Labour market frictions in a small open economy model of the Czech Republic

Daniel Němec[1]

Abstract. This contribution examines the impacts of introducing search and matching frictions in an open economy DSGE framework of the Czech economy. Model estimates should help to understand the driving forces behind important labour market variables: the wage bargaining power of unions, the match elasticity of unemployed, the efficiency of the matching process, separation rate and the flexibility of wages. Search and matching aspect provides satisfactory description of employment flows in the Czech economy. Moreover, the model of the open economy fits the business cycle features of the main economic variables better than the closed model.

Keywords: search and matching model, Bayesian estimation, DSGE model, small open economy.

JEL classification: C51, E24, J60
AMS classification: 91B40, 91B51

1 Introduction

The goal of my contribution is to reveal structural properties of the Czech labour market in the last twelve years and the main sources of unemployment dynamics. This contribution follows my previous research (see Němec [8]) in this area based on closed economy model and examines and compares the impacts of introducing search and matching frictions in an open economy DSGE framework of the Czech economy. For this purpose, I use a small open economy model with search and matching frictions incorporated into standard macroeconomic dynamic stochastic general equilibrium model (DSGE). This model is originally developed and estimated by Jakab and Kónya [7]. There are only few models in the literature which incorporate features to explicitly analyse labour market dynamics and search and matching frictions. In particular, Albertini et al. [1] investigate labour market dynamics in New Zealand economy by estimating a structural small open economy model enriched with standard search and matching frictions. A similar model augmented with different wage setting frameworks and frictions is estimated on Hungarian data by Jakab and Kónya [7]. Search and matching model is an important tool to model labour market dynamics. Model estimates should help to understand the driving forces behind important labour market variables: the wage bargaining power of unions, the match elasticity of unemployed, the efficiency of the matching process, separation rate and the flexibility of wages. One of the main questions of my contribution is how flexible is the Czech labour market. There is not an unique measure of the labour market flexibility but one can focus on some key features which might be connected with a flexible labour market. The labour market in the Czech Republic was influenced by the opening of markets which started in 1990. As Flek and Večerník [3] pointed out, the market reforms, trade and price liberalisation and the establishment of standard labour market institutions (aiming on improvement of labour mobility and flexibility) produced an inevitability of rising unemployment. Unlike other transition countries the rise of unemployment was delayed and unemployment rate hitted 10-years peak in 2004. Flek and Večerník [3] argues that the labour market alone was not fully responsible for this poor performance. Some obstacles (to better macroeconomic performance and job creation) were linked with a relatively weak supply-side flexibility of the Czech economy. These authors conclude that the Czech labour market loses its flexibility due to high reservation wage and due to the obstacles connected with the necessary layoffs. This conclusion is confirmed by Gottvald [4]. On the other hand, he pointed out that the diminishing flexibility in 90s was accompanied by the high probability of changing job (without an episode of unemployment). He

[1]Masaryk University, Faculty of Economics and Administration, Department od Economics, Lipová 41a, 602 00 Brno, Czech Republic, nemecd@econ.muni.cz

observed decreasing flows of workers among industries (i.e. low labour mobility). I am convinced that some of these issues may be confronted with the results of presented contribution.

2 Model

Small open economy DSGE model presented and estimated in this contribution is developed by Jakab and Kónya [7]. The model includes a non-Walrasian labour market with matching frictions and hiring costs. The model has two final good sectors, producing domestically sold and exported differentiated goods from a homogenous good. This homogenous good is produced using labour, capital, and imported intermediates. Search and matching frictions are incorporated only in this wholesales sector. Price rigidities are influencing only the final good producers. The wage bargaining and price setting decisions are thus separated. Imports are used as intermediate goods only. The model, its log-linearised form and steady-states equations are described in more detail in the original paper of Jakab and Kónya [7]. In this contribution, I will present only the main model concept and features which are necessary to understand the meaning and interpretations of model parameters. Moreover, some differences between the original paper and my specifications are emphasized.

