of the terms in the welfare expression.

[4] Notice that $1/\bar{\varrho}$ (resp. $1/\bar{\tau}$) can be interpreted as the average steady-state duration of unemployment (resp. of a job vacancy).

a model without labour market frictions. We show that the central banker has an incentive to stabilize inflation that depends on the average steady-state durations of unemployment and job vacancy. In work in progress (Moyen and Sahuc, 2005b) we take up the task of identifying optimal rules in the context of a larger model of the U.S. business cycle.

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Table 1. Variation of the relative weights as a function of $\bar{\varrho}$ and $\bar{\tau}$

	$\lvert\lambda_{yy^*}\rvert$	$\lvert\lambda_{nn^*}\rvert$	$\lvert\lambda_{vv^*}\rvert$	$\lvert\lambda_{yn}\rvert$	$\lvert\lambda_{yv}\rvert$	$\lvert\lambda_{yv^n}\rvert$	$\lvert\lambda_{ny^n}\rvert$	$\lvert\lambda_{nv^n}\rvert$
$\nearrow \bar{\varrho}$	$\nearrow$	-	$\nearrow$	-	$\nearrow$	$\nearrow$	$\nearrow$	$\nearrow$
$\nearrow \bar{\tau}$	$\searrow$	-	$\searrow$	-	$\searrow$	$\searrow$	$\searrow$	$\searrow$

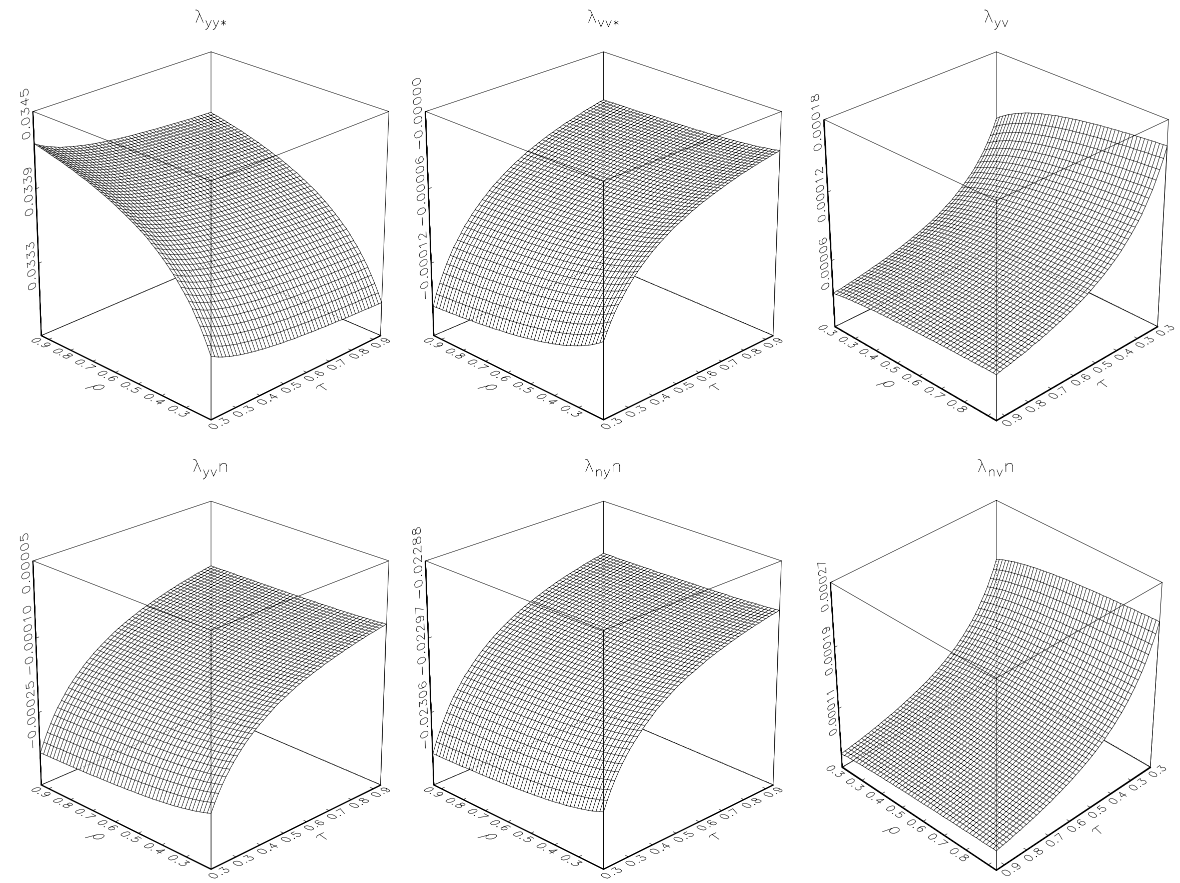
Table 2. Calibration

Description	Parameter	Quarterly Value
Preferences		
Discount factor	β	0.99
Intertemporal elasticity of substitution	σ	2
Labour-supply elasticity	φ	2
Technology		
Price elasticity of demand	θ	10
Probability of not resetting price	α	0.75
Labour market		
Separation rate	s	0.05
Elasticity in the matching function	ε	0.5
Steady-state values		
Average duration of unemployment (quarters)	$1/\bar{\varrho}$	2
Average duration of a job vacancy (quarters)	$1/\bar{\tau}$	2
Vacancies costs–output ratio	$\varsigma\bar{V}/\bar{Y}$	0.01
Consumption–output ratio	$\bar{C}/\bar{Y}$	0.99

Table 3. Values of the relative weights as a function of α

α	λ_{yy^*}	λ_{nn^*}	λ_{vv^*}	λ_{yn}	λ_{yv}	λ_{yv^n}	λ_{ny^n}	λ_{nv^n}
0.60	0.1063	0.0541	-0.0002	0.0541	0.0002	-0.0005	-0.0725	0.0003
0.75	*0.0337*	0.0172	-7e-5	*0.0172*	*0.0001*	*-0.0002*	*-0.0230*	*0.0001*
0.90	0.0047	0.0024	-2e-5	0.0024	2e-5	-2e-5	-0.0032	2e-5

Figure 1. Effects of labour market frictions on the relative weights



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