# Wage rigidities and labour market performance in the Czech Republic

Daniel Němec[1], Martin Macíček[2]

**Abstract.** The main goal of our contribution is to evaluate the impact of structural characteristics of the Czech labour market on the business cycle and to quantify the role of wage rigidities in the labour market performance. The Czech economy is represented by a small dynamic stochastic general equilibrium model of an open economy. The model economy consists of three types of agents: firms, households and central bank. Model parameters are estimated using the quarterly data of the Czech Republic for the period from the first quarter of 2000 to the last quarter of 2014. The comparison of two alternative wage setting model schemes shows that the Nash bargaining wage setting with the real wage persistence fits the data better than the Calvo type of wage rigidities modelling approach. The existence of hiring costs in the Czech economy was proved as significant and the estimated hiring costs account for 0.77% of the gross domestic product.

**Keywords:** wage rigidities, labour market frictions, DSGE model, hiring costs, Czech labour market

**JEL classification:** E32, J60
**AMS classification:** 91B40

## 1 Introduction

The aim of this paper is to evaluate the impact of structural characteristics of the Czech labour market on the business cycle and to quantify the role of wage rigidities in the labour market performance in the period of growth and prosperity on one hand and the deep fall into the worldwide recession, that initiated in 2008 in the USA by the severe problems of a mortgage sector and spread rapidly throughout the whole world, on the other hand. To achieve this goal we make use of a Dynamic Stochastic General Equilibrium (DSGE) model of the small open economy. Our paper extends the previous investigations of the efficiency and flexibility of the Czech labour market carried out by Němec [5] and Němec [6]. We incorporate two types of wage rigidities into the model in order to take into consideration the complicated process of wage setting and permit involuntary unemployment in the model. Since firms are nowadays changing their hiring strategies and are far more prone to find and train their own talents, rather then relying on a short time working relationships, the model considers hiring costs which could be considerably high.

## 2 The Model

We use a medium-scale small open economy (SOE) DSGE model presented in Sheen and Wang [7]. The authors build the model by further developing the works of Adolfson et al. [1] and Blanchard and Galí [2]. The model economy consists of three types of agents: firms, households and central bank. We assume that government distributes all taxes to households as a lump sum payment, so there is no need to introduce government in the model explicitly. Firms are divided into four categories. Domestic intermediate goods-producing firms employ labour and capital services from households, depending on the relative wage and rental price of capital, to produce intermediate goods. These goods are further sold to domestic final producers, who combine intermediate goods and transform them into a homogeneous goods. These

[1]Masaryk University, Faculty of Economics and Administration, Department of Economics, Lipová 41a, 602 00 Brno, Czech Republic, nemecd@econ.muni.cz
[2]Masaryk University, Faculty of Economics and Administration, Department of Economics, Lipová 41a, 602 00 Brno, Czech Republic, 369753@mail.muni.cz