The representative household maximizes intertemporal utility

$$\max_{c_t, i_t, b_t} E_0 \sum_{t=0}^{\infty} \beta^t \mathrm{e}^{\epsilon_t^c} \left[\frac{(c_t - hc_{t-1})^{1-\nu}}{1-\nu} - \chi_t n_t \right], \tag{1}$$

where c_t is consumption, n_t is employment rate, i_t is investment, b_t is bonds held by household expressed in local currency, χ_t is disutility from work (stochastic factor with expected value $\overline{\chi}$), ν is intertemporal elasticity of substitution and h represents habit persistence. Households constraints are:

$$c_t + i_t + \frac{b_t}{p_t R_t} = \frac{b_{t-1}}{p_t} + (1-u_t)w_t + u_t b_u + r_t^k K_{t-1} + d_t, \tag{2}$$

$$K_t = (1-\delta)K_{t-1} + \left[1 - \Phi\left(\frac{\mathrm{e}^{\epsilon_t^I} i_t}{i_{t-1}} \right) \right] i_t, \tag{3}$$

where u_t is unemployment rate, p_t is the consumer price index, w_t is the real wage rate, r_t^k is the (real) rental rate on capiral, K_t is the capital stock, d_t is lump sum net income from other sources. he investment adjustment cost $\Phi(\cdot)$ is increasing and convex with $\Phi(1) = \Phi'(1) = 0$ and $\Phi''(1) > 0$. Unemployment benefits b_u are financed by lump-sum taxes included in d_t. The wholesale sector produces a homogeneous product, using capital, imported intermediates and labour. The model assumes that each firm employs one worker. The Cobb-Douglas production function may be thus rewritten in a per-worker form:

$$y_t = \mathrm{e}^{a_t} k_t^{\alpha} y_{m,t}^{\alpha_z(1-\alpha)}, \tag{4}$$

where a_t is an exogenous shock, k_t is capital per-worker, $y_{m,t}$ is imported intermediates per-worker, α is the share of capital and α_z is the share of imported inputs intermediates. Demand for inputs is determined by the relative price of wholesale goods, $p_{w,t}$ and (exogenous) foreign currency price of the intermediate input, $p_{m,t}$. The labour market is subject to search and matching frictions. Each job may be destroyed with (exogenous) job destruction probability, ρ_t. Search frictions are captured by a standard Cobb-Douglas matching function:

$$m_t = \sigma_m \mathrm{e}^{\epsilon_{mf,t}} v_t^{\sigma} u_t^{1-\sigma}, \tag{5}$$

where m_t is the number of new matches, v_t is the number of open vacancies, u_t is the number of unemployed. Parameter $0 < \sigma < 1$ is a match elasticity of the unemployed and $\sigma_m \epsilon_{mf,t}$ is stochastic process measuring the efficiency of the matching process. Evolution of employment, n_t is given by

$$n_t = (1-\rho_t)n_{t-1} + m_t. \tag{6}$$

The model assumes that new matches are productive immediately, but the workers who loose their jobs have to wait one period before searching for a new job (Němec [8] assumes that it takes one period for new matches to be productive). Aggregate probability of filling a vacancy (job filling rate) may be defined as $q_t = m_t/v_t$, job finding rate $s_t = m_t/u_t$ and job market tightness is defined as $\theta_t = v_t/u_t$.

Wage setting processes are different for the wages of new hires and wages in existing jobs. Nominal wages w_t in existing jobs are bargained with a probability of $1-\gamma_w$, otherwise the wage remains at last period's wage. For new hires, the nominal wage is bargained with probability $(1-\nu_w)$. Unemployed workers receive unemployment benefit b_u which is important for determination of the wages. Negotiated wages w^* are set as a solution of the Nash bargaining problem, where parameter η represents bargaining power of the workers. The trajectory of the average wage is given by evolution of the newly set wages and by those wages which cannot be set optimally:

$$w_t = \frac{m_t}{n_t}\left[\nu_w w_{t-1} + (1-\nu_w)w_t^*\right] + \frac{(1-\rho_t)n_{t-1}}{n_t}\left[\gamma_w w_{t-1} + (1-\gamma_w)w_t^*\right]. \tag{7}$$

Job creation is fully derived in Jakob and Kónya [7]. The final good sector operates under the condition of an infinite number of monopolistically competing firms buying wholesale good (and differentiating it). Final goods, $y_t(i)$ are aggregated using the following (CES) utility function (index):

$$y_t = \left[\int_0^1 y_t(i)^{\frac{1}{1+\mu_t}} di\right]^{1+\mu_t}, \tag{8}$$

where μ_t is the time-varying markup parameter. The firms can reoptimize prices with probability $1-\gamma$. Remaining firms are able to increase their prices by indexation (parameter ν_p). Resulting Phillips curve is expressed by the means of perceived inflation. In this model, agents apply a real-time adaptive algorithm to identify the underlying inflation rate (learning algorithm is applied only to the domestic sector):

$$\hat{\pi}_t^p = \rho_\pi \hat{\pi}_{t-1}^p + gl(\hat{\pi}_t - \hat{\pi}_{t-1}^p) + \epsilon_{gl,t}, \tag{9}$$

