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Investigating Differences Between the Czech and Slovak Labour Market Using a Small DSGE Model with Search and Matching Frictions

Daniel Němec*

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Abstract This contribution reveals some structural properties of the Czech and Slovak labour markets. A search and matching model incorporated into a small standard DSGE model is estimated using Bayesian techniques. Two sources of rigidities are implemented: wage bargaining mechanism and "search and matching" process matching workers and firms. The results show that the search and matching aspect provides satisfactory description of employment flows in both economies, and that the institutional characteristics do not differ too much in both economies. The model estimates provide interesting evidence that wage bargaining process is determined mainly by the power of firms. These results support the view of flexible wage environment in both economies. On the other hand, firms are confronted by increasing vacancy posting costs that limit vacancies creation. Relative low separation rate provides evidence of reduced mobility of the workers.

Keywords Search and matching model, closed DSGE model, Bayesian estimation, labour market flexibility
JEL classification C51, E24, J60

1. Introduction

Employment and unemployment dynamics are the most important factors of economic activity. Labour market and its structural properties are the key determinants of the business cycles fluctuations. The goal of this contribution is to reveal possible structural differences of the Czech and Slovak labour markets in the last twelve years. Using real macroeconomic data of these economies, it is possible to estimate some key labour market indicators: wage bargaining power of unions, match elasticity of the unemployed, and the efficiency of the matching process. All these indicators are crucial for evaluation of institutional properties of the labour market which influence directly the ability of an economy to accommodate exogenous shocks. And besides, these institutional characteristics determine the effectiveness of the fiscal and monetary policy and the discussion of labour market reforms.

For this purpose, I use a small model with search and matching mechanisms incorporated into standard macroeconomic dynamic stochastic general equilibrium model

* Masaryk University, Faculty of Economics and Administration, Department of Economics, Lipová 41a, 602 00 Brno, Czech Republic. Phone: +420 549 49 6260, Email: nemecd@econ.muni.cz.

(DSGE). Search and matching model is an important tool to model labour market dynamics. This model is a log-linear version of the model originally developed by Lubik (2009). A similar model approach with staggered wages is used by Neugebauer and Wesselbaum (2010).

The search and matching model is an attractive framework for analysis employment and unemployment dynamics and trends. It is based on the fact that both the flows of unemployed agents and the flows of unfilled job vacancies created by firms are able to meet an equilibrium relationship. This equilibrium is based on a matching function which could be seen simply as a standard production function with two inputs: the unemployed and the vacancies. New matches are an outcome of this matching process. As a result, new matches enter the production sectors of the economy. The labour market is not a traditional frictionless Walrasian market for many reasons. First, finding a new job or a worker is uncoordinated, and not all unemployed are able to find a vacancy, and vice versa. Second, filling a vacancy is a time-consuming and costly process for both firms and workers. The wage is mostly an outcome of wage bargaining process where firms or workers may possess some degree of market power. The labour market does not clear and the economy is characterised by coexistence of unemployed workers and unfilled job vacancies. Moreover, the labour market might be characterised by some wage rigidities which are modelled similarly to the price rigidities in a the standard New Keynesian models. But this property is not an integral part of search and matching framework.

One of the main questions of this paper is how flexible the Czech and Slovak labour markets are. There is no unique measure of the labour market flexibility but one can focus on some key features which might be connected with a flexible labour market. In case of the Slovak labour market, Gertler (2010) studies the relationship between the local unemployment rate and wage level using a panel data approach. He has confirmed that wages in Slovakia are relatively flexible, which is an important part of labour market flexibility concept. However, this overall wage flexibility was only poorly influenced by the institutional arrangements of the Slovak labour market. Wage rigidities in Slovakia are precisely studied by Gertler and Senaj (2010). Using sectoral and company level data, the authors revealed relatively small extent of nominal and real rigidities. This flexibility was helpful in the euro adoption in 2009. Moreover, the degree of wage flexibility is in the interest of all central banks operating in a regime of inflation targeting due to fact that it influences effectiveness of monetary transmission mechanism.

Similarly to the Slovak labour market, the labour market in the Czech Republic was influenced by the opening of markets which started in 1990. As Flek and Večerník (2005) 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 including Slovakia, the rise of unemployment was delayed and unemployment rate hit its ten-year peak in 2004 (see Figure A2 in the Appendix). Flek and Večerník (2005) argue 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 as a whole. These authors conclude that the Czech labour market loses its flexibility due to high reservation wage and due to obstacles connected with the necessary layoffs. This conclusion is confirmed by Gottwald (2005), who, on the other hand, pointed out that the diminishing flexibility in the 1990s was accompanied by a high probability of changing job without any episode of unemployment. He observed decreasing flows of workers among industries, i.e. low labour sectoral mobility. Other aspects of the Czech labour market are analysed by Mareš and Sirovátka (2005) who emphasized the role of long-term unemployment. This is a problem the Slovak labour market faces as well. Wage flexibility on regional level was discussed by Galuščák and Münich (2005).

As for the other labour market institutions, Behar (2009) studied the role of labour market institutions on the labour market performance in the new member countries of the European Union. Applying principal component analysis on the key macro variables of the Central and Eastern European (CEE) countries, he found out that tax wedges and duration of benefits were important factors of the poor labour market outcomes. Moreover, he concluded that labour market policies and institutions in the CEE countries are generally more flexible than those in the rest of Europe.

I am convinced that some of these issues may be confronted with the results of the presented DSGE model. The wage flexibility will be evaluated on the basis of the estimated bargaining power of the workers. The estimated match elasticity of unemployed and the efficiency of the matching process might be helpful to discuss the extent of labour market mobility. Some other important institutional properties will be connected with the estimated unemployment benefits, separation rate and the costs of creating the new job position. All these estimates may help to reveal strong and weak points of the Czech and Slovak labour markets.

2. Model

As mentioned previously, I shall use the model developed by Lubik (2009). It is a simple search and matching model incorporated within a standard DSGE framework. The labour market is subject to friction due to a time-consuming search process for workers and firms. The wages are determined by the outcome of a bargaining process which serves as a mechanism to redistribute the costs of finding a partner.

