Modelling Czech and Slovak labour markets: A DSGE model with labour frictions

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Content

Motivation

- DSGE models with labour market rigidities:
  - models with wage bargaining mechanism,
  - models with "search and matching" functions.
- An alternative to the perfectly competitive Walrasian labour market model $\rightarrow$ integration into standard macroeconomic models.
- Description of employment flows in the economy $\rightarrow$ influence on business cycles.
- Revealing some structural properties of the labour market.

Labour markets properties

- Slovak labour market:
  - wages relative flexible,
  - overall wage flexibility only poorly influenced by the institutional arrangements.
- Czech labour market:
  - losing its flexibility due to high reservation wage and due to the obstacles connected with the necessary layoffs,
  - decreasing flows of workers among industries and problem with long-term unemloyment.

Introduction

- Log-linear version of Lubik (2009): *Estimating a Search and Matching Model of the Aggregate Labor Market*.
- Simple search and matching model: labour market subject to frictions.
- Time-consuming search process for workers and firms.
- Cost of finding a job/worker $\rightarrow$ shared rents.
- Wages as an outcome of a bargaining process.
- Simple general equilibrium framework $\times$ key labour market features.

Households

- Intertemporal utility of a representative household:

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

- C aggregate consumption, $n \in [0,1]$ fraction of employed household members (determined in the matching market), $\beta \in (0,1)$ discount factor, $\sigma \geq 0$ coefficient of relative risk aversion, χ_t exogenous stochastic process (labour shock).
- Budget constraint:

$$C_t + T_t = w_t n_t + (1 - n_t) b + \Pi_t,$$

- b unemployment benefits (financed by a lump-sum tax T_t), Π_t profits from ownership of the firms, w wage.

Households (cont.)

- No explicit labour supply (outcome of the matching process) $\Rightarrow$ F.O.C.:

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

- λ_t Lagrange multiplier on the budget constraint.

Labour Market

- Search frictions:
$$m(u_t, v_t) = \mu_t u_t^{\xi} \nu_t^{1-\xi},$$
- u_t unemployed job seekers, ν_t vacancies, $m(u_t, \nu_t)$ matching rate, $0 < \xi < 1$ match elasticity of the unemployed, μ_t efficiency of the matching process.
- Aggregate probability of filling a vacancy:
$$q(\theta_t) = m(u_t, \nu_t)/\nu_t,$$
- $\theta_t = \frac{\nu_t}{u_t}$ labour market tightness.

Labour Market (cont.)

- Assumption: one period for new matches to be productive; old and new matches destroyed at a constant rate.
- Evolution of employment ($n_t = 1 - u_t$):

$$n_t = (1 - \rho) \left[n_{t-1} + \nu_{t-1} q(\theta_{t-1}) \right],$$

- $0 < \rho < 1$ constant separation rate (inflows into unemployment).

Firms

- Monopolistic competition (deviation from standard S&M framework).
- Demand function of a firm:

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

- y_t firm's production (its demand), Y_t aggregate output, p_t price set by the firm, P_t aggregate price index, ϵ demand elasticity.
- Production function:

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

- A_t aggregate technology process, $0 < \alpha \leq 1$ curvature in production ($\Rightarrow$ fixed and firm-specific capital).

Firms (cont.)

- Maximizing intertemporal profit function $(n_t,\ v_t,\ p_t)$:

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

- subject to the employment accumulation equation and production function equation.
- Profits evaluated in terms of marginal utility λ_j.
- Cost of vacancy posting $\frac{\kappa}{\psi} v_t^{\psi}$, $\kappa > 0$, $\psi > 0$ ($0 < \psi < 1$, posting costs exhibit decreasing returns, $\psi > 1$ costs are increasing, $\psi = 1$ fixed vacancy costs).

Firms (cont.)

- First-order conditions:

$$\tau_t = \alpha \frac{y_t}{n_t} \frac{\epsilon}{1+\epsilon} - w_t + (1-\rho) E_t \beta_{t+1} \tau_{t+1},$$
$$\kappa \nu_t^{\psi-1} = (1-\rho) q(\theta_t) E_t \beta_{t+1} \tau_{t+1},$$

- $\beta_{t+1} = \beta \frac{\lambda_{t+1}}{\lambda_t}$ stochastic discount factor, τ_t Lagrange multiplier for employment constraint (current-period marginal value of a job).

Wage Determination

- Bilateral bargaining process $\rightarrow$ wage rates to maximize the joint surplus from employment relationship:

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

- $\eta \in [0,1]$ bargaining power of workers, $\frac{\partial \mathcal{W}_t(n_t)}{\partial n_t}$ marginal value of a worker to the household's welfare, $\frac{\partial \mathcal{J}_t(n_t)}{\partial n_t}$ marginal value of a worker to the firm.
- $\frac{\partial \mathcal{J}_t(n_t)}{\partial n_t} = \tau_t$ (F.O.C. for the firms with respect to the employment).

Wage Determination (cont.)

- Recursive representation for $\frac{\partial \mathcal{W}_t(n_t)}{\partial n_t}$:

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

- Using employment equation:

$$\frac{\partial n_{t+1}}{\partial n_t} = (1-\rho)[1-\theta_t q(\theta_t)].$$

- Real payments valued at the marginal utility λ_t.

Wage Determination (cont.)

- Standard optimality condition for wages:

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

- After some intuitive algebra:

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

Closing the model

- Lump-sum taxes T + balanced budget:

$$T_t = (1 - n_t)b.$$

- Social resource constraint:

$$C_t + \frac{\kappa}{\psi}\nu_t^{\psi} = Y_t.$$

- Law of motion for aggregate employment:

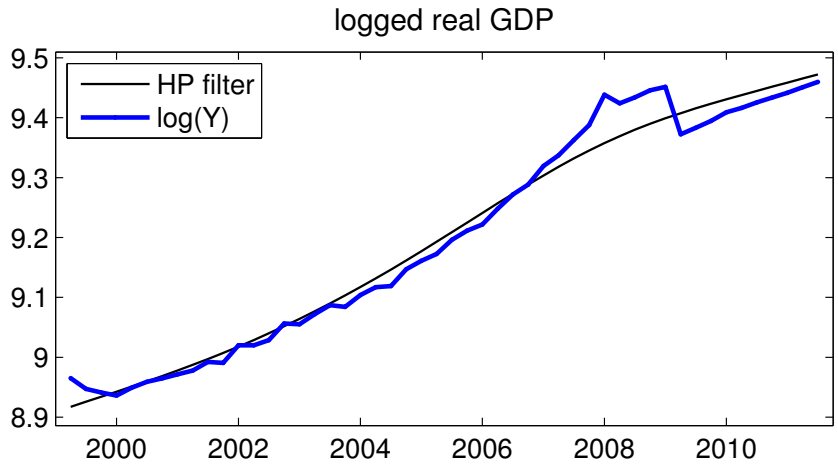
$$n_t = (1 - \rho)\left[n_{t-1} + \mu_{t-1}u_{t-1}^{\xi}\nu_{t-1}^{1-\xi}\right].$$