where $\hat{\pi}_t$ is the observed inflation rate, $\hat{\pi}_t^p$ is the perceived inflation rate (expressed in log deviation from the steady state) and parameter gl influences the speed of learning. Jakab and Kónya [7] show that the price Phillips curve takes the same form as in a model without learning. In their specification, the inflation variable is the difference between the true and perceived inflation:

$$d\hat{\pi}_t = \hat{\pi}_t - \hat{\pi}_t^p. \tag{10}$$

Learning shock is an enhancement of the original model which allows a better identification of the model parameters. Moreover, due this enhancement, both the learning parameter and the autoregressive parameter are estimated consistently within the model identification procedure. The wholesale sector is composed into $n_{d,t}$ firms (and workers) producing domestically sold goods. These are used for consumption, investment and exogenous and unproductive government consumption (an AR(1) process):

$$n_{d,t} y_t = c_t + i_t + g_t. \tag{11}$$

Monetary policy is represented by a simple Taylor rule:

$$\hat{r}_t = \xi_r \hat{r}_{t-1} + (1-\xi_r)(\xi_\pi E_t \hat{\pi}_{t+1} + \xi_e \hat{e}_t) + \epsilon_t^m, \tag{12}$$

where monetary authority sets the interest rate (log deviation from the steady state) $\hat{r}_t$ as a reaction to the expected inflation gap, $E_t\hat{\pi}_{t+1}$, and the exchange rate gap, $\hat{e}_t$. The model describes a small open economy. In this case, a modified UIP (uncovered interest rate parity) holds, where the interest rate on home currency denominated foreign bonds is given by the constant world interest rate plus an endogenous risk premium:

$$\frac{e_t R_t}{E_t e_{t+1}} = \left[\frac{1}{\beta} + \psi(\mathrm{e}^{-(B_t-\overline{B})-1)}\right]\mathrm{e}^{\epsilon_{uip,t}}, \tag{13}$$

where ψ is debt elasticity of financial risk premium (a function of the net foreign asset position B_t). Export demand equation in log-linearized form is $\hat{n}_{x,t}+\hat{y}_t = -\theta_x \hat{p}_{x,t} + \mathrm{e}^{\epsilon_{x,t}}$, where ˆ denotes the appropriate deviations fro steady states. Proportion of workers employed in the export sector is $n_{x,t} = n_t - n_{d,t}$, export price is $p_{x,t}$, θ_x determines the price elasticity of exports and $\epsilon_{x,t}$ is export demand shock. For further details see Jakab and Kónya [7]. All equations are log-linearized around the fixed steady state.

3 Estimation results and model evaluation

The data set for the Czech Republic used for estimation is from the first quarter 1996 to the fourth quarter 2011. The data comes from the OECD database. The observed variables are nominal short-term

Description	Parameter	Value	Source
Discount factor	β	0.99	Jakab and Kónya [7]
Steady-state share of capital	α	0.33	Herber and Němec [5]
Steady-state share of imported inputs	α_z	0.51	Herber and Němec [5]
Depreciation rate	δ	0.025	Herber and Němec [5]
Investments adjustment cost	$\Phi''(1)$	5	Herber and Němec [5]
Debt elasticity of financial risk premium	ψ	0.001	Jakab and Kónya [7]
AR parameter of government spending shock	ρ_g	0.6525	estimated outside the model
AR parameter of import price shock	ρ_{p_m}	0.8678	estimated outside the model
Average (steady state) mark-up in final goods	$\overline{\mu}$	0.20	Jakab and Kónya [7]
Average (steady-state) job finding rate	$\overline{s}$	0.0806	Hobijn and Sahin [6]
Average (steady-state) unemployment rate	$\overline{u}$	0.077	estimated outside the model
Average (steady-state) separation rate	$\overline{\rho}$	0.0067	$\overline{s} * \overline{u}/(1-\overline{u})$

Table 1 Calibrated parameter values and description

interest rate, real investments (intensive form – i.f.), real consumption (i.f.), real exports, real imports (i.f.), real government spending (i.f.), nominal wages, employment (based on unemployment level and rate), CPI inflation rate, import and export prices denominated in foreign currency, and the exchange rate.[1] All variables are expressed in logarithms and filtered using Hodrick-Prescott filter with the standard smoothing parameter ($\lambda = 1600$) for quarterly data. Parameters are estimated using Bayesian techniques. All computations have been performed using Dynare toolbox for Matlab (Adjemian et al. [2]). Table 1 reports calibrated model parameters. Table 2 describes prior densities of estimated parameter. The priors (and calibrations) are similar to those used by Jakab and Kónya [7] with regards to the patterns of the Czech economy (see Herber and Němec [5] and Němec [8]). The standard deviations are rather uninformative. The log-linearized model contains 37 equations, 11 AR(1) shocks and two uncorrelated shocks ($\hat{\mu}_t$, $\hat{\chi}_t$).