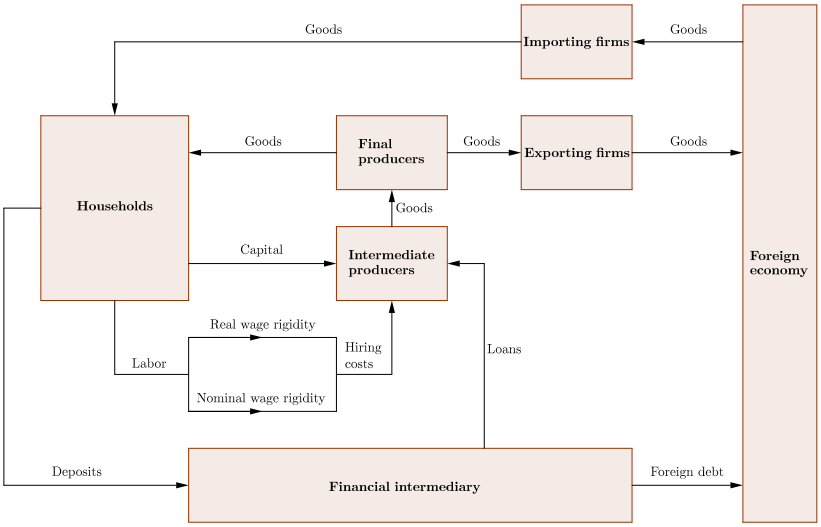


**Figure 1** Simplified diagram of the model flows

goods, that can be used either for consumption and investment, are sold both to domestic households and abroad. Trading with foreign economies is ensured by the existence of importing and exporting firms. The New Keynesian framework assumes monopolistic competition, thus the firms themselves set their prices optimally subject to Calvo [3] type pricing mechanism. Since inflation is assumed to be well maintained by the central bank, firms which do not optimize their prices in current period simply index their prices to the inflation. Firms have to finance all their wage bills by borrowing at the nominal cash rate. Infinitely long lived optimizing households gain utility from leisure, real balances and consumption, that is subject to the habit formation. They offer capital and labour to intermediate goods producing firms. These employers face hiring costs when employing a new worker. These costs can take a form of initial trainings for a new employee, time until she starts to do her job properly, time of her colleagues when giving her advices, the processes of choosing the right candidates, the costs of assessment centers etc., firms internalize these costs when making their price decisions, making inflation dependent on lagged, current and future expected unemployment rate. Further two alternative schemes of wage setting are considered. Nominal wage rigidities are arising from assumption that the labour is differentiated, thus giving workers power to set wages according to the Calvo [3] type of nominal rigidities. Real wage rigidities alternative is introduced by making real wages depend on the lagged real wage and the current Nash bargaining wage. A central bank conducts monetary policy by applying a Taylor type interest rate rule. Further insight into the model functioning provides simplified model diagram displayed in Figure 1.

## 3 Data and methodology

To estimate the model we use Czech quarterly time series from 2000Q1 to 2014Q4. The data are taken from databases of Czech National Bank, Czech Statistical Office, Ministry of labour and Social Affairs and Eurostat. Economic and Monetary Union of the European Union is perceived as a foreign economy. More detailed description of original time series is offered in Table 1. Kalman filter is employed to evaluate the likelihood function of the model and two Metropolis-Hastings chains are run to estimate the posterior density. One milion draws are taken and 70% are discarded in order to minimize the impact of initial values. We also try to control the variance of the candidate distribution to achieve the acceptance ratio of draws around 0.3. Foreign economy is modeled independently as a VAR(1) process. Many of the model parameters are calibrated. Discount factor $\beta$ and steady state–level of unemployment $\overline{U}$ are set to match the observed interest rate and unemployment rate of the data sample. Parameter $\vartheta$ is set to 1, according to Blanchard and Gali [2], implying the unit elasticity of hiring cost to the current labour market conditions. Following Jääskelä and Nimark [4], steady–state level of domestic goods inflation $\overline{\pi}^d$ is set to 1.005 and the shares of consumption and investments in imports are set to $\omega_c = 0.2$, $\omega_i = 0.5$ respectively. The curvature of the money demand function $\sigma_q = 10.62$, constant determining the level of utility the households gain from real balances $A_q = 0.38$, elasticity of labour supply $\sigma_L = 1$ and

| Time series | Description | Detail |
|---|---|---|
| CPI | Consumer price index | Seasonally adjusted, 2014 = 100 |
| Wnom | Nominal wages | |
| C | Real consumption | |
| I | Real investment | Gross fixed capital formation |
| X | Real exports | |
| M | Real imports | |
| Y | Real GDP | |
| Ynom | Nominal GDP | |
| R | Nominal interest rate | 3M Interbank Rate - PRIBOR |
| U | Unemployment rate | |
| E | Nominal exchange rate | Exchange Rate CZK/EUR |
| Yst | Foreign real GDP | GDP EMU |
| CPIst | Foreign CPI | CPI EMU, 2014 = 100 |
| Rst | Foreign nominal interest rate | 3M EURIBOR |
| RER | Real exchange rate | = E × (CPI/CPIst) |
| DI | GDP deflator | =100 × (Ynom/Y) |
| W | Real wages | =100 × (Wnom/DI) |
| L | labour force | Seasonally adjusted |
| Lgr | labour force growth | $= \log(L_t) - \log(L_{t-1})$ |

