Labour market rigidities: A DSGE approach

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Abstract. DSGE models are frequently applied tools in modern macroeconomic modelling. They are used to describe the behavior of the economy. The goal of this paper is to capture the dynamics of the labour market in a small open economy. For our estimation we chose a specific DSGE model and applied it to the Hungarian economy. This model contains search and matching mechanisms, while the wages and the worked hours are the result of the Nash bargaining problem. The wage and price rigidities are modelled according to the approach developed by Rotemberg. This method somewhat differs from the widely used Calvo price setting. The model is able to capture the great degree of openness of the Hungarian economy and the relatively high levels of frictions. Furthermore the model confirms the weakness of the trade unions. Surprisingly, the results show quite low influence of the labour market on the dynamics of the rest of the economy.

Keywords: DSGE model, labour market, frictions, search and matching, small open economy.

JEL classification: E32, J60
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1 Introduction

In this paper we try to investigate the labour market dynamics of the Hungarian economy in the time period from the second quarter of 2001 to the fourth quarter of 2013. Our selection therefore covers only the inflation targeting era. For the estimation, we use a dynamic stochastic general equilibrium (DSGE) model developed and estimated by Albertini et al. [1]. They used New Zealand data and managed to get a reasonable estimate of the behavior of the real economy.

Significant amount of papers with similar aiming were created in the past two decades. The article of Mortensen and Pissarides [7] can be considered pioneering in the developing of the search and matching framework. Their work serves as a basis for many researchers and macroeconomic modellers. Incorporating these search and matching mechanisms into their paper, Jakab and Kónya [4] estimated a model for the Hungarian economy for the period from 1995 to 2008. They divided the data to two periods given the introduction of inflation targeting in 2001 and carried out two separate estimations. They found out that many of the model parameters were affected only partially by this change, for example price stickiness slightly increased while the bargaining power of workers remained unaltered. The same model was also estimated for the Czech economy by Němec[9].

The price and wage frictions in this paper are modelled according to the approach developed by Rotemberg [12]. Same pricing method was chosen by Zanetti [13], who investigated the impact of introducing trade unions into a DSGE model. He found the model with unions to be better at replicating the business cycle properties of the euro area, than the model without them. Also using Rotemberg-style price stickiness, Neugebauer and Wesselbaum [8] compared models with and without wage and price rigidities. Their analysis on United States data shows, that the model with rigidities is significantly better at matching the properties of the observed data, than the model with no frictions. Modelling nominal rigidities based on Rotemberg [12] differs in some aspects from the widely used Calvo [3] approach. As pointed out by Lombardo and Vestin [5], Rotemberg-style price adjustment causes real costs for all firms. On the other side, Calvo-style price setting allows only a section of firms to change their prices. This

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causes a movement of demand between firms with and without optimized prices. For detailed discussion about the two types of price setting see Ascari et al. [2], Lombardo and Vestin [5] or Nisticó [10].

1.1 Characteristics of Hungarian economy

The growth of Hungarian gross domestic product was really stable until the first signs of crisis appeared in 2007. The attempt to recover from this situation failed completely after the main wave of the financial crisis hit the country in 2008. Since then the output has a downward trend. In 2001 inflation targeting was applied by the central bank. The target was continuously adjusted down from 7% to its present value of 3%. This helped to reduce the inflation from over 10% in 2000 to 3% in 2013. The average unemployment rate in the examined period was around 8%. It grew gradually from 5.5% in 2002 to its maximum of more than 11% in 2010, partially because of the crisis. The worked hours were fluctuating almost perfectly around their average, thus did not change significantly in the long run. On the other hand, the wage was strongly influenced by the crisis and dropped considerably. The data show, that while wages and hours are less volatile than the output, the volatilities of unemployment and vacancies are much higher. Furthermore, the hours and the wages are lagged behind the output by three periods and the unemployment by one.