Table 3 presents[2] the posterior estimates of parameters and 90% highest posterior density intervals. It may be seen (in comparison with the Table 2) that most of the parameters are moved considerably from their prior means. The data seems to be strongly informative. The results for the open economy model are not too much different from those from the closed economy model (see Němec [8]). But, there are some interesting results which should be emphasized. The first surprising estimate is the bargaining power of workers, η. The mean value of this parameter is almost 0.4 with a 90% HPDI that is shifted away from the prior density. This implies that the firms can gain a lot of their entire surplus. The firms may be thus willing to create vacancies. Lower bargaining power of the workers is typical for the flexible labour markets which bring the wage dynamics to the line with productivity growth. The opposite results by Němec [8] are not confirmed. In the open economy framework, the separation rate parameter (its deviation from the calibrated steady-state value) is modelled as time-varying parameter. Smoothed trajectory of this variable provides a significant evidence of variability. Its steady-state value supports the view of less flexible Czech labour market with limited ability to destroy old and new matches. Low flexibility is meant to be associated with the restricted flows of the workers among industries. On the other hand, periods of the economic slowdown starting at the end of 2008 show that the separation rate is considerably higher – twice as big as the steady-state value. The estimate of parameter bu corresponds to a reasonable value of 0.30 for the Czech economy which is in accordance with the real unemployment benefits paid within the Czech social insurance system (similar estimate to the closed economy model). The posterior mean of the matching function parameter, σ, is in accordance with the common values in literature (see Němec [8] for further references). The trajectories of selected smoothed variables and shock innovations show (like the results for a closed economy model) a relative sharp decline in the

[1] Intensive form means that the variables are divided by the level of employment. Nominal wages (instead of the real wages) are used in the log-linearized version of the model. I used the following data sets: private final consumption, investments, government final consumption expenditure, exports and imports of goods and services (millions of national currency, chained volume, national reference year 2005, quarterly levels, s.a.); consumer price index (all items, 2005=100, s.a.); export and import price index (2000=100, s.a.); index of hourly earnings (manufacturing, 2005=100, s.a.); registered unemployment level and rate (s.a.); short-term interest rates (per cent per annum); exchange rate (USD/CZK).

[2] Due to the maximal allowed range of the contribution, all the figures (data, smoothed variables and shock, IRFs and shock decompositions) are a part of the corresponding conference presentation and may be obtained upon a request.

development of variable q_t (probability of filling a vacancy) at the end of the year 2006. This evidence is in favour of theories which stressed the role of an obvious lack of employees in the Czech economy. This tendency was reverted as a result of the last global economic slowdown starting at the end of 2008. This downturn influenced a fall of the matching rates below their steady-state values. The starting recession has re-established the equilibrium on the labour market which may be documented by the trajectory of labour market tightness. The improvement of labour market institutions may be associated with the development of efficiency shock. No remarkable tendencies may be found on the Czech labour markets.

Description	Parameter	Density	Mean	Std. Dev.
Intertemporal elasticity in consumption	ν	Normal	1.50	0.40
Habit persistence	h	Beta	0.60	0.15
Indexation – final good price	ν_p	Beta	0.50	0.15
Indexation – export price	ν_x	Beta	0.50	0.15
Calvo parameter – final good sector	γ	Beta	0.50	0.15
Calvo parameter – exporters	γ_x	Beta	0.50	0.15
Calvo parameter – old wages	γ_w	Beta	0.50	0.15
Calvo parameter – new wages	ν_w	Beta	0.50	0.15
Bargaining power of the workers	η	Beta	0.50	0.15
Unemployment benefits	b_u	Beta	0.50	0.15
Steady state of disutility of labour	$\overline{\chi}$	Beta	0.20	0.05
Elasticity of matching	σ	Beta	0.70	0.20
Price elasticity of exports	θ_x	Beta	0.50	0.15
Taylor rule – exchange rate	ξ_e	Beta	0.30	0.10
Taylor rule – interest rate smoothing	ξ_r	Beta	0.50	0.15
Taylor rule – inflation	ξ_π	Normal	1.50	0.15
Adaptive learning parameter	gl	Beta	0.30	0.10
AR coefficients of shocks	$\rho_{\{a,mf,uip,x,I,m,\pi,\rho,c\}}$	Beta	0.50	0.15
Std. dev. of AR(1) shocks	$\sigma_{\epsilon_{\{c,I,a,mf,m,x,uip,\rho,gl\}}}$	Inv. Gamma	0.01	∞
Std. dev. of uncorrelated shocks	$\sigma_{\epsilon_{\{\chi,\mu\}}}$	Inv. Gamma	0.001	∞
Std. dev. of gov. consumption shock	$\sigma_{\{\epsilon_g\}}$	Inv. Gamma	0.03	0.01
Std. dev. of import prices shock	$\sigma_{\{\epsilon_{pm}\}}$	Inv. Gamma	0.02	0.01