2.1 Households

A representative household maximizes its expected utility function

$$E_t \sum_{j=t}^{\infty} \beta^{j-t} \left[\frac{C_j^{1-\sigma} - 1}{1-\sigma} - \chi_j n_j \right], \tag{1}$$

where C_j is aggregate consumption, $n_j \in [0,1]$ is a fraction of employed household members, $\beta \in (0,1)$ is the discount factor and $\sigma \geq 0$ is the coefficient of relative risk aversion. Households consist of employed or unemployed persons who are seeking employment. Employment is fully determined by the matching process. It is assumed that the labour force is normalised to one. The fraction of employed household members is equivalent to the employment rate in the economy due the fact that we deal with the representative household. Variable χ_j represents an exogenous stochastic process which may be taken as a labour shock. The budget constraint is defined as

$$C_t + T_t = w_t n_t + (1 - n_t)b + \Pi_t, \tag{2}$$

where b is unemployment benefit financed by a lump-sum tax, T_t. Variable Π_t are profits from ownership of the firms, and w_t is wage. There is no explicit labour supply because it is an outcome of the matching process. The first-order condition is thus simply

$$C_t^{-\sigma} = \lambda_t, \tag{3}$$

where λ_t is the Lagrange multiplier on the budget constraint.

2.2 Labour market

The labour market is characterized by search frictions captured by a standard Cobb-Douglas matching function

$$m(u_t, v_t) = \mu_t u_t^{\xi} v_t^{1-\xi}, \tag{4}$$

where unemployed job seekers, u_t, and vacancies, v_t, are matched at rate defined by $m(u_t, v_t)$. Parameter $0 < \xi < 1$ is a match elasticity of the unemployed, and μ_t is stochastic process measuring the efficiency of the matching process. Aggregate probability of filling a vacancy may be defined as

$$q(\theta_t) = m(u_t, v_t)/v_t, \tag{5}$$

where $\theta_t = v_t/u_t$ is a standard indicator of the labour market tightness. The model assumes that it takes one period for new matches to be productive. Moreover, old and new matches are destroyed at a constant separation rate, $0 < \rho < 1$, which corresponds to the inflows into unemployment. As mentioned above, the labour force is normalised to one. Evolution of employment or equivalently employment rate, $n_t = 1 - u_t$, is given by

$$n_t = (1 - \rho)\left[n_{t-1} + v_{t-1} q(\theta_{t-1})\right]. \tag{6}$$

2.3 Firms

For simplicity, and as a deviation from the standard search and matching framework, the model assumes monopolistic behaviour of the firm in each sub-market. Demand function of a firm is defined by

$$y_t = \left(\frac{p_t}{P_t}\right)^{-1-\omega} Y_t, \tag{7}$$

where y_t is the firm's production (and its demand), Y_t is aggregate output, p_t is price set by the firm, P_t is aggregate price index and ω is demand elasticity which will be not treated as a stochastic process in my empirical application. Production function of each firm is

$$y_t = A_t n_t^{\alpha}, \tag{8}$$

where A_t is an aggregate technology (stochastic) process and $0 < \alpha \leq 1$ introduces curvature in production. Capital is fixed and firm-specific. It is not necessary to use different notation for the desired number of workers, n_t. The number of workers is equivalent to the fraction of employed household members or aggregate employment rate. Alternatively, it could be assumed that each firm is able to hire one worker. The total number of productive firms will thus be equivalent to the employed household members, or employment rate.

The firm controls the number of workers, n_t, number of posted vacancies, v_t, and its optimal price, p_t, by maximizing the inter-temporal profit function

$$E_t \sum_{j=1}^{\infty} \beta^{j-t} \lambda_j \left[p_j \left(\frac{p_j}{P_j} \right)^{-(1+\omega)} Y_j - w_j n_j - \frac{\kappa}{\psi} v_j^{\psi} \right], \tag{9}$$

subject to the employment accumulation equation (7) and production function (8). Profits are evaluated in terms of marginal utility λ_j. The costs of vacancy posting is $(\kappa/\psi) \cdot v_t^{\psi}$, where $\kappa > 0$ and $\psi > 0$. For $0 < \psi < 1$, posting costs exhibit decreasing returns. For $\psi > 1$, the costs are increasing while vacancy costs are fixed for $\psi = 1$. The first-order conditions are

$$\tau_t = \alpha \frac{y_t}{n_t} \frac{\omega}{1+\omega} - w_t + (1-\rho) E_t \beta_{t+1} \tau_{t+1}, \tag{10}$$

$$\kappa v_t^{\psi-1} = (1-\rho) q(\theta_t) E_t \beta_{t+1} \tau_{t+1}, \tag{11}$$

where $\beta_{t+1} = \beta \cdot (\lambda_{t+1}/\lambda_t)$ is a stochastic discount factor and τ_t is the Lagrange multiplier associated with employment constraint. The first condition represents current-period marginal value of a job. The second condition is a link between the cost of vacancy and the expected benefit of a vacancy in terms of the marginal value of a worker (adjusted by the job creation rate, $q(\theta_t)$).

2.4 Wage bargaining

Wages are determined as the outcome of a bilateral bargaining process between workers and firms. Both sides of the bargaining maximize the joint surplus from employment relationship:

$$S_t \equiv \left(\frac{1}{\lambda_t} \frac{\partial \mathcal{W}_t(n_t)}{\partial n_t} \right)^{\eta} \left(\frac{\partial \mathcal{J}_t(n_t)}{\partial n_t} \right)^{1-\eta}, \tag{12}$$

where $\eta \in [0,1]$ is the bargaining power of workers, $\frac{\partial \mathcal{W}_t(n_t)}{\partial n_t}$ is the marginal value of a worker to the household's welfare and $\frac{\partial \mathcal{J}_t(n_t)}{\partial n_t}$ is the marginal value of a worker to the firm. The term $\frac{\partial \mathcal{J}_t(n_t)}{\partial n_t} = \tau_t$ is given by the first-order condition (10). Recursive representation for $\frac{\partial \mathcal{W}_t(n_t)}{\partial n_t}$ is derived as

$$\frac{\partial \mathcal{W}_t(n_t)}{\partial n_t} = \lambda_t w_t - \lambda_t b - \chi_t + \beta E_t \frac{\partial \mathcal{W}_{t+1}(n_{t+1})}{\partial n_{t+1}} \frac{\partial n_{t+1}}{\partial n_t}. \tag{13}$$