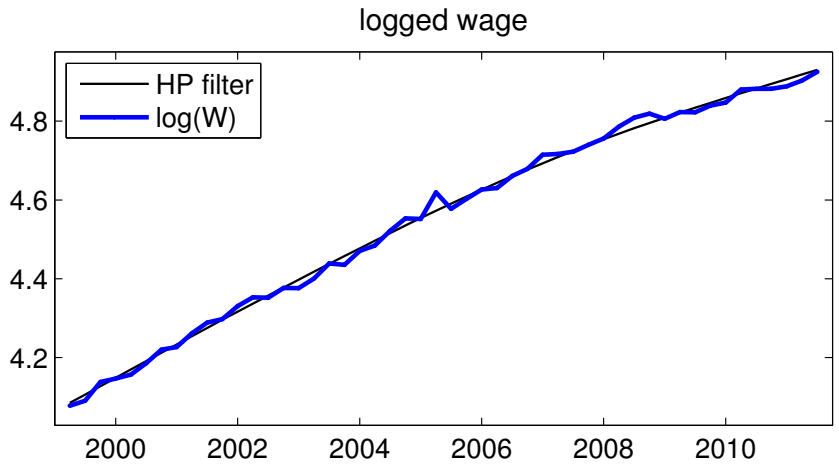
- Shocks: technology A_t, labour χ_t, matching $\mu_t \rightarrow$ independent $AR(1)$ processes (in logs) with coefficients ρ_i, $i \in (A, \xi, \mu)$.
- Innovations $\epsilon_t^i \sim N(0, \sigma_i^2)$.

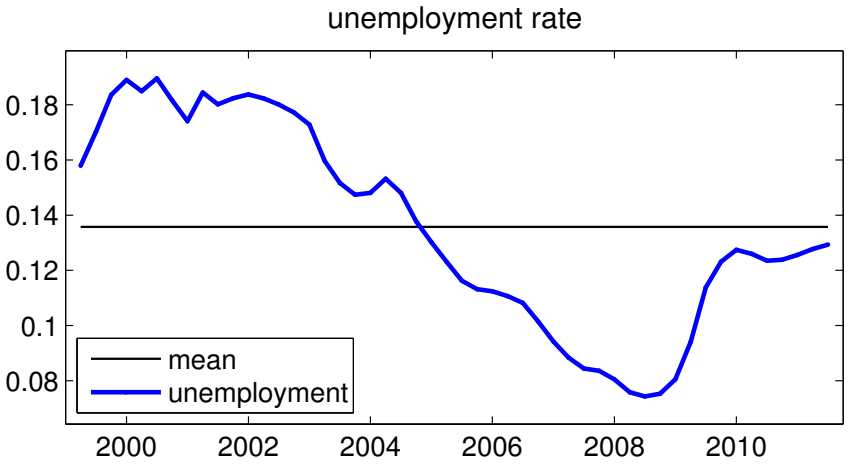
Data and estimation techniques

- Quarterly data: 1st quarter 1999 – 4th quarter 2010:
  - 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.
- Bayesian techniques combined with Kalman filtering procedures (all computations performed using Dynare toolbox for Matlab).

Figure – source data SVK







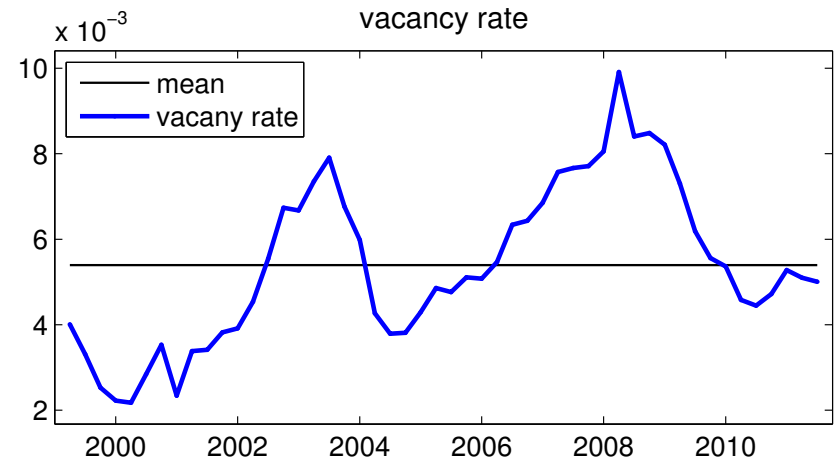
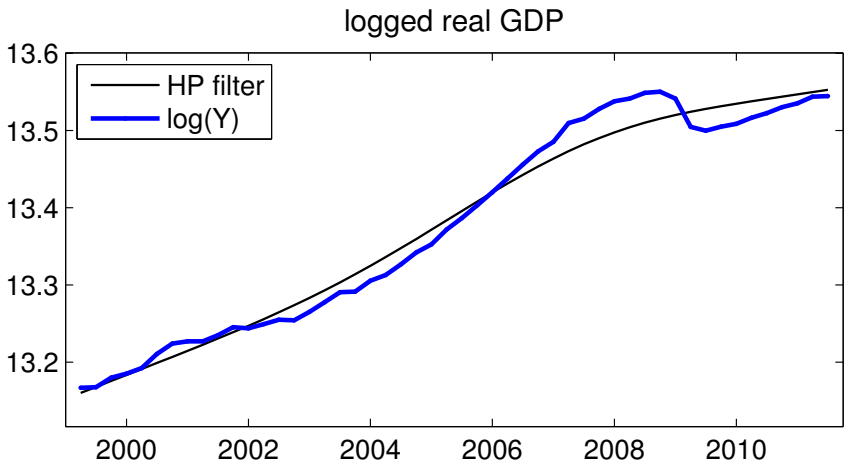
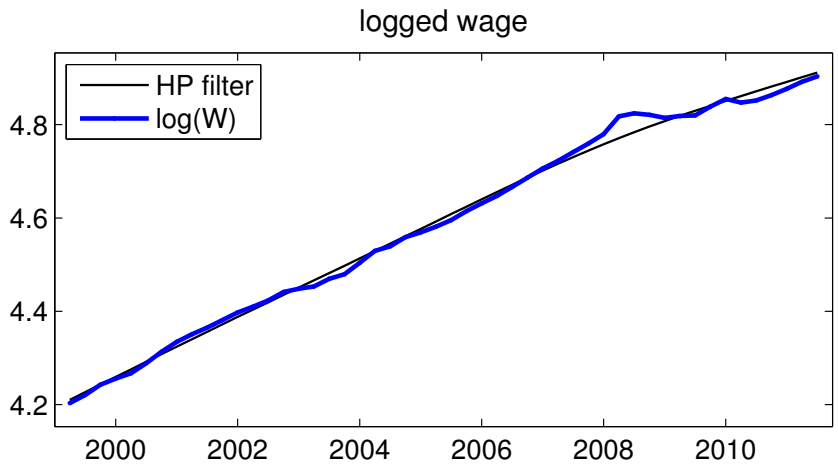
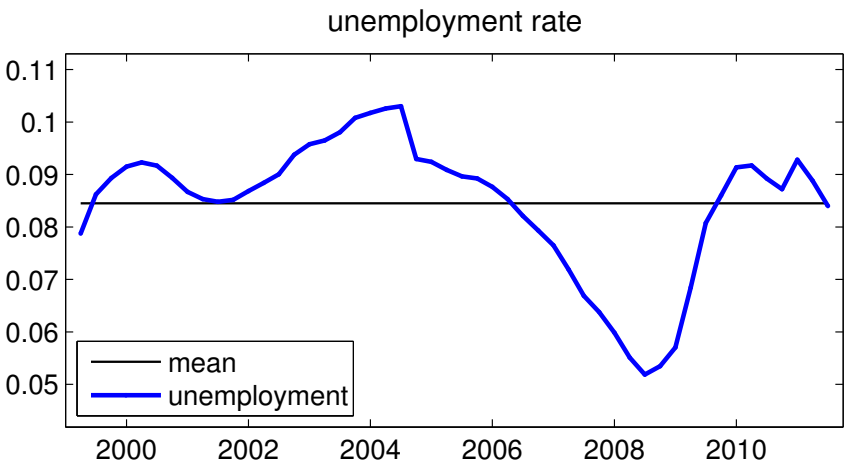