**Table 1** Original time series description

utilization cost parameter $\sigma_a \equiv \frac{a''(1)}{a'(1)} = 0.049$ are set according to Adolfson et al. (2007) [1]. Capital share $\alpha$, separation rate $\delta$, depreciation rate $\delta_k$ are set to match the Czech macroeconomic conditions.

| Parameter | Description | Value |
|---|---|---|
| $\beta$ | discount factor | 0.99 |
| $\delta$ | separation rate | 0.1 |
| $\vartheta$ | elasticity of hiring cost to labour market condition | 1 |
| $\delta_k$ | depreciation rate | 0.02 |
| $\alpha$ | capital share | 0.35 |
| $\omega_c$ | import share of consumption good | 0.2 |
| $\omega_i$ | import share of investment good | 0.5 |
| $\sigma_q$ | money demand curvature parameter | 10.62 |
| $\sigma_L$ | labour supply elasticity | 1 |
| $A_L$ | labour dis-utility constant | 1 |
| $A_q$ | money utility constant | 0.38 |
| $\sigma_a$ | utilization cost parameter | 0.049 |
| $\overline{\pi}^d$ | steady-state level of domestic goods inflation | 1.005 |
| $\overline{U}$ | steady-state level of unemployment | 0.071 |

**Table 2** Calibrated parameters

All model calibrated parameters are summarized in Table 2. In prior definition we use the setting of Adolfson et al. [1] and Jääskelä and Nimark [4]. We set this priors as symmetrical as possible to prevent a potential distortion of the posterior estimates.

## 4 Estimation results and model assessment

In this paper two rival models are considered. RWHC model containing real wage rigidities and hiring costs and the alternative NWHC model that assumes nominal wage rigidities with the assumption of hiring costs. We compare the posterior log-likelihoods of the models using the Bayes factor. The RWHC model provides a better data fit compared to its rival. The logarithm of Bayes factor under the null hypothesis of nominal wage rigidities extends to 15, meaning the model with real wage rigidities is strongly favored by the data. The results of the benchmark model estimation are thoroughly depicted in Table 3 and Table 4. The posterior estimate of a habit formation parameter $b$ is 0.78. This indicates substantially high level of households preference of a smooth consumption paths, i.e., households are willing to save and borrow money to keep their level of consumption relatively stable in time. The key parameter in labour market setup is the constant $B$, which determines the steady state level of hiring costs. The point estimate of this parameter is 0.19 with 90% confidence interval ranging from 0.12 to 0.26. This result indicates the significant support of hiring costs by the data. Although the hiring costs are not included in the theoretical model's output we are able to derive the hiring costs to GDP ratio using some algebraic manipulations. The resulting share is 0.77% with the 90% confidence interval between 0.48 to

1.08 percent. The estimated posterior mean of parameter $B$ is a bit smaller under nominal wage rigidity, with the value of $B = 0.15$ and the resulting hiring cost to GDP ratio of 0.60%.