Using employment equation (6), it holds $\frac{\partial n_{t+1}}{\partial n_t} = (1-\rho)[1-\theta_t q(\theta_t)]$. All real payments are valued at the marginal utility λ_t. Standard optimality condition for wages may be derived as

$$(1-\eta)\frac{1}{\lambda_t}\frac{\partial \mathcal{W}_t(n_t)}{\partial n_t} = \eta \frac{\partial \mathcal{J}_t(n_t)}{\partial n_t}. \tag{14}$$

After straightforward adjustments are carried out, the expression for the wage bargained is given as

$$w_t = \eta \left[\alpha \frac{y_t}{n_t}\frac{\omega}{1+\omega} + \kappa v_t^{\psi-1}\theta_t\right] + (1-\eta)\left[b + \chi_t C_t^{\sigma}\right]. \tag{15}$$

2.5 Closing the model

The model assumes that unemployment benefits, b, are financed by lump-sum taxes, T_t, where a condition of balanced budget holds, i.e. $T_t = (1-n_t)b$. Social resource constraint is thus $C_t + (\kappa/\psi)\cdot v_t^{\psi} = Y_t$. The technology shock A_t, the labour shock χ_t and the matching shock μ_t are assumed to be independent $AR(1)$ processes (in logs) with coefficients ρ_i, $i \in (A, \xi, \mu)$ and autoregression residuals $\varepsilon_t^i \sim N(0, \sigma_i^2)$.

2.6 Log-linear model

For estimation purposes, I did not use the non-linear form of the model mentioned in the previous subsections. Of course, the non-linear form is important for us in order to understand the meaning of the key structural model parameters. Instead of that, I use a log-linear version of the model which is not a part of the original contribution of Lubik (2009). Using log-linear approximations of the non-linear model has many advantages (for detailed discussion see DeJong and Dave 2007). Using log-linear approximation allows to solve the model parameters and to estimate the model parameters using standard tools and techniques developed for linear systems. This approximation is helpful in understanding the behaviour of the corresponding non-linear model. Solving and estimating non-linear models with rational expectations is a difficult and challenging task. Of course, linear approximation may lead to inaccurate results if the economic system is far away from its steady-state. Log-linearisation includes the transformation of the variables into a form where deviations from the steady-state are given in logarithmic terms, i.e. percentage deviations of the original variables expressed in a level form.

In the following equations, the line over a variable means its steady-state value. Steady-state values are derived simply from the non-linear equations. Initial steady-state values are calibrated regarding the observed data for the Czech economy as follows: $\mu^* = A^* = \chi^* = 1$, $\beta^* = 0.99$, $u^* = 0.0763$, $v^* = 0.0127$. Initial steady-state values are calibrated for the Slovak economy in a similar way as follows: $\mu^* = A^* = \chi^* = 1$, $\beta^* = 0.99$, $u^* = 0.1357$, $v^* = 0.0054$. Remaining steady-states are computed using these values and the prior means of all parameters. The variables with a tilde represent the gaps from their steady-states. It should be mentioned, that the gaps are computed as log-differences, e.g. $\tilde{u} = \log u - \log u^*$.

$$\tilde{\lambda}_t = -\sigma\tilde{C}_t \qquad \tilde{m}_t = \tilde{\mu}_t + \xi\tilde{u}_t + (1-\xi)\tilde{v}_t$$

$$\tilde{q}_t = \tilde{m}_t - \tilde{v}_t \qquad \tilde{\theta}_t = \tilde{v}_t - \tilde{u}_t$$

$$\tilde{n}_t = -\frac{\overline{u}}{1-\overline{u}}\tilde{u}_t \qquad \tilde{n}_t = \frac{1}{\overline{n}+\overline{vq}}\left[\overline{u}\tilde{n}_{t-1} + \overline{qv}(\tilde{v}_{t-1} + \tilde{q}_{t-1})\right]$$

$$\tilde{y}_t = (-1-\omega)(\tilde{p}_t - \tilde{P}_t) + \tilde{Y}_t \qquad \tilde{y}_t = \tilde{A}_t + \alpha\tilde{n}_t$$

$$\tilde{\tau}_t = \frac{1}{\alpha\frac{\overline{y}}{\overline{n}}\frac{\omega}{1+\omega}\overline{w} + (1-\rho)\overline{\beta}\overline{\tau}}\left[\alpha\frac{\omega}{1+\omega}(\tilde{y}_t - \tilde{n}_t) - \overline{w}\tilde{w}_t + (1-\rho)\overline{\tau}\overline{\beta}E_t\left(\tilde{\beta}_{t+1} + \tilde{\tau}_{t+1}\right)\right]$$

$$\tilde{w}_t = \frac{1}{\overline{w}}\left[\eta\left(\alpha\frac{\omega}{1+\omega}\frac{\overline{y}}{\overline{n}}(\tilde{y}_t - \tilde{n}_t) + \kappa\overline{v}^{\psi-1}\overline{\theta}\left((\psi-1)\tilde{v}_t + \tilde{\theta}_t\right)\right) + (1-\eta)\overline{\chi}\overline{C}^{\sigma}(\tilde{\chi}_t + \sigma\tilde{C}_t)\right]$$

$$\begin{aligned}(\psi-1)\tilde{v}_t &= \tilde{q}_t + E_t\left(\tilde{\beta}_{t+1} + \tilde{\tau}_{t+1}\right)\\ \tilde{\beta}_t &= \tilde{\lambda}_t + \tilde{\lambda}_{t-1}\\ \tilde{Y}_t &= \frac{1}{\overline{C} + \frac{\chi}{\psi}\overline{v}^{\psi}}\left(\overline{C}\tilde{C}_t + \kappa\overline{v}^{\psi}\tilde{v}_t\right)\end{aligned}$$

$$\tilde{A}_t = \rho_A\tilde{A}_{t-1} + \varepsilon_t^A \qquad \tilde{\chi}_t = \rho_\chi\tilde{\chi}_{t-1} + \varepsilon_t^\chi$$

$$\tilde{\mu}_t = \rho_\mu\tilde{\mu}_{t-1} + \varepsilon_t^\mu \qquad \tilde{Y}_t = \rho_Y\tilde{Y}_{t-1} + \varepsilon_t^Y$$

The last equation results from the fact that variable $\tilde{Y}$ is an observed variable. We have thus four shocks (ε_t^i for four observed variables – $\tilde{u}$, $\tilde{v}$, $\tilde{w}$ and $\tilde{Y}$). The model consists of 17 endogenous variables (variable $(\tilde{p}_t - \tilde{P}_t)$ is a single variable in my application), four shocks and 14 parameters.