Figure – source data CZE







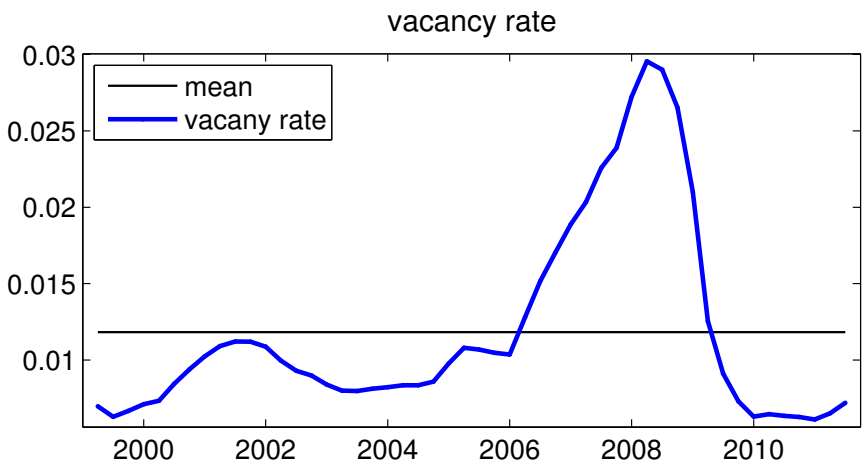
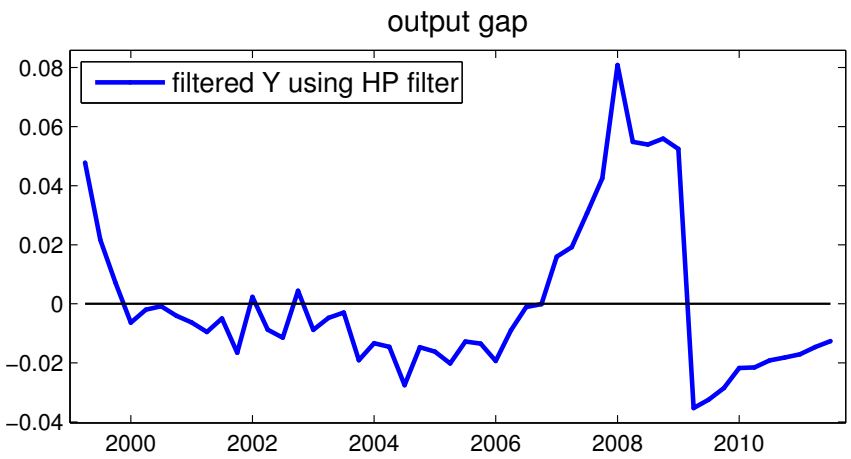
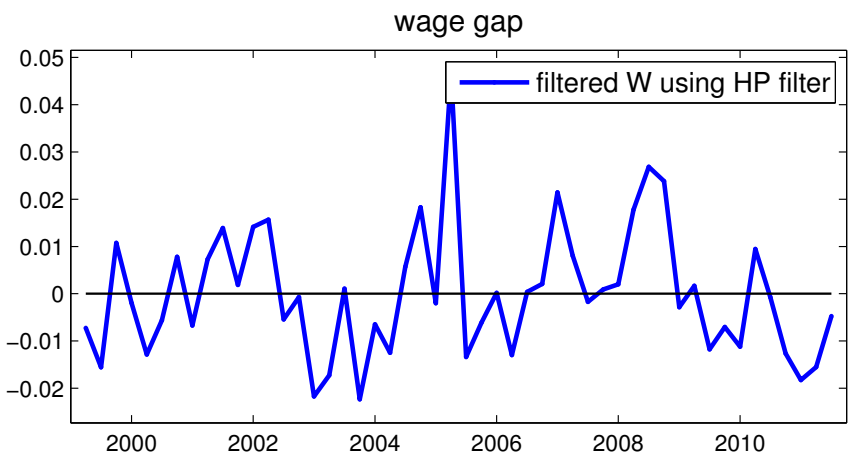
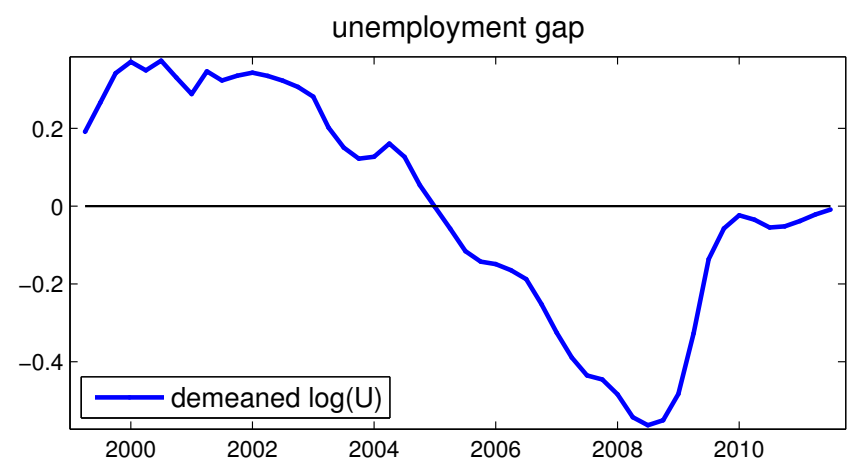