| | | | Prior | | Posterior | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Description | Distribution | Mean | Std | Mean | Std | 5% | 95% |
| $b$ | habit formation | Beta | 0.65 | 0.10 | 0.78 | 0.05 | 0.71 | 0.86 |
| $B$ | tightness coefficient | Normal | 0.12 | 0.05 | 0.19 | 0.04 | 0.12 | 0.26 |
| $\tilde{S}''$ | curvature of investment adjustment cost | Normal | 7.694 | 4.00 | 11.31 | 2.68 | 6.83 | 15.57 |
| $\tilde{\phi}_a$ | risk premium | InvGamma | 0.01 | 0.01 | 0.52 | 0.36 | 0.09 | 1.00 |
| $f$ | real wage AR(1) persistence | Normal | 0.50 | 0.20 | 0.42 | 0.09 | 0.27 | 0.57 |
| $\eta_c$ | imported consumption elasticity | InvGamma | 1.20 | 5.00 | 4.44 | 1.22 | 2.51 | 6.27 |
| $\eta_i$ | imported investment elasticity | InvGamma | 1.20 | 5.00 | 1.18 | 0.14 | 1.05 | 1.36 |
| $\eta_f$ | export elasticity | InvGamma | 1.20 | 5.00 | 6.01 | 1.20 | 4.03 | 7.90 |
| $\overline{\mu}^z$ | steady-state growth rate | Normal | 1.0025 | 0.001 | 1.004 | 0.001 | 1.002 | 1.005 |
| $\overline{\lambda}^d$ | s–s. markup: domestic | InvGamma | 1.20 | 3.00 | 1.91 | 0.26 | 1.47 | 2.32 |
| $\overline{\lambda}^{mc}$ | s–s. markup: imported-consumption | InvGamma | 1.20 | 3.00 | 1.09 | 0.03 | 1.04 | 1.13 |
| $\overline{\lambda}^{mi}$ | s–s. markup: imported-investment | InvGamma | 1.20 | 3.00 | 1.11 | 0.04 | 1.05 | 1.17 |
| Calvo lottery | | | | | | | | |
| $\xi_d$ | domestic firm | Beta | 0.60 | 0.15 | 0.35 | 0.07 | 0.23 | 0.45 |
| $\xi_{mc}$ | consumption import firm | Beta | 0.60 | 0.15 | 0.36 | 0.06 | 0.25 | 0.46 |
| $\xi_{mi}$ | investment import firm | Beta | 0.60 | 0.15 | 0.56 | 0.15 | 0.31 | 0.80 |
| $\xi_x$ | exporter | Beta | 0.60 | 0.15 | 0.57 | 0.06 | 0.47 | 0.68 |
| Monetary policy parameters | | | | | | | | |
| $\rho_R$ | interest rate smoothing | Beta | 0.85 | 0.05 | 0.78 | 0.03 | 0.73 | 0.83 |
| $r_\pi$ | inflation response | Normal | 1.70 | 0.30 | 2.46 | 0.22 | 2.10 | 2.82 |
| $r_y$ | output response | Normal | 0.125 | 0.05 | 0.04 | 0.03 | -0.02 | 0.10 |
| $r_s$ | real exchange rate response | Normal | 0.00 | 0.05 | 0.004 | 0.04 | -0.07 | 0.08 |
| $r_{\Delta_\pi}$ | inflation change response | Normal | 0.00 | 0.10 | 0.15 | 0.08 | 0.02 | 0.27 |
| $r_{\Delta_y}$ | output change response | Normal | 0.00 | 0.10 | 0.16 | 0.05 | 0.07 | 0.24 |
| Persistence parameters | | | | | | | | |
| $\rho_{\zeta^c}$ | consumption preference | Beta | 0.50 | 0.15 | 0.55 | 0.11 | 0.37 | 0.73 |
| $\rho_{\zeta^N}$ | labour preference | Beta | 0.50 | 0.15 | 0.57 | 0.14 | 0.34 | 0.79 |
| $\rho_{\mu^z}$ | permanent technology | Beta | 0.50 | 0.15 | 0.66 | 0.08 | 0.55 | 0.79 |
| $\rho_\epsilon$ | temporary technology | Beta | 0.50 | 0.15 | 0.89 | 0.05 | 0.82 | 0.97 |
| $\rho_\phi$ | risk premium | Beta | 0.50 | 0.15 | 0.59 | 0.16 | 0.33 | 0.85 |
| $\rho_\Gamma$ | investment-specific technology | Beta | 0.50 | 0.15 | 0.59 | 0.08 | 0.45 | 0.72 |
| $\rho_{\tilde{z}^*}$ | asymmetric foreign technology | Beta | 0.50 | 0.15 | 0.52 | 0.15 | 0.27 | 0.77 |
| $\rho_{\lambda^d}$ | markup: domestic | Beta | 0.50 | 0.15 | 0.83 | 0.09 | 0.70 | 0.95 |
| $\rho_{\lambda^{mc}}$ | markup: imported-consumption | Beta | 0.50 | 0.15 | 0.88 | 0.05 | 0.81 | 0.95 |
| $\rho_{\lambda^{mi}}$ | markup: imported-investment | Beta | 0.50 | 0.15 | 0.50 | 0.15 | 0.26 | 0.75 |
| $\rho_{\lambda^x}$ | markup: export | Beta | 0.50 | 0.15 | 0.87 | 0.07 | 0.78 | 0.96 |