3. Data and priors

The model for the Czech and the Slovak economy is estimated using the quarterly data set covering a sample from 1999Q1 to 2011Q2. The observed variables are real output (GDP, in logs), hourly earnings (in logs), unemployment rate and rate of unfilled job vacancies. All data are seasonally adjusted.

The original data come from databases of the OECD, the Czech Statistical Office (CZSO) and the Ministry of Labour, Social Affairs and Family of the Slovak Republic (SAFSR) and the Statistical Office of the Slovak Republic (SOSR). The source data and model data are presented in Figures A1–A4. I used the following data sets:

– GDP at purchaser prices, constant prices 2000, s.a., CZSO, millions of CZK;

- GDP at purchaser prices, constant prices 2000, s.a., SOSR, millions of EUR;
- Index of hourly earnings (manufacturing), 2005=100, s.a., OECD;
- Registered unemployment rate, s.a., OECD;
- Unfilled job vacancies, level (transformed to ratio of unfilled vacancies to labour force), s.a., OECD and SAFSR.

All the data are seasonally adjusted by the corresponding data providers using TRAMO/SEAT procedure.

Real output and hourly earnings are de-trended using Hodrick-Prescott filter with the smoothing parameter $\lambda = 1600$. The rate of unfilled job vacancies and unemployment rate was demeaned prior estimation. The variables used are expressed as corresponding gaps. It should be mentioned, that the unemployment gap and the gap of vacancies were computed as log differences. Both series and their means were thus expressed in logarithms before differencing. This approach is consistent with the log-linear equations (see Section 2.6). The estimation results are in some ways different from the ones presented by Němec (2011). He used simply the corresponding differences. The approach presented in this article is more appropriate and fully consistent with log-linear version of the model based on the Taylor series expansion of logarithmic function. I will not use the mark ˜ to explicitly express the appropriate gaps.

Table 1. Parameters' description

Description	Parameter
Discount factor	β
Labour elasticity	α
Demand elasticity	ω
Relative risk aversion	σ
Match elasticity	ξ
Separation rate	ρ
Bargaining power of the workers	η
Unemployment benefits	b
Elasticity of vacancy creation cost	ψ
Scaling factor on vacancy creation cost	κ
AR coefficients of shocks	$\rho_{\{\chi,A,\mu,Y\}}$
Standard deviation of shocks	$\sigma_{\{\chi,A,\mu,Y\}}$

Parameters are estimated using Bayesian techniques combined with Kalman filtering procedures. All computations have been performed using Dynare toolbox for Matlab (version 4.2.5) developed by Adjemian et al. (2011). Tables 1 and 2 report the model parameters and the corresponding prior densities. The priors and calibrated quantities are similar to those used by Lubik (2009), and may be found in the Table 2. On the other hand, the standard deviations are rather uninformative.

Table 2. Prior densities

Parameter	Density	Priors SVK		Priors CZE	
		Mean	Std. Dev.	Mean	Std. Dev.
β	fixed	0.99		0.99	
α	fixed	0.67		0.67	
ω	fixed	10.00		10.00	
σ	gamma	1.00	0.50	1.00	0.50
ξ	gamma	0.70	0.10	0.70	0.10
ρ	gamma	0.10	0.05	0.10	0.05
η	uniform	0.50	0.30	0.50	0.30
b	beta	0.20	0.15	0.20	0.15
ψ	gamma	1.00	0.50	1.00	0.50
κ	gamma	0.10	0.05	0.10	0.05
$\rho_{\{\chi,A,\mu,Y\}}$	beta	0.80	0.20	0.80	0.20
$\sigma_{\{\chi,A,\mu\}}$	inv. gamma	0.01	1.00	0.01	1.00
$\sigma_{\{Y\}}$	inv. gamma	0.05	1.00	0.05	1.00

4. Estimation results and model evaluation

Table 3 presents the posterior estimates of parameters and 90% highest posterior density intervals. In comparison to the Table 2 it may seem that most of the parameters are moved considerably from their prior means. The data seems to be strongly informative. Before discussing the policy implications of these results, it is necessary to check some important properties of the model. In order to see how the model fits the data, sample moments, autocorrelation coefficients and cross-correlations are computed. These statistics were computed from simulation of the estimated models with parameters set at their posterior means. All these statistics correspond to the four observed series: unemployment gap, u, gap of vacancies, v, gap of the wages, w, and output gap, Y. The results may be found in the Tables A1–A6.

The models for both economies are successful in matching all sample moments and autocorrelation coefficients. These moments are mostly within the appropriate 90% highest posterior density intervals. This ability is not typical for such a small-scale model. Similar results were obtained comparing the model statistics with the statistics resulting from an appropriate vector autoregressive model. Unlike the results of Němec (2011), there is no exception regarding the fit of the sample moments. The model using the data for unemployment gap and vacancies gap as log-differenced variables does not predict volatility in wages higher then observed.