Figure – model data SVK







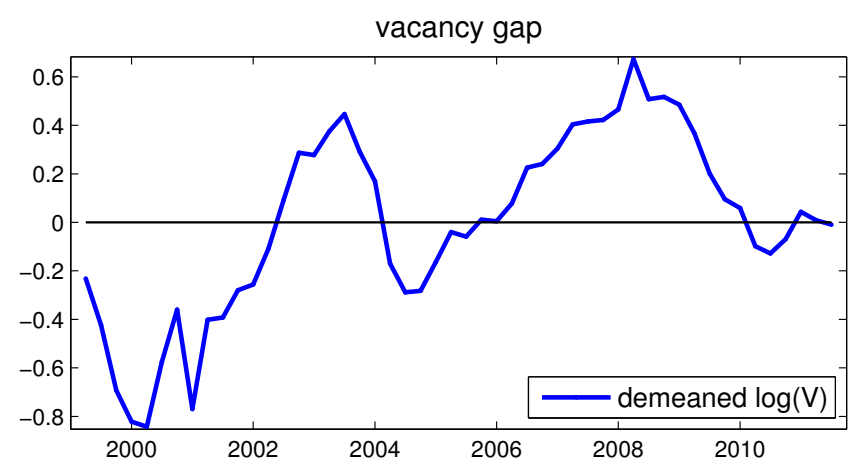
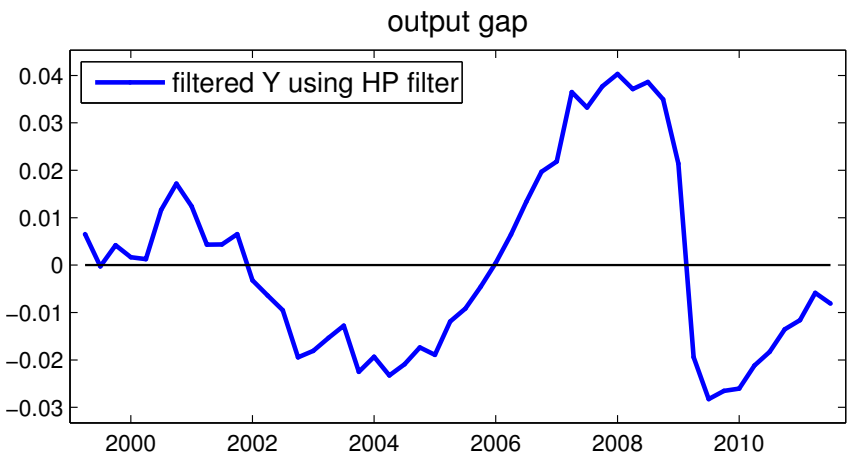
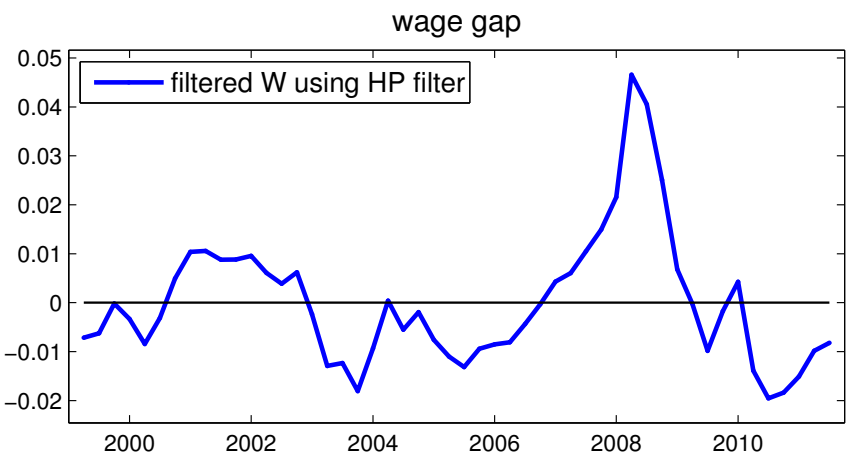
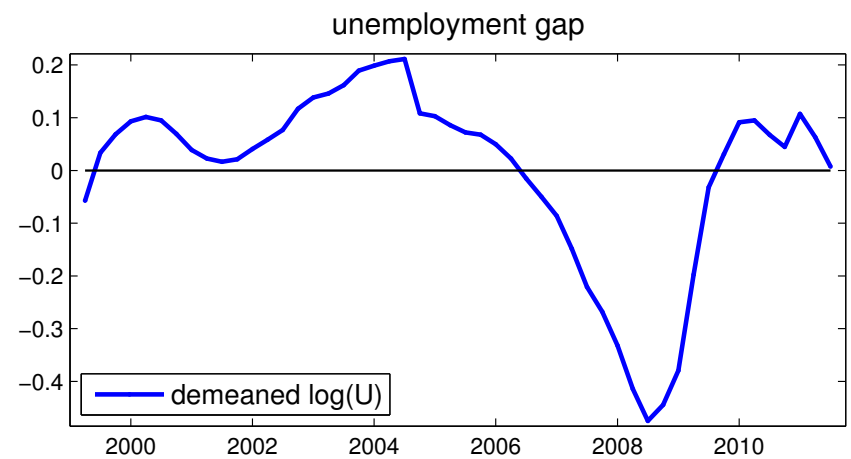
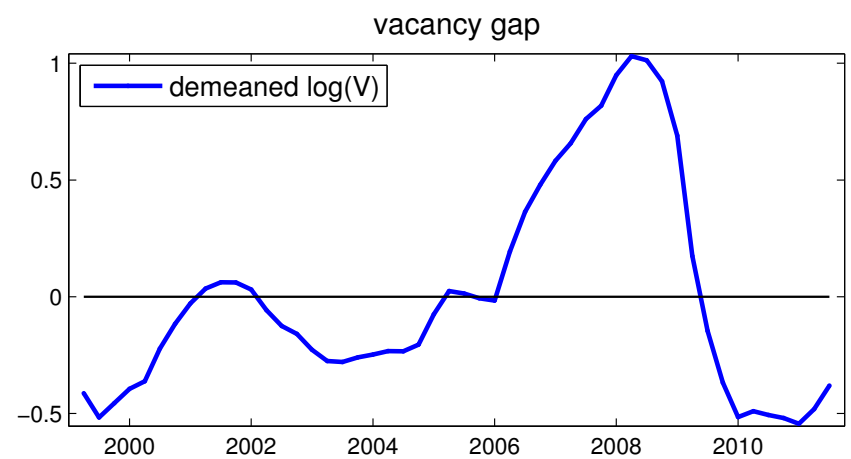


Figure – model data CZE









Parameters description and prior densities

Description	Parameter	Density	Priors SVK		Priors CZE	
			Mean	Std. Dev	Mean	Std. Dev
Discount factor	β	—	0.99	—	0.99	—
Labor elasticity	α	—	0.67	—	0.67	—
Demand elasticity	ϵ	—	10	—	10	—
Relative risk aversion	σ	G	1.00	0.50	1.00	0.50
Match elasticity	ξ	G	0.70	0.10	0.70	0.10
Separation rate	ρ	G	0.10	0.05	0.10	0.05
Bargaining power of the workers	η	U	0.50	0.3	0.50	0.3
Unemployment benefits	b	B	0.20	0.15	0.20	0.15
Elasticity of vacancy creation cost	ψ	G	1.00	0.50	1.00	0.50
Scaling factor on vacancy creation cost	κ	G	0.10	0.05	0.10	0.05
AR coefficients of shocks	$\rho_{\{\chi,A,\mu,Y\}}$	B	0.8	0.2	0.8	0.2
Standard deviation of shocks	$\sigma_{\{\chi,A,\mu\}}$	IG	0.01	1	0.01	1
Standard deviation of shocks	$\sigma_{\{Y\}}$	IG	0.05	1	0.05	1