**Table 3** Prior and posterior

The elasticity of investment with respect to price of an existing capital can be derived from the first order condition of households choosing the level of investment maximizing their utility function and linearizing this condition around the steady state. Solving the resulting equation forward and inserting back the original model variables we obtain the expression from which the elasticity can be easily derived. We use the equation to determine the elasticity of investment to a temporary rise in the price of current installed capital as $\frac{1}{(\overline{\mu}^z)^2\tilde{S}''}$ and the elasticity of investment to a permanent rise in the price of installed capital as $\frac{1}{(\overline{\mu}^z)^2\tilde{S}''(1-\beta)}$. The posterior estimate of an investment adjustment cost $\tilde{S}''$ is 11.31. Evaluating these expressions at our point estimates delivers the elasticities of 0.088 for a temporary rise of a price and 8.78 for a permanent rise respectively. The posterior estimate of the risk premium parameter $\tilde{\phi}_a = 0.52$ implies (using the uncovered interest rate parity condition), that a 1 percent increase in net foreign assets reduces the domestic interest rate by 0.52 percent. The point estimate of real wage persistence $f$ reached the value 0.42 implying a significant degree of real wage rigidity in the labour market. The comparison of values of consumption $\eta_c$ and investment $\eta_i$ imported elasticity parameters reveals, that the demand for a consumption of a foreign goods is significantly more sensitive to the changes of relative prices than the demand for investment goods. The export elasticity is with its value $\eta_f = 6.01$ most sensitive. The point estimate of $\overline{\mu}^z$ at 1.004 suggests, that the economy is growing only slowly in the steady state, this could well be caused by the time period chosen, where the economic crisis covers the substantial part of a data range. From the estimates of steady–state markups we can derive the information, that the domestic firms have the most market power compared to other types of firms, since they can afford to set a highest markup. The estimates of the Calvo lottery parameters vary greatly across the different firm types. The lowest estimate of Calvo parameter belongs to the domestic firm. The value $\xi_d = 0.35$ implies the average price fix duration of slightly more than 1.5 quarters. The second least rigid price

setting mechanism goes to consumption importing firms with average price fix duration of 1.6 quarters. The results indicate that the investment importing firms together with exporters are unable to adjust their prices most frequently with average price fix durations of 2.27 and 2.32 quarters respectively.

| | | Prior | | | Posterior | | | |
|---|---|---|---|---|---|---|---|---|
| Parameter | Description | Distribution | Mean | Std | Mean | Std | 5% | 95% |
| $\sigma_{\zeta^c}$ | preference shock: consumption | InvGamma | 0.50 | 3.00 | 3.29 | 0.83 | 2.05 | 4.46 |
| $\sigma_{\zeta^N}$ | preference shock: labour supply | InvGamma | 0.50 | 3.00 | 2.70 | 0.58 | 1.77 | 3.61 |
| $\sigma_{\mu^z}$ | permanent technology shock | InvGamma | 0.50 | 3.00 | 0.50 | 0.10 | 0.35 | 0.66 |
| $\sigma_{\epsilon}$ | temporary technology shock | InvGamma | 0.50 | 3.00 | 0.43 | 0.06 | 0.32 | 0.53 |
| $\sigma_{\phi}$ | risk premium shock | InvGamma | 0.50 | 3.00 | 0.41 | 0.18 | 0.15 | 0.66 |
| $\sigma_{\Gamma}$ | investment specific technology shock | InvGamma | 0.50 | 3.00 | 11.21 | 3.16 | 6.28 | 16.13 |
| $\sigma_{\tilde{z}^*}$ | asymmetric foreign technology shock | InvGamma | 0.50 | 3.00 | 0.22 | 0.07 | 0.12 | 0.32 |
| $\sigma_R$ | monetary policy shock | InvGamma | 0.50 | 3.00 | 0.28 | 0.06 | 0.18 | 0.37 |
| $\sigma_{\lambda^d}$ | markup shock: domestic production | InvGamma | 0.50 | 3.00 | 1.22 | 0.38 | 0.70 | 1.71 |
| $\sigma_{\lambda^{mc}}$ | markup shock: imported-consumption | InvGamma | 0.50 | 3.00 | 3.89 | 0.93 | 2.58 | 5.21 |
| $\sigma_{\lambda^{mi}}$ | markup shock: imported-investment | InvGamma | 0.50 | 3.00 | 0.45 | 0.33 | 0.12 | 0.90 |
| $\sigma_{\lambda^x}$ | markup shock: export | InvGamma | 0.50 | 3.00 | 4.96 | 1.03 | 3.43 | 6.41 |