My results are in accordance with the authors arguing that the model with search and matching frictions in the labour market is able to generate negative correlation between vacancies and unemployment (see Lubik and Krause (2007)). Unfortunately, the values of cross-correlation coefficients (see the lowest bounds of HPDI in the Table A3 and Table A6) are not sufficient for the correlations of wages and the rest of observable

Table 3. Parameter estimates

	SVK			CZE		
	Posterior mean	90% HPDI		Posterior mean	90% HPDI	
σ	0.2843	0.1319	0.4248	0.4517	0.2989	0.5648
ξ	0.8196	0.7645	0.8782	0.7758	0.7229	0.8316
ρ	0.0677	0.0185	0.1259	0.0705	0.0563	0.0843
η	0.0046	0.0000	0.0099	0.0022	0.0000	0.0050
b	0.1566	0.0001	0.2988	0.4557	0.4083	0.5052
ψ	2.2769	1.7870	2.7440	1.9257	1.8313	2.0563
κ	0.1245	0.0811	0.1759	0.0875	0.0524	0.1259
ρ_χ	0.2514	0.0616	0.4554	0.7347	0.6994	0.7641
ρ_A	0.9449	0.8785	1.0000	0.9851	0.9802	0.9914
ρ_μ	0.9563	0.9188	0.9998	0.8222	0.7211	0.8804
ρ_Y	0.8079	0.6948	0.9267	0.9184	0.8632	0.9806
σ_χ	0.0170	0.0141	0.0199	0.0085	0.0071	0.0099
σ_A	0.5063	0.1300	0.8161	0.3181	0.2429	0.3981
σ_μ	0.0640	0.0531	0.0743	0.0666	0.0551	0.0767
σ_Y	0.0168	0.0142	0.0194	0.0097	0.0082	0.0112

variables, especially in the case of the model for the Czech economy. The similar experience may be found in the results for U.S. labour market provided by Lubik (2009). Lubik pointed out that this may be due to presence of a matching shock which can act as a residual in employment and wage equations.

As for the impulse-response functions, the IRFs correspond to the standard economic theory, with the exception of the responses on technology shocks. These responses are too persistent. Both analysed economies show similar dynamics. The existing persistent response to the technology and output shocks might be in accordance with hysteresis hypothesis. Hysteresis of unemployment implies in its 'full hysteretic' form that the economic shocks have permanent effects on the equilibrium unemployment. Regarding the presented results, it means that the return to the equilibrium state of the economy takes a very long time. It is important to note that both technology and output shocks cannot be easily distinguished from each other in this simple model framework.

5. Discussion and concluding remarks

Let us take a detailed look on the concise interpretation of the estimation results. There are some remarkable results which should be emphasized.

The bargaining power of workers, η, is the first surprising estimate. The mean value of this parameter is almost 0 for both countries with a 90 percent coverage region that is shifted considerably away from the prior density. This implies that the firms can gain the most of their entire surplus. The firms are thus willing to create vacancies. This result is in accordance with the results of Lubik (2009) or Yashiv (2006), who aimed to model the U.S. labour market. Low bargaining power of workers is typical for flexible labour markets which bring the wage dynamics to the line with productivity growth.

The estimated separation rate, ρ, is the second interesting result. This parameter is considerably lower than the one estimated by Lubik (2009). Its value supports the view of the Czech and Slovak labour market markets being less flexible and having a limited ability to destroy old and new matches. In this case, low flexibility is meant to be indirectly associated with the restricted flows of the workers among industries. The model structure does not allow testing or estimating the sectoral mobility directly.

The vacancy posting elasticity, ψ, is the third remarkable estimate. The posterior means 2.3 for the Slovak labour market and 1.9 for the Czech labour market are shifted away from the prior mean. The vacancy creation is thus more costly because of increasing marginal posting costs, i.e. increasing in the level of vacancies or labour market tightness, θ. Lubik (2009) estimated this parameter at the mean value of 2.53. In this case, the high value of ψ may be interpreted as a balancing factor which restricts potentially excessive vacancy creation driven by the low bargaining power. In case of the analysed labour markets, this higher value provides an evidence of specifically less flexible labour markets.

The estimate of parameter b corresponds to the remarkably high value of 0.46 for the Czech economy which might be in accordance with the real unemployment benefits paid within the Czech social insurance system (40% of average wage). The lower value of 0.16 for the Slovak economy might support the view of lower reservation wage for this country.

The posterior mean of the matching function parameter, ξ, is in accordance with the common values in literature, see Lubik (2009) or Christoffel et al. (2009). We can see that an 1% increase in unemployment tends to rise the matching rate by 0.8%. At least, short-term unemployed seem to be willing to search for a new job. Applying the model on the data of short-term unemployment does not change the estimation results. It is true that Slovakia in particular suffers from a high rate of long-term unemployment. But, the model is estimated using the log-deviations from the steady-state which do not differ regardless of the unemployment rate specification.

Figures A5–A8 present the trajectories of selected (unobserved) smoothed variables. We can see a relatively sharp decline in the development of variable q (probability of filling a vacancy) at the end of the year 2006. This evidence is in favour of conclusion presented by Němec and Vašíček (2010) who stressed the role of an obvious lack of employees in the Czech economy. Their results are based on the reduced form model framework. Similar results may be found for the Slovak economy as well. This tendency was reverted as a result of the last global economic slowdown starting at the end of 2008. This downturn of both economies influenced a fall of the matching rates m below their steady-state values. On the other hand, we can see that the starting recession (grey area) has re-established the equilibrium on both labour markets (see the trajectories of employment rate and labour market tightness). The improvement of labour market institutions might be associated with the development of efficiency shock (μ). From this point of view, one can see that some remarkable changes on the

Czech and Slovak labour markets started at the end of 2004 and at the beginning of the 2006, respectively. Institutional reforms seem to be effective in these periods.

Unfortunately, because of simple but coherent structure of the model presented in this paper, there might be some drawbacks which should be mentioned, and which are connected to some suggestions for further research and for checking the robustness of current results. Some preliminary results confirm the robustness of the estimates associated with the labour market sector of the model. A robustness check based on estimating the model using the information provided by a variety of filters or by direct linking of the observable data to the DSGE model as proposed by Canova (2011) and Canova (2012) could be an interesting econometric exercise. Inclusion of price rigidities and monetary policy allows for analysing implications of wages and labour market shocks on inflation process (see Thomas (2008)). Another important extension could consist of incorporating new sources of wage rigidities as proposed by Krause and Lubik and Krause (2007), Neugebauer and Wesselbaum (2010), Riggi and Massimiliano (2010), or Christoffel et al. (2009). This model feature might be used to compare the relevance of other particular sources of labour market frictions. Incorporating labour market rigidities into an open economy will be an important step because foreign demand should play a significant role in the development of both economies. The direct effects of labour market shocks on the economy dynamics will become more obvious. The observed problematic might be further extended for the other CEE countries, especially V4 countries due the fact that these labour markets have similar history.