Table 2 Prior densities and description of estimated parameters

4 Conclusion

Unlike the results of Němec [8] or Albertini et al. [1], historical shock decomposition reveals the fact that the variation in unemployment and vacancies is not solely due to shocks to the labour market. There is a strong connection between the labour market and the rest of the economy. My estimates of Calvo parameters for old wages and new wages are $\gamma_w = 0.44$ and $\nu_w = 0.2$ respectively. Average duration of wage contracts are thus 1.8 quarters for the old hires and 1.25 quarters for the new matches. From this point of view, the wages are flexible. Adaptive learning mechanism and its parameters provide us with an evidence about a plausible montery policy in the Czech economy (the accomodation parameter gl is relatively low). The reaction function of the Czech National Bank is based on the parameters $\xi_r = 0.1$, $\xi_\pi = 1.4$ and $\xi_e = 0.41$. The smoothing parameter ξ_r is extremely low (comparing with the results by Herber and Němec [8]) and, on the other hand, exchange rate parameter ξ_e is unusually higher. There might be two explanations. Firstly, incorporating labour market features provides a new insight into the Taylor rule of the Czech economy. Secondly, omitting output gap from the Taylor rule may lead exactly to this kind of bias. Search and matching aspects provides satisfactory description of employment flows in the Czech economy. Historical shock decomposition may show that the model of the open economy fits the business cycle features of the main economic variables better than the closed model. Foreign demand plays a significant role in the development of the Czech economy and direct effects of labour market shocks on the economy and labour market are more obvious due to rich structure of the model.

	Posterior mean	90% HPDI			Posterior mean	90% HPDI	
ν	1.6752	1.4386	1.9717	h	0.9171	0.8547	0.9533
ν_p	0.2899	0.1938	0.4088	γ	0.6702	0.5769	0.7597
ν_x	0.3639	0.1762	0.5659	γ_x	0.5307	0.4805	0.5662
ν_w	0.1998	0.0964	0.2908	γ_w	0.4388	0.3918	0.4837
η	0.3967	0.3171	0.4607	bu	0.2965	0.2915	0.3015
$\overline{\chi}$	0.1347	0.0506	0.2205	σ	0.6384	0.5326	0.7618
θ_x	0.4492	0.3475	0.5468	gl	0.0925	0.0606	0.1245
ξ_r	0.0995	0.0435	0.1535	ξ_π	1.3944	1.3516	1.4230
ξ_e	0.4135	0.3923	0.4343	ρ_ρ	0.3366	0.2561	0.4141
ρ_c	0.4182	0.3593	0.4848	ρ_I	0.2460	0.1713	0.3174
ρ_a	0.3331	0.2717	0.3911	ρ_{mf}	0.5760	0.5401	0.6148
ρ_m	0.0718	0.0283	0.1149	ρ_x	0.7405	0.6825	0.8218
ρ_{uip}	0.1509	0.0938	0.2022	ρ_π	0.5710	0.4880	0.6508
σ_{ϵ_c}	0.4064	0.2396	0.5326	σ_{ϵ_I}	0.0711	0.0118	0.0157
σ_{ϵ_a}	0.0138	0.0118	0.0157	$\sigma_{\epsilon_{mf}}$	0.1279	0.0693	0.1810
σ_{ϵ_m}	0.2021	0.1709	0.3211	σ_{ϵ_x}	0.0497	0.0423	0.0567
$\sigma_{\epsilon_{uip}}$	0.2222	0.1824	0.2603	σ_{ϵ_g}	0.0302	0.0260	0.0351
$\sigma_{\epsilon_{pm}}$	0.0204	0.0177	0.0226	σ_{ϵ_ρ}	0.5723	0.4790	0.6584
σ_χ	0.0024	0.0002	0.0028	σ_μ	0.0811	0.0684	0.0930
$\sigma_{\epsilon_{gl}}$	0.0145	0.0050	0.0239				

Table 3 Parameter estimates

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