**Table 4** Standard errors of exogenous shocks

The point estimates of monetary policy parameters reveal that the central bank makes an effort to keep the interest rate path relatively smooth, $\rho_R = 0.78$, and responses more than proportionately to inflation when setting the nominal interest rate, $r_\pi = 2.46$. The parameter of response to the real exchange rate is not significant, therefore it seems that the Czech national bank is not influenced by its changes directly when targeting interest rates. The direct response to the output turned out to be insignificant too. Although the values of last two parameters are small, they are significant. Thus the central bank puts a little weight on direct responses to the inflation change and output change.

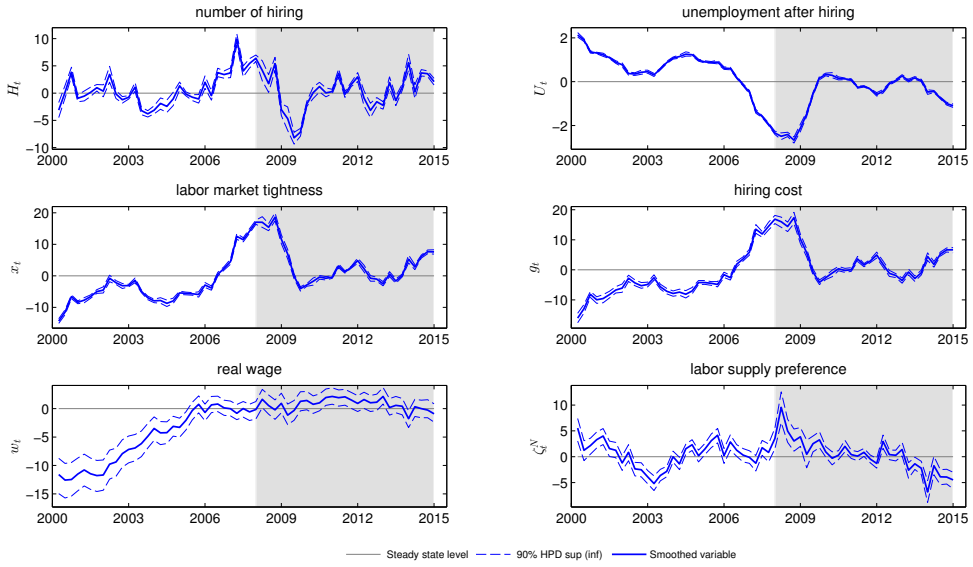


**Figure 2** Smoothed paths of labour market variables

We proceed with the evaluation of the Czech labour market and its structural changes throughout the last 15 years, using our benchmark model. To analyze the development of the Czech labour market we focus on the following variables: $H_t$ (number of hiring – number of hires is the difference between current and lagged employment, after accounting for separation), $U_t$ (unemployment after hiring – due to the assumption of normalized labour force, we can write $U_{t-1} = 1 - N_{t-1}$, where $N_t$ is the employment after hiring ends in time $t$), $x_t$ (labour market tightness – can be interpreted as the job-finding rate from the perspective of the unemployed), $g_t$ (stationary hiring cost), $w_t$ (real wage – compiled as a weighted sum of a Nash bargaining wage and its own lagged value), $\zeta_t^N$ (labour supply preference – the time varying weight that households assign to the labour dis-utility relatively to the utility gained from consumption and real balances). In Figure 2 the smoothed paths of these variables, together with 90% HPD interval, are depicted. The shaded area denotes the period of the latest recession starting in 2008. This moment is a clear break point for the Czech labour market and the worldwide economy in general. The number