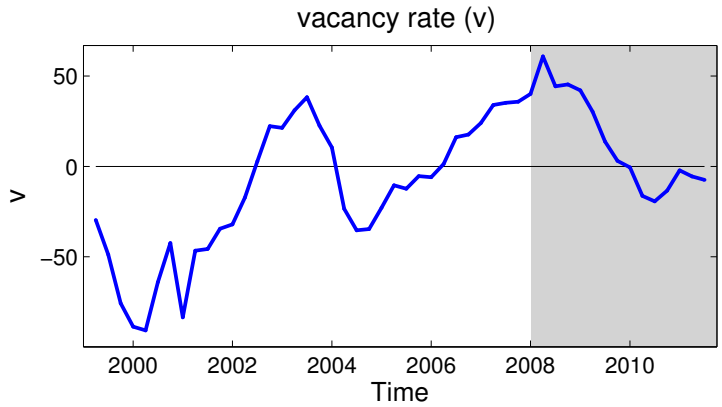
Parameter estimates

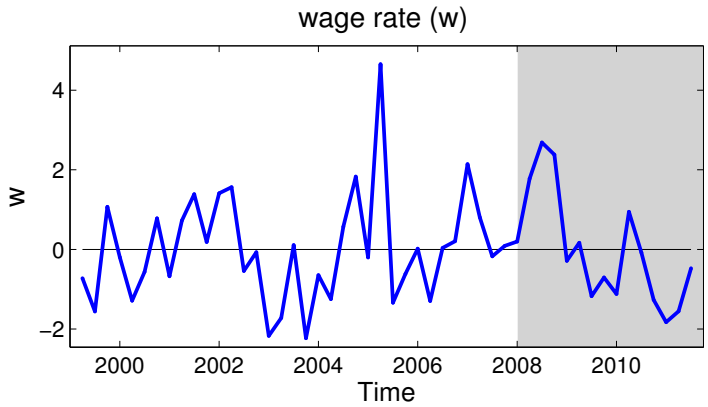
	SVK			CZE		
	Posterior mean	90% HPDI		Posterior mean	90% HPDI	
σ	0.2843	0.1319	0.4248	0.4517	0.2989	0.5648
ξ	0.8196	0.7645	0.8782	0.7758	0.7229	0.8316
ρ	0.0677	0.0185	0.1259	0.0705	0.0563	0.0843
η	0.0046	0.0000	0.0099	0.0022	0.0000	0.0050
b	0.1566	0.0001	0.2988	0.4557	0.4083	0.5052
ψ	2.2769	1.7870	2.7440	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

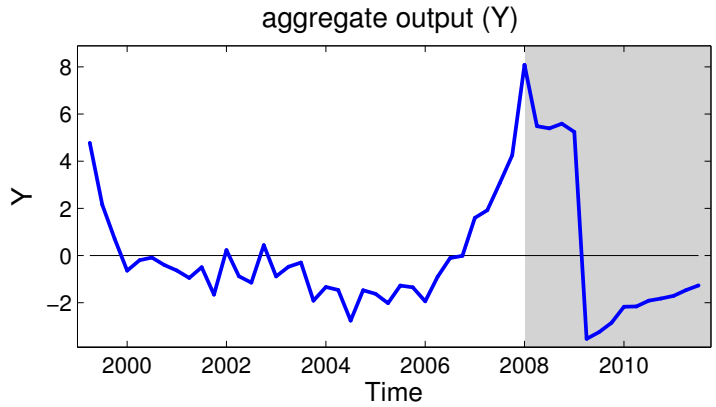
Comments

- Bargaining power of workers, η –almost 0 for both countries $\Rightarrow$ the firms are willing to create vacancies.
- Separation rate, ρ – considerably lower than the one estimated for U.S. economy $\Rightarrow$ less flexible Czech and Slovak labour market with limited ability to destroy old and new matches (restricted flows of the workers among industries).
- Vacancy posting elasticity, ψ – shifted away from the prior mean $\rightarrow$ the vacancy creation is more costly because of increasing marginal posting costs.
- The estimate of parameter b – remarkably high value of 0.46 for the Czech economy (in accordance with the real unemployment benefits) $\times$ lower value of 0.16 for the Slovak economy supports the view of lower reservation wage for this country.
- Matching function parameter, ξ in accordance with the common values in literature.

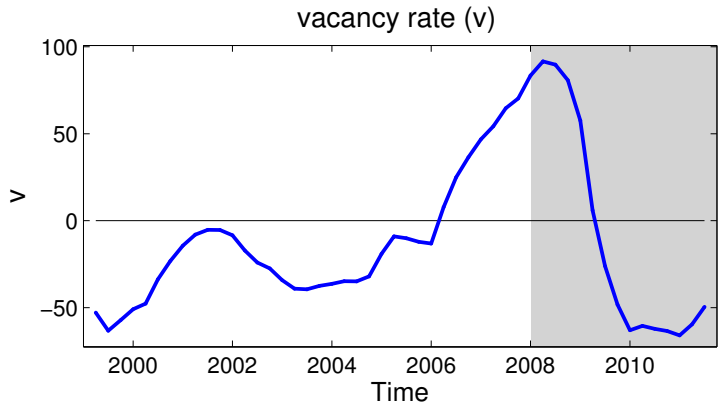
Trajectories of selected (smoothed) variables – SVK (1/3)

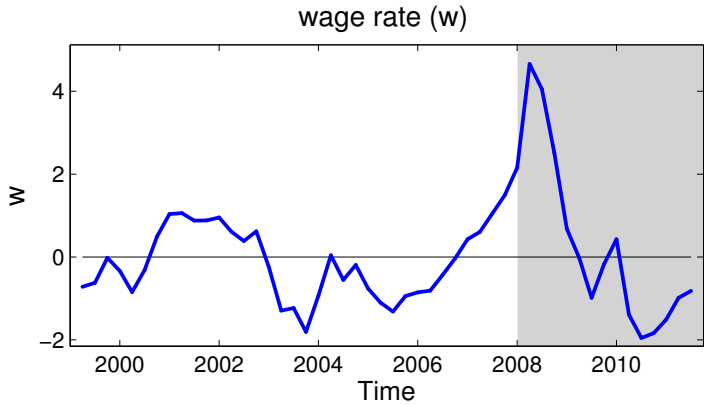


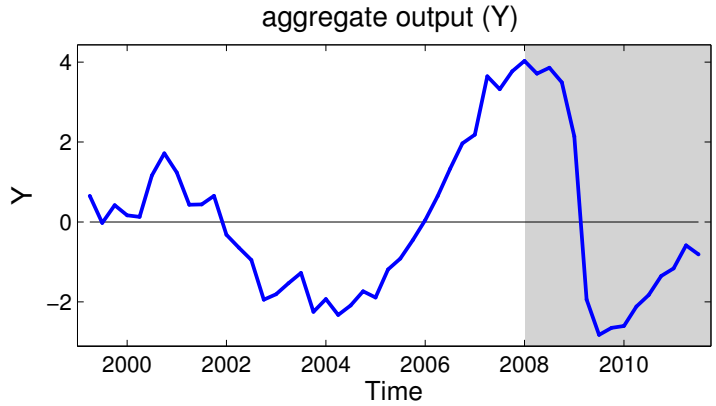




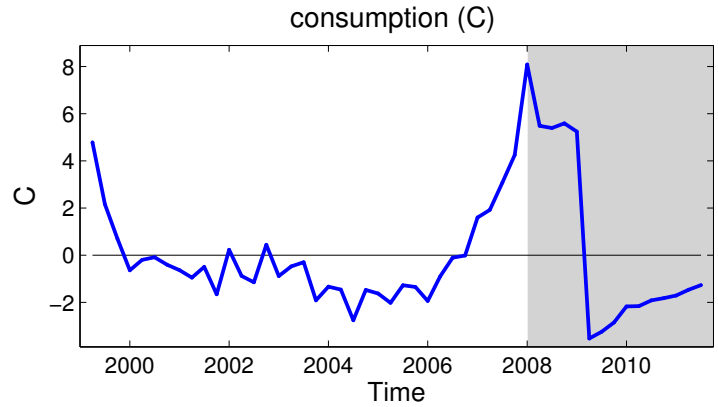
Trajectories of selected (smoothed) variables – CZE (1/3)