Regardless of the suggestions mentioned above, the estimated model provides a satisfactory description of employment flows in both economies, and is able to replicate observed data and some of its basic properties. Surprisingly, the structural properties of both labour markets do not differ too much from each other, and are similar to the properties of the U.S. labour market. This evidence is in accordance with the conclusions of Behar (2009). As for the labour markets flexibility, my results support the view of a flexible wage environment in both economies, which is in accordance with the studies discussed in the introductory section herein. On the other hand, the firms are confronted by the increasing vacancy posting costs that limit vacancies creation. Moreover, the lower separation rate might provide us with the evidence of a reduced ability of the workers to change jobs and a reduced willingness of the firms to layoffs. As a result, one can observe lower geographical and sectoral mobility in the economy. Knowledge of the degree of labour market flexibility is important not only for considering the intended extents of future labour market reforms and for the evaluation of the reforms up to now, but also for the precise setting of monetary policy. Even low-friction labour market might considerably influence the effectiveness of the monetary policy operating under the inflation targeting regime.

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Appendix: Figures and Tables

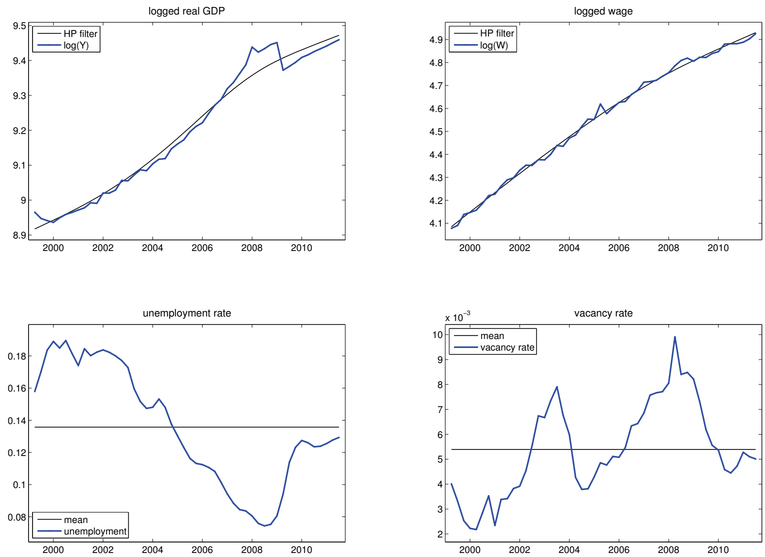

Figure A1. Slovak source data

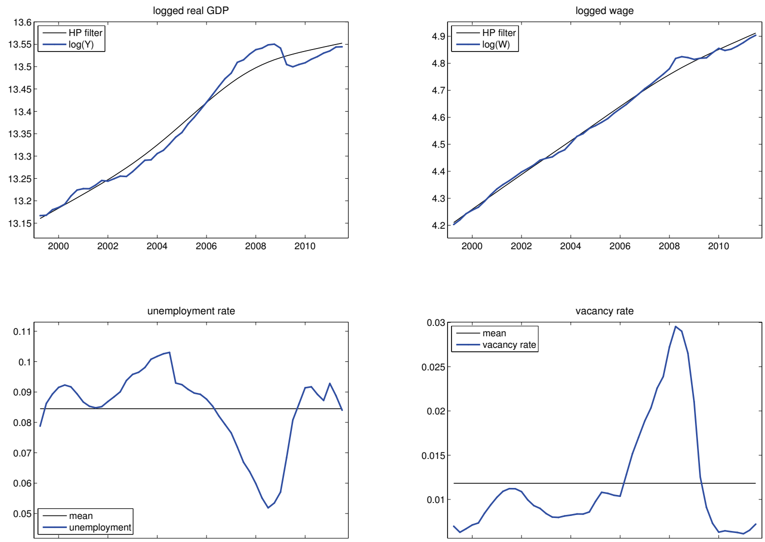

Figure A2. Czech source data

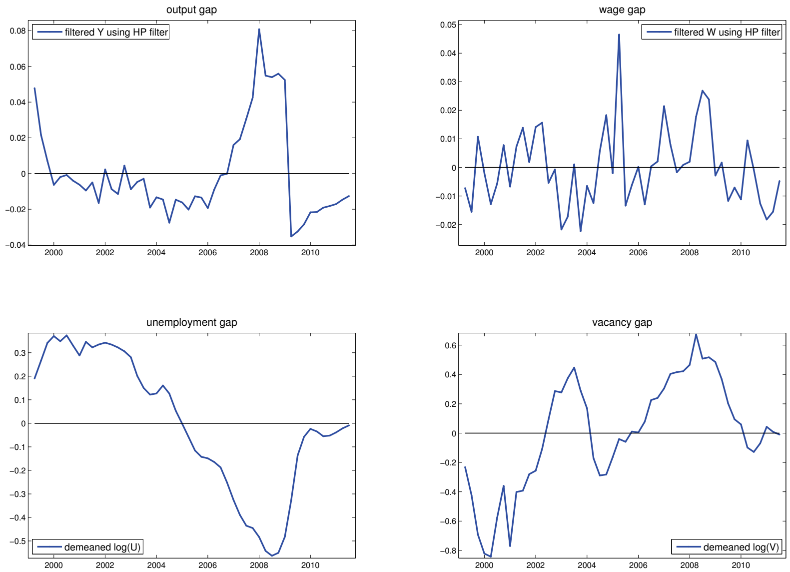

Figure A3. Slovak model data

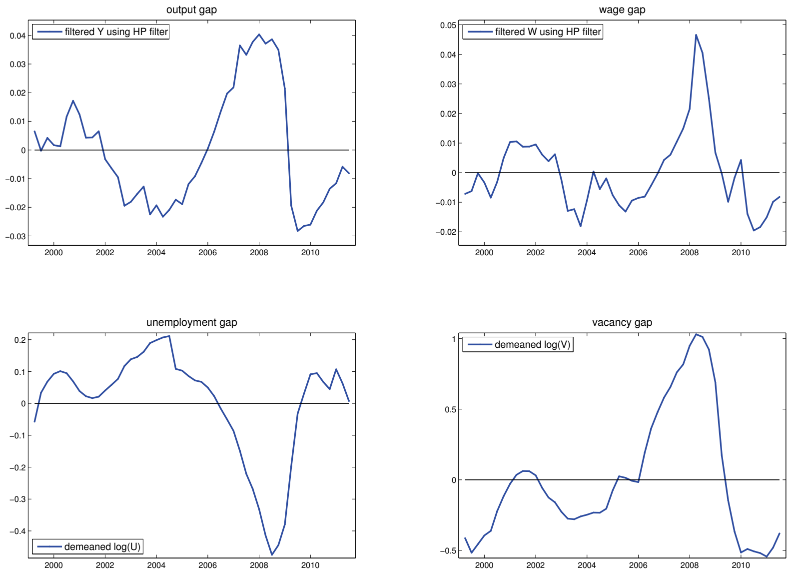

Figure A4. Czech model data

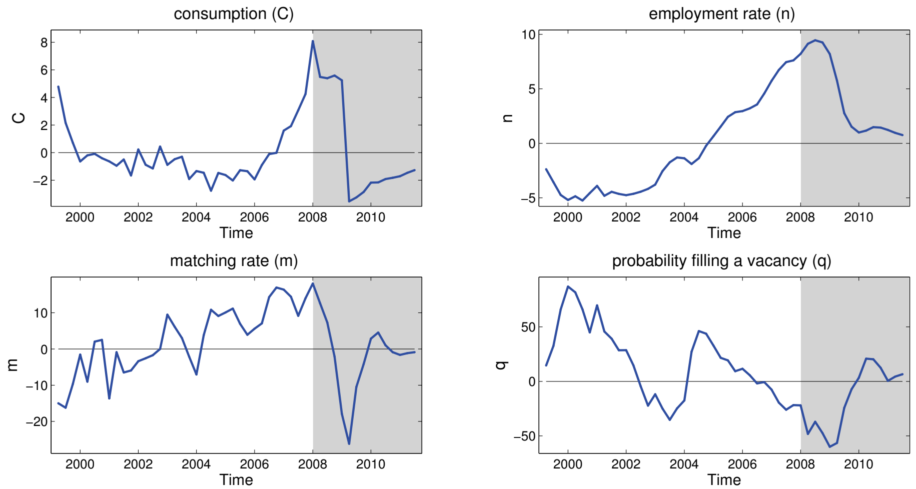

Figure A5. Smoothed variables (SVK)

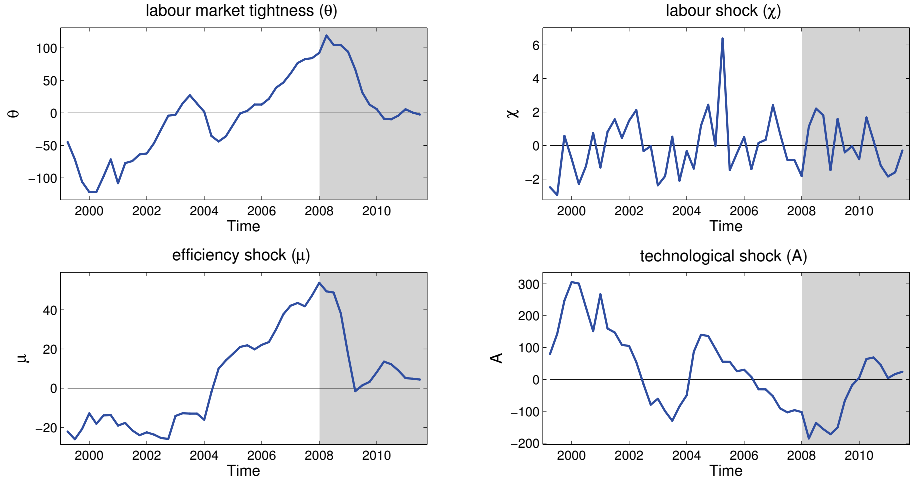

Figure A6. Smoothed variables (SVK)

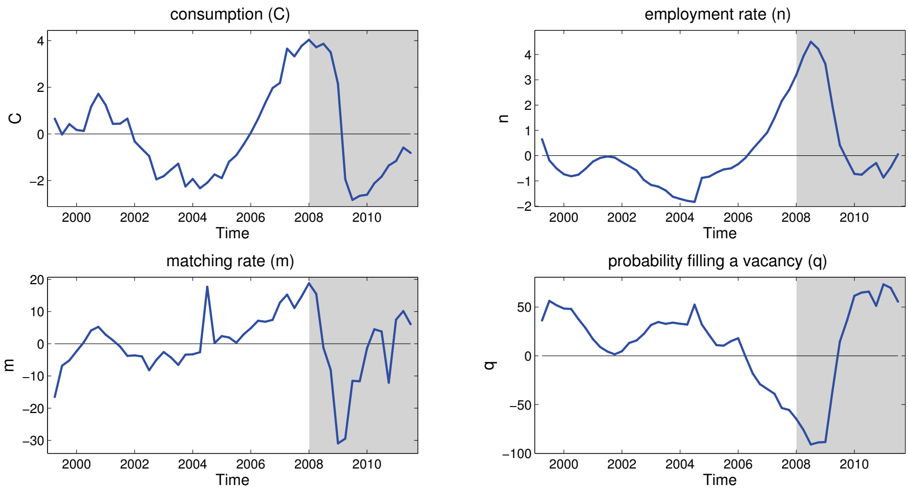

Figure A7. Smoothed variables (CZE)