of hiring oscillated until 2006 when the short period of growth started. In 2008 it reached its peak and then collapsed during the most severe period of financial crisis. From 2011 until now this variable gained again the stability and returned on its original path. The unemployment was declining continuously till 2008, where the unemployment rate hit the bottom. After a short period of a gradual rise the variable returned to the steady state level. In the last year the unemployment seems to be at the beginning of the another period of a decline. The labour market tightness and hiring cost are tightly bounded together. Both variables were growing steadily and hit the peak in 2008 corresponding to the lowest value of the unemployment rate. When the number of unemployed is low, the labour market is tight and therefore it is more expensive for firms to hire new workers. Following a sudden dip both labour market tightness and hiring costs fluctuated slightly and in 2014 took a growth path. The real wage experienced a long period of a remarkable growth. In 2006 the level of real wages had stabilized and since then fluctuated around the steady state level. During the last periods it seems that the real wages are slightly decreasing. The last variable depicted in the Figure 2 is the labour supply preference. We can see that from 2002 to 2005 the households were giving a relatively small weight to the dis-utility from working. In 2008 this variable shot up and returned to the steady state level in 2012. During this period the labour supply preference was very high relatively to the consumption and real balances preference, meaning agents were hesitating a lot, whether to actively participate in the working process. During the last periods the variable has been decreasing significantly.

## 5 Conclusion

The comparison of two alternative wage setting model schemes revealed that the Nash bargaining wage setting with the real wage persistence, reflecting the cautious approach of agents, fits the data better than the Calvo type of wage rigidities modeling approach. During the conjuncture preceding the crisis, number of hiring were exceptionally high, corresponding with the period of the lowest unemployment throughout the last fifteen years. This boom was accompanied with the increased labour market tightness which further resulted in costly hiring for firms hiring new employees. The outbreak of a sharp economic slump that followed decreased the new hires rapidly, the unemployment shot up and households started to consider their labour supply preferences more seriously. The latest improvement in the unemployment rate, tendencies in the labour market related variables and the optimistic economic atmosphere indicate the hints of hope to the Czech labour market and the economy in general.

## Acknowledgements

This work was supported by funding of specific research at Faculty of Economics and Administration, project MUNI/A/1040/2015. This support is gratefully acknowledged.

## References

[1] Adolfson, M., Lasén, S., Lindé, J., and and Villant, M.: Bayesian estimation of an open economy DSGE model with incomplete pass-through. *Journal of International Economics* **72** (2007), 481–511.

[2] Blanchard, O., and Galí, J.: labour Markets and Monetary Policy: A New Keynesian Model with Unemployment. *American Economic Journal: Macroeconomics* **2** (2010), 1–30.

[3] Calvo, G. A.: Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics* **12** (1983), 383–398.

[4] Jääskelä, J. P., and Nimark, K.: A Medium-Scale New Keynesian Open Economy Model of Australia. *Economic Record* **87** (2011), 11–36.

[5] Němec, D.: Investigating Differences Between the Czech and Slovak Labour Market Using a Small DSGE Model with Search and Matching Frictions. *The Czech Economic Review* **7** (2013), 21–41.

[6] Němec, D.: Measuring Inefficiency of the Czech Labour Market. *Review of Economic Perspectives - Národohospodářský obzor* **15** (2015), 197–220.

[7] Sheen, J., and Wang, B. Z.: An Estimated Small Open Economy Model with Labour Market Frictions. *SSRN Electronic Journal* ( 2012).