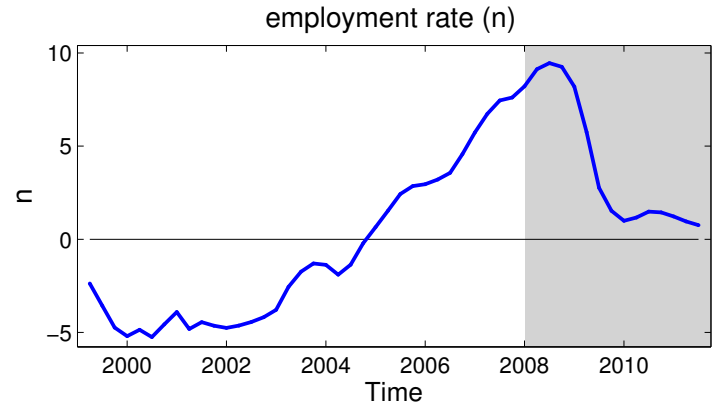


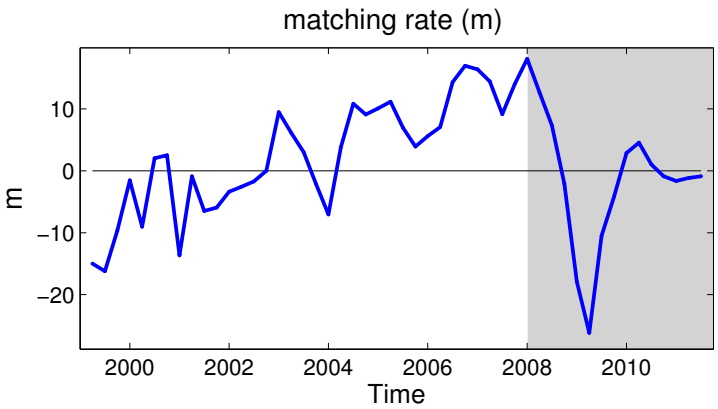


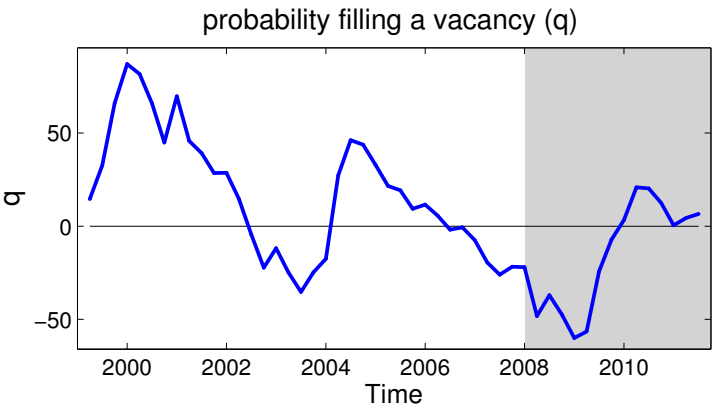


Trajectories of selected (smoothed) variables – SVK (2/3)

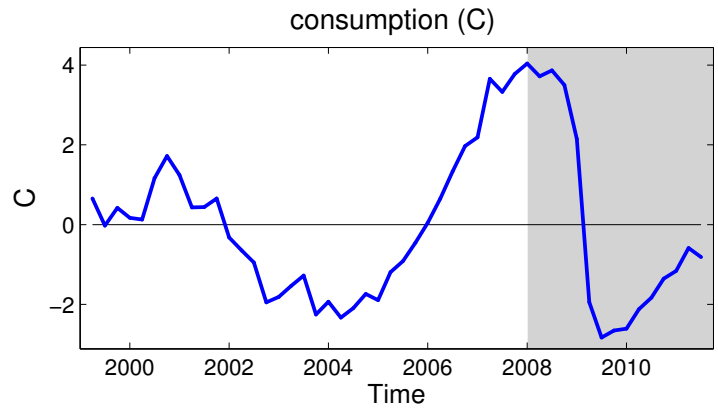


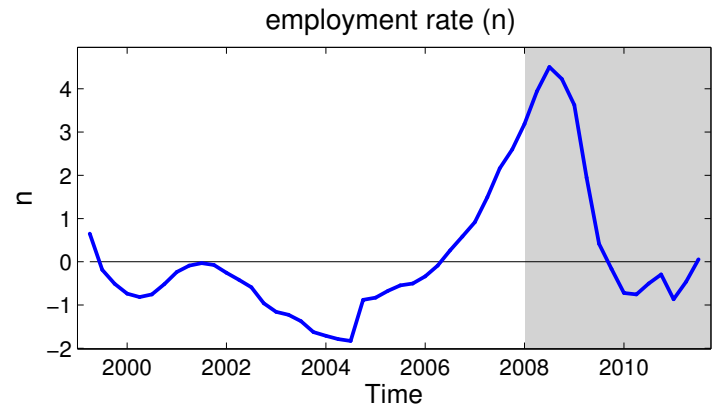


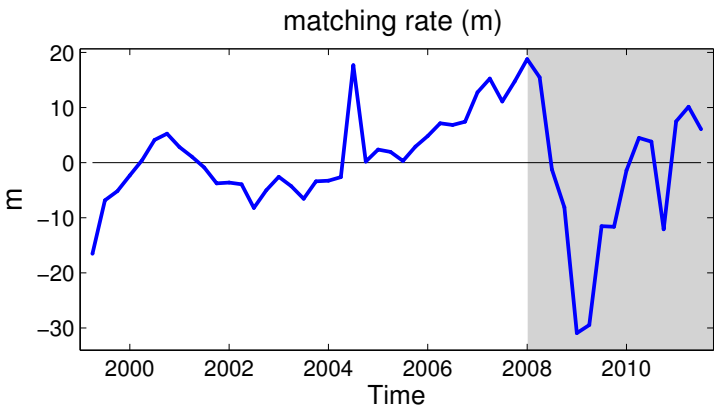


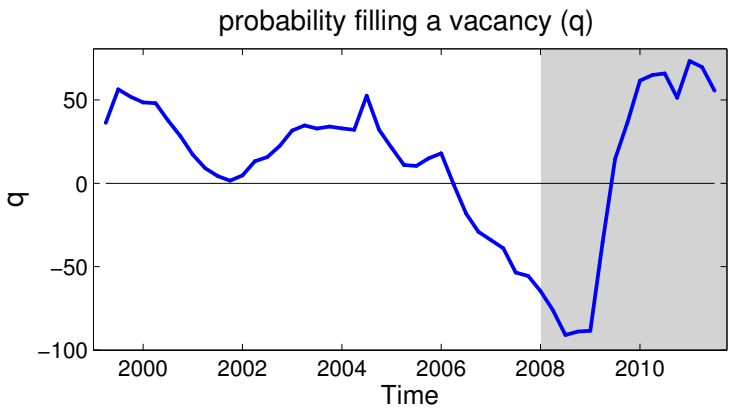


Trajectories of selected (smoothed) variables – CZE (2/3)