2 The model

The small open economy model developed by Albertini et al. [1] is estimated in this paper. It is characterized by a non-Walrasian labour marker with search and matching fictions based on Mortensen and Pissarides [7]. Homogenous workers and firms meet at this market and negotiate the wage and the amount of hours worked through a Nash bargaining process. No capital or government is present. Price and wage setting problem is separated between two distinct types of domestic firms. Foreign products are imported and sold unaltered on the final good market. The model contains several kinds of frictions. First, the matching function ensures a certain delay, so the unemployed do not find jobs instantly. Second, vacancy creation is costly, so the firms do not post jobs recklessly. Finally, firms have to pay a certain adjustment cost if they want to change the wages or prices.

2.1 Labour market

At each time period t, workers can be employed or unemployed. On the other side, job positions can be filled or vacant. The number of new worker–vacancy pairs, M_t is given by Cobb-Douglas matching function with constant returns to scale:

$$M_t = \varepsilon_t^m S_t^\nu V_t^{1-\nu}, \tag{1}$$

where ε_t^m is the shock of matching efficiency, S_t is the number of job seekers, V_t is the number of vacancies and parameter $0 < \nu < 1$ represents the elasticity of the matching function. The evolution of employment, N_t can be written as:

$$N_t = (1 - \rho^x)N_{t-1} + M_t, \tag{2}$$

where ρ^x is the exogenous and constant rate of job destruction. Considering constant labour force, L (and normalizing it to 1), the number of seekers is defined by the following equation:

$$S_t = 1 - (1 - \rho^x)N_{t-1}. \tag{3}$$

Therefore the number of seekers is different from the number of unemployed ($U_t = 1 - N_t = S_t - M_t$). Moreover, employees who lose their job in time t can be re-employed in the same period.

2.2 Agents

The model consists of three agents: homogenous households, firms, and monetary authority. The utility of households depends on the amount of leisure and consumption, C_t. The set of consumption goods is defined as a combination of domestic and imported goods. The decision making is given by the following utility function:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \varepsilon_t^c \left[log(C_t - \vartheta \bar{C}_{t-1}) - N_t \kappa_t^h \frac{h_t^{1+\phi_h}}{1+\phi_h} \right]. \tag{4}$$

Parameter $0 < \beta < 1$ is the standard discount factor, ε_t^c is the preference shock, ϑ is the parameter of habit. κ_t^h represents the parameter of disutility from working, ϕ_h is the inverse of Frisch elasticity and h_t is the hours the household decides to work. The income of households consists of wage, unemployment benefits, interests from holding bonds and profits from holding firms shares.

Three kinds of firms are present in the economy. The first kind of the firms is represented by producers of domestic intermediate goods, who are the only firms hiring workers. They sell their products at a perfectly competitive market to the second type of firms, the domestic final good producers. Importers represent the third category. They offer differentiated foreign goods at the domestic market. The last two operate on monopolistically competitive markets, thus they can set the prices of their goods. However, they face quadratic price adjustment costs, as in Rotemberg [12].

Labour is the only input used by the intermediate good producers. The output, $Y_{I,t}$ is determined by a production function:

$$Y_{I,t} = \varepsilon_t^a (N_t h_t)^{\zeta}, \tag{5}$$

where ε_t^a is the productivity shock, ζ is the labor share, N_t represents the workers and h_t the hours. Maximization of profit comes from the following function:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \frac{\lambda_t}{\lambda_0} \left[mc_t Y_{I,t} - \frac{W_t}{P_{H,t}} h_t N_t - \Gamma(V_t) - \Upsilon(W_t) N_t \right], \tag{6}$$

where λ is the Lagrange multiplier from the households maximization problem. mc_t is the price for which the intermediate good producers sell their goods to the final good producers. W_t is the nominal wage, $\Gamma(V_t)$ is the hiring cost and $\Upsilon(W_t)$ is the wage adjustment cost. The hiring cost has the following form (taken from Rotemberg [11]):

$$\Gamma(V_t) = \frac{\kappa_t^v}{e} V_t^{\,e}, \tag{7}$$

where $\kappa_t^v > 0$ is the scaling factor and $e > 0$ is the elasticity of creating a vacancy. For the case when $e = 1$, the marginal cost of hiring a new employee is constant. The wage adjustment cost function has the following form:

$$\Upsilon(W_t) = \frac{\psi_W}{2} \left(\frac{\pi_{w,t}}{\tilde{\pi}_{w,t-1}} - 1 \right)^2 h_t Y_{I,t}, \tag{8}$$