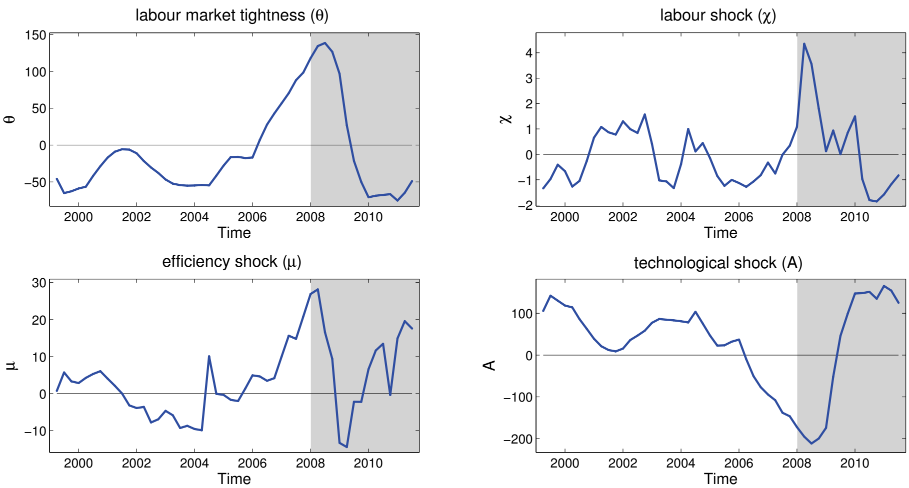

Figure A8. Smoothed variables (CZE)

Table A1. Sample moments for SVK

		Sample moments	
		Mean	Std. dev.
u	data	−0.04	0.291
	model	−0.00	0.154
	90% HPDI	(−0.30, 0.25)	(0.083, 0.260)
v	data	−0.06	0.374
	model	0.01	0.386
	90% HPDI	(−0.57, 0.67)	(0.243, 0.635)
w	data	−0.00	0.014
	model	0.00	0.017
	90% HPDI	(−0.01, 0.01)	(0.014, 0.021)
Y	data	−0.00	0.026
	model	0.00	0.027
	90% HPDI	(−0.02, 0.02)	(0.020, 0.038)

Table A2. Autocorrelation coefficients for SVK

		Lags for autocorrelation coefficients			
		1	2	3	4
u	data	0.98	0.93	0.86	0.79
	model	0.91	0.79	0.66	0.53
	90% HPDI	(0.85, 0.97)	(0.63, 0.91)	(0.35, 0.84)	(0.12, 0.77)
v	data	0.92	0.81	0.67	0.52
	model	0.82	0.67	0.54	0.43
	90% HPDI	(0.65, 0.94)	(0.39, 0.88)	(0.21, 0.81)	(0.11, 0.74)
w	data	0.22	0.19	0.04	−0.23
	model	0.31	0.14	0.08	0.05
	90% HPDI	(0.07, 0.52)	(−0.13, 0.36)	(−0.17, 0.32)	(−0.15, 0.28)
Y	data	0.76	0.58	0.42	0.25
	model	0.73	0.52	0.36	0.24
	90% HPDI	(0.53, 0.87)	(0.22, 0.75)	(0.03, 0.66)	(−0.11, 0.57)

Table A3. Correlation matrix for SVK

		u	v	w	Y
u	data	1.00	−0.75	−0.25	−0.50
	model	1.00	−0.29	0.04	0.01
	90% HPDI	(1.00, 1.00)	(−0.82, 0.48)	(−0.31, 0.41)	(−0.48, 0.54)
v	data	−0.75	1.00	0.09	0.38
	model	−0.29	1.00	−0.15	−0.02
	90% HPDI	(−0.82, 0.48)	(1.00, 1.00)	(−0.47, 0.17)	(−0.58, 0.51)
w	data	−0.25	0.09	1.00	0.28
	model	0.04	−0.15	1.00	0.40
	90% HPDI	(−0.31, 0.41)	(−0.47, 0.17)	(1.00, 1.00)	(0.15, 0.63)
Y	data	−0.50	0.38	0.28	1.00
	model	0.01	−0.02	0.40	1.00
	90% HPDI	(−0.48, 0.54)	(−0.58, 0.51)	(0.15, 0.63)	(1.00, 1.00)

Table A4. Sample moments for CZE

		Sample moments	
		Mean	Std. dev.
u	data	−0.01	0.170
	model	0.00	0.134
	90% HPDI	(−0.2, 0.2)	(0.081, 0.204)
v	data	−0.11	0.456
	model	0.00	0.301
	90% HPDI	(−0.88, 0.88)	(0.170, 0.517)
w	data	−0.00	0.014
	model	0.00	0.010
	90% HPDI	(−0.01, 0.01)	(0.007, 0.013)
Y	data	0.00	0.020
	model	0.00	0.020
	90% HPDI	(−0.03, 0.03)	(0.013, 0.031)

Table A5. Autocorrelation coefficients for CZE

		Lags for autocorrelation coefficients			
		1	2	3	4
u	data	0.95	0.84	0.69	0.52
	model	0.88	0.71	0.55	0.40
	90% HPDI	(0.76, 0.95)	(0.50, 0.87)	(0.27, 0.79)	(0.04, 0.71)
v	data	0.95	0.83	0.67	0.50
	model	0.83	0.69	0.57	0.47
	90% HPDI	(0.65, 0.93)	(0.37, 0.87)	(0.22, 0.81)	(0.09, 0.74)
w	data	0.84	0.60	0.37	0.19
	model	0.72	0.52	0.37	0.26
	90% HPDI	(0.50, 0.86)	(0.25, 0.73)	(0.07, 0.63)	(−0.06, 0.54)
Y	data	0.92	0.78	0.61	0.43
	model	0.81	0.65	0.51	0.40
	90% HPDI	(0.63, 0.93)	(0.40, 0.86)	(0.22, 0.78)	(0.02, 0.74)

Table A6. Correlation matrix for CZE

		u	v	w	Y
u	data	1.00	−0.85	−0.75	−0.78
	model	1.00	−0.41	−0.05	−0.02
	90% HPDI	(1.00, 1.00)	(−0.81, 0.16)	(−0.55, 0.44)	(−0.65, 0.56)
v	data	−0.85	1.00	0.76	0.82
	model	−0.41	1.00	−0.03	−0.01
	90% HPDI	(−0.81, 0.16)	(1.00, 1.00)	(−0.53, 0.46)	(−0.63, 0.52)
w	data	−0.75	0.76	1.00	0.70
	model	−0.05	−0.03	1.00	0.61
	90% HPDI	(−0.55, 0.44)	(−0.53, 0.46)	(1.00, 1.00)	(0.31, 0.84)
Y	data	−0.78	0.82	0.70	1.00
	model	−0.02	−0.01	0.61	1.00
	90% HPDI	(−0.65, 0.56)	(−0.63, 0.52)	(0.31, 0.84)	(1.00, 1.00)