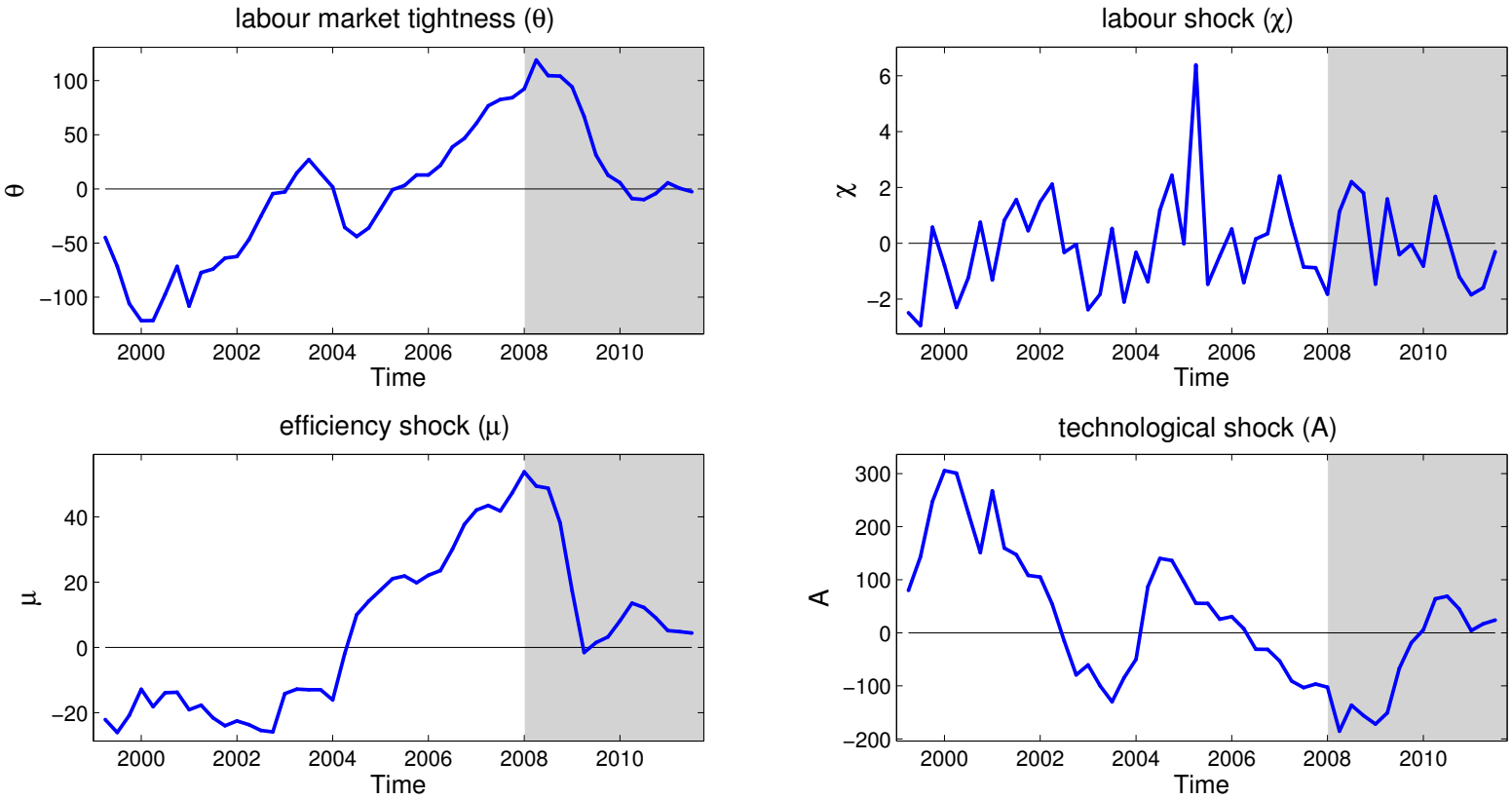




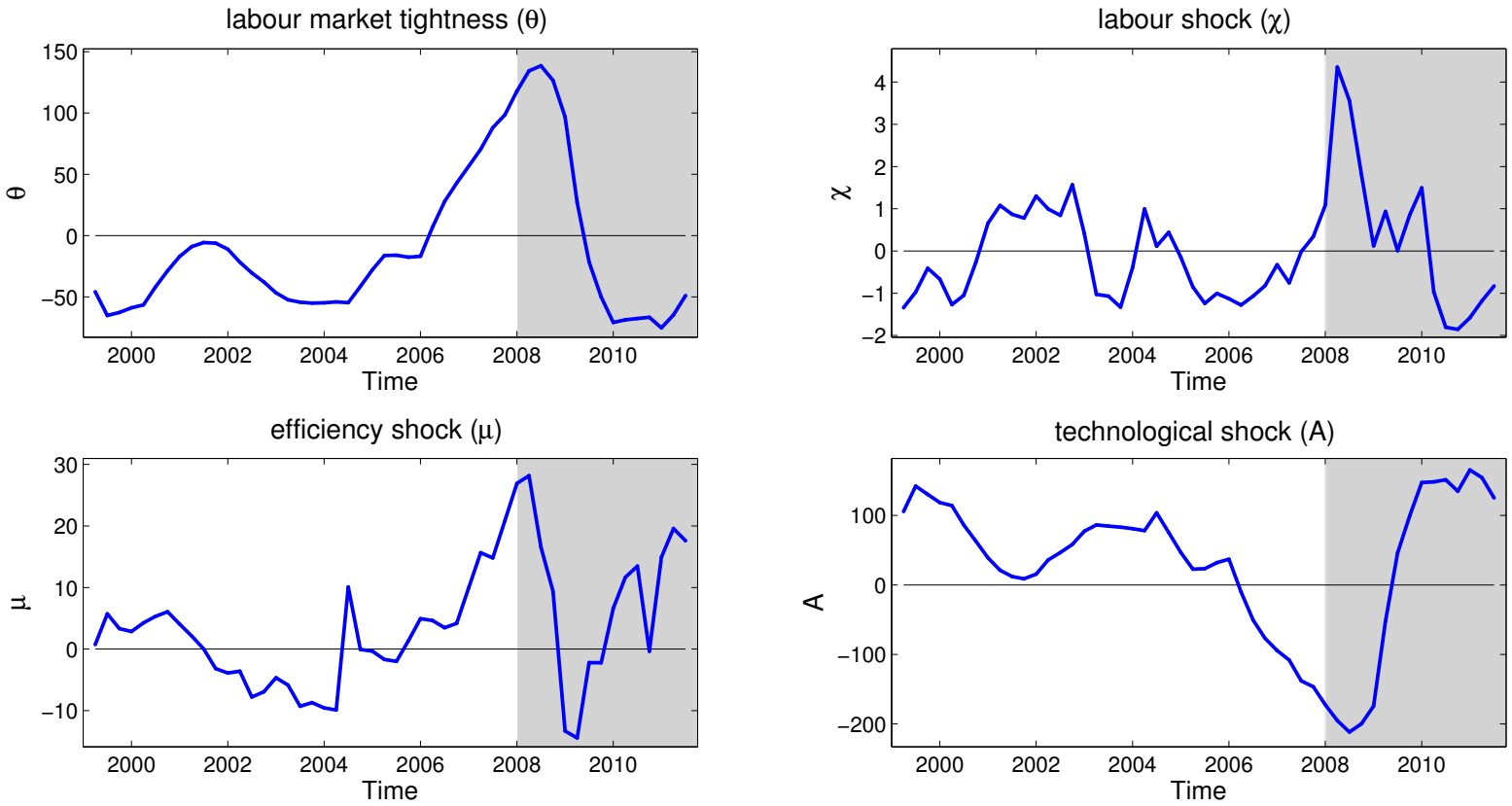




Trajectories of selected (smoothed) variables – SVK (3/3)



Trajectories of selected (smoothed) variables – CZE (3/3)



Comments

- Relative sharp decline in the development of variable q (probability of filling a vacancy) at the end of the year 2006 $\rightarrow$ the role of an obvious lack of employees in the Czech economy.
- Similar results for the Slovak economy.
- Downturn of both economies influenced a fall of the matching rates m below their steady-state values.
- The starting recession has reestablished the equilibrium on both labour markets (see the trajectories of employment rate and labour market tightness).
- The improvement of labour market institutions (trajectory of efficiency shock, μ) $\rightarrow$ remarkable changes on the Czech and Slovak labour markets started at the end of 2004 and at the beginning of the 2006 respectively.

IRFs and historical shocks decomposition.

- Except the responses on technology shocks (which is too persistent), the rest of IRFs in accordance with the standard economic theory.
- Similar dynamics of both economies.
- The persistent response of the technology and output shocks in accordance with hysteresis hypothesis (hysteresis of unemployment)?
- Similar historical shocks decomposition in both economies + important role of the technology (more important in the Czech economy) and matching shocks.

Sample moments and autocorrelation coefficients (SVK)

		Sample moments		Lags for autocorrelation coefficients			
		Mean	Std. dev.	1	2	3	4
u	data	0.00	0.009	0.91	0.71	0.45	0.16
	model	-0.00	0.010	0.88	0.70	0.51	0.35
	90% HPDI	$(-0.01, 0.01)$	$(0.007, 0.014)$	$(0.79, 0.94)$	$(0.48, 0.83)$	$(0.11, 0.72)$	$(-0.08, 0.62)$
ν	data	0.00	0.004	0.91	0.71	0.45	0.17
	model	0.00	0.008	0.72	0.54	0.40	0.29
	90% HPDI	$(-0.01, 0.01)$	$(0.006, 0.011)$	$(0.55, 0.87)$	$(0.25, 0.80)$	$(0.08, 0.73)$	$(-0.09, 0.67)$
w	data	0.00	0.014	0.80	0.53	0.29	0.14
	model	0.00	0.054	0.72	0.52	0.36	0.24
	90% HPDI	$(-0.04, 0.04)$	$(0.041, 0.071)$	$(0.57, 0.84)$	$(0.30, 0.72)$	$(0.06, 0.61)$	$(-0.09, 0.57)$
Y	data	0.00	0.020	0.91	0.74	0.54	0.33
	model	0.00	0.017	0.79	0.62	0.47	0.36
	90% HPDI	$(-0.01, 0.01)$	$(0.012, 0.024)$	$(0.64, 0.88)$	$(0.33, 0.77)$	$(0.09, 0.70)$	$(0.01, 0.63)$

Correlation matrix (SVK)

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

Sample moments and autocorrelation coefficients (CZE)

		Sample moments		Lags for autocorrelation coefficients			