where ψ_W is the wage adjustment cost parameter, $\pi_{w,t} = W_t / W_{t-1}$ is the wage inflation and $\tilde{\pi}_{w,t-1} = \pi_{w,t-1}^{\gamma_W} \bar{\pi}_w^{\gamma_W}$. Parameter γ_W serves as the weight of the wage from the previous period in the wage setting process. Wage is set along with the worked hours in a Nash bargaining process. Here the total surplus is being divided between the firms and the workers:

$$\max \varphi_t^{1-\xi_t} \mu_t^{\xi_t}, \tag{9}$$

where φ_t is the surplus of households, μ_t is the surplus of firms and parameter $0 < \xi_t < 1$ represents the bargaining power of firms.

The profit functions of the domestic final good producers and the importers look similar as the profit function in equation (6). However, they do not have wage and hiring costs and instead of wage setting cost, they face price adjustment costs.

Finally, the monetary policy is present via a simple Taylor rule:

$$i_t = i_{t-1}^{\rho_r} \left[\frac{1}{\beta} \left(\frac{E_t \pi_{t+1}}{\pi} \right)^{\rho_\pi} \left(\frac{Y_t}{Y} \right)^{\rho_Y} \left(\frac{Y_t}{Y_{t-1}} \right)^{\rho_{\Delta Y}} \left(\frac{e_t}{e_{t-1}} \right)^{\rho_e} \right]^{1-\rho_r} \varepsilon_t^m. \tag{10}$$

Thus when the monetary authority sets the nominal interest rates, it takes into consideration the interest rates from the previous period, the expected inflation, the output and the nominal exchange rate, e_t.

3 Estimation results

For the estimation of the model we use quarterly data of the Hungarian economy from the second quarter of 2001 to the last quarter of 2013. Eleven observed variables are selected – eight for the domestic economy and three for the foreign sector (represented by countries of the euro area). The variables are gross domestic product per economically active population, CPI inflation, nominal interest rate, real effective exchange rate, unemployment rate, average hours per worker, real wage, number of vacancies per economically active population and for the foreign economy: output, inflation and nominal interest rate. These data sets are acquired from the OECD and Bloomberg databases. All of them are seasonally adjusted and filtered. Domestic and foreign inflations and interest rates are demeaned and the remaining seven are detrended using Hodrick-Prescott filter with smoothing parameter $\lambda = 1600$. The Dynare 4.4.2 toolbox for MATLAB was used for the estimations.

We calibrate the model using some values from the available literature and some calculated from the data. The discount factor β is set to a frequently used value 0.99. The share of foreign goods in the domestic consumption is calculated as the import share on GDP and set to 0.4. The share of labour in production is set to 66%. Debt elasticity of financial risk premium is set to 0.001 according to Jakab and Kónya [4]. The steady state of the scaling factor, κ^v is set to 0.05 as in Lubik [6]. The scaling factor to disutility of work, κ^h is set in a way to get 1/3 of hours worked from the total amount of time. The steady state value of unemployment is calculated as the average value in the observed period and set to 0.082. The steady state of job finding rate ($\bar{f} = 0.18$) is taken from Jakab and Kónya [4]. Given the steady state equations, the separation rate is calculated as $\rho^x = \frac{\bar{f}(1-\bar{N})}{\bar{N}(1-\bar{f})} = 0.0196$.

Table 1 contains the prior densities of the estimated parameters. The prior for the deep-habit parameter is set like in Jakab and Kónya [4] to detect possible differences between the estimation results. The inverse of Frisch elasticity and the elasticity of substitution between domestis and foreign goods are set to 1. The bargaining power of firms is set to 0.8 with respect to the fact, that Hungarian trade unions are weak. With no information on the elasticity of matching, we decided to use the value in the middle of its (0,1) interval. As in Albertini et al. [1] or Lubik [6], the elasticity of vacancy adjustment is set to show linear hiring cost ($e = 1$). However, the large variance allows the cost function to change its form to concave or convex. We kept the price and wage setting parameters as they are stated in Albertini et al. [1] and combined the monetary policy parameters from Albertini et al. [1] and Jakab and Kónya [4].