		Mean	Std. dev.	1	2	3	4
u	data	-0.01	0.170	0.95	0.84	0.69	0.52
	model	0.00	0.134	0.88	0.71	0.55	0.40
	90% HPDI	$(-0.2, 0.2)$	$(0.081, 0.204)$	$(0.76, 0.95)$	$(0.50, 0.87)$	$(0.27, 0.79)$	$(0.04, 0.71)$
ν	data	-0.11	0.456	0.95	0.83	0.67	0.50
	model	0.00	0.301	0.83	0.69	0.57	0.47
	90% HPDI	$(-0.88, 0.88)$	$(0.170, 0.517)$	$(0.65, 0.93)$	$(0.37, 0.87)$	$(0.22, 0.81)$	$(0.09, 0.74)$
w	data	-0.00	0.014	0.84	0.60	0.37	0.19
	model	0.00	0.010	0.72	0.52	0.37	0.26
	90% HPDI	$(-0.01, 0.01)$	$(0.007, 0.013)$	$(0.50, 0.86)$	$(0.25, 0.73)$	$(0.07, 0.63)$	$(-0.06, 0.54)$
Y	data	0.00	0.020	0.92	0.78	0.61	0.43
	model	0.00	0.020	0.81	0.65	0.51	0.40
	90% HPDI	$(-0.03, 0.03)$	$(0.013, 0.031)$	$(0.63, 0.93)$	$(0.40, 0.86)$	$(0.22, 0.78)$	$(0.02, 0.74)$

Correlation matrix (CZE)

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

Comments

- The model is very successful in matching sample moments and autocorrelation coefficients (not typical for such a small-scale model!).
- 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.
- Cross-correlation coefficients not sufficient for the correlations of unemployment and the rest of observable variables (similar experience for U.S. labour market) $\rightarrow$ presence of matching shock (acting as a residual in employment and wage equations).

Conclusion

- Good ability to identify most structural parameters.
- Plausible description of labour market dynamics and properties of the Czech and Slovak labour market.
- Convincing evidence that wage bargaining process is determined mainly by the power of the firms.
- The structural properties of both markets do not differ too much from the properties of the U.S. labour market.
- Flexible wage environment in both economies $\times$ the firms are confronted by the increasing vacancy posting costs that limit vacancies creation $+$ the lower separation as an evidence of reduced mobility of the workers.

Further research

- Robustness check based on estimation using the information provided by a variety of filters or by direct linking of the observable data to the DSGE model.
- Model comparison based on various wage bargaining settings.
- Inclusion of price rigidities and monetary policy (monetary rule) $\rightarrow$ to analyse implications of wages and labor market shocks on inflation process.
- Incorporating labour market rigidities into an open economy model (the direct effects of labour market shocks should become more obvious).

Thank you for your attention.

Comments?

Suggestions?