Description	Symbol	Prior density	Posterior mean	90% HPDI
Habit	ϑ	$\beta(0.6, 0.15)$	0.4621	[0.3453;0.5794]
Inverse of Frisch elasticity	ϕ_h	$\Gamma(1, 0.2)$	1.2297	[1.0914;1.3550]
El. of substitution (dom. & for.)	η	$\Gamma(1, 0.2)$	0.5275	[0.4020;0.6613]
Bargaining power of firms	ξ	$\beta(0.8, 0.1)$	0.9252	[0.8515;0.9956]
Elasticity of matching	ν	$\beta(0.5, 0.2)$	0.7475	[0.6224;0.8646]
Elasticity of vacancy creation	e	$\Gamma(1, 0.5)$	3.4066	[2.7184;4.0442]
Price and wage setting				
Backward looking price (dom. good)	γ_H	$\beta(0.75, 0.1)$	0.7814	[0.6835;0.8719]
Backward looking price (for. good)	γ_F	$\beta(0.75, 0.1)$	0.8224	[0.7387;0.9329]
Backward looking wage parameter	γ_W	$\beta(0.75, 0.1)$	0.6582	[0.5389;0.7805]
Price adjustment cost (dom. good)	ψ_H	$\Gamma(50, 15)$	33.7960	[22.9016;46.8907]
Price adjustment cost (for. good)	ψ_F	$\Gamma(50, 15)$	71.4257	[51.8088;85.4372]
Wage adjustment cost	ψ_W	$\Gamma(50, 15)$	7.2486	[4.9227;9.5241
Monetary policy				
Interest rate smooth.	ρ_r	$\beta(0.5, 0.1)$	0.4645	[0.3064;0.5982]
Inflation	ρ_π	$\Gamma(1.5, 0.25)$	3.5043	[2.9219;4.0426]
Output gap	ρ_Y	$\mathcal{N}(0.25, 0.1)$	0.1359	[0.0490;0.2315]
Difference of output	$\rho_{\Delta Y}$	$\mathcal{N}(0.25, 0.1)$	0.2068	[0.0576;0.3313]
Exchange rate	ρ_e	$\mathcal{N}(0.25, 0.1)$	0.5216	[0.3545;0.6731]

Table 1 Estimation results (parameters)

	Prior density: $\beta(0.5, 0.2)$			Prior density: $\Gamma^{-1}(0.01, \infty)$		
Description	Persist.	Post. mean	90% HPDI	St. dev.	Post. mean	90% HPDI
Productivity	ρ_a	0.5686	[0.4327;0.7067]	σ_{ϵ_a}	0.0115	[0.0096;0.0133]
UIP	ρ_{uip}	0.7590	[0.6828;0.8401]	$\sigma_{\epsilon_{uip}}$	0.0066	[0.0047;0.0085]
Preference	ρ_c	0.4930	[0.3850;0.6076]	σ_{ϵ_c}	0.0756	[0.0592;0.0918]
Cost-push	ρ_H	0.3061	[0.1541;0.4429]	σ_{ϵ_H}	0.4854	[0.3316;0.6434]
Monetary	ρ_m	0.1193	[0.0335;0.1999]	σ_{ϵ_m}	0.0243	[0.0175;0.0309]
Matching	ρ_χ	0.4126	[0.2879;0.5372]	σ_{ϵ_χ}	0.1184	[0.0990;0.1375]
Bargaining	ρ_ξ	0.4373	[0.2321;0.6740]	σ_{ϵ_ξ}	0.0738	[0.0043;0.1499]
Vacancy	ρ_v	0.6508	[0.4653;0.8291]	σ_{ϵ_v}	0.0100	[0.0023;0.0178]
Disutility of work	ρ_h	0.1415	[0.0333;0.2450]	σ_{ϵ_h}	0.0999	[0.0718;0.1269]
For. output	ρ_{Y^*}	0.7539	[0.6477;0.8599]	$\sigma_{\epsilon_{Y^*}}$	0.0048	[0.0040;0.0055]
For. inflation	ρ_{π^*}	0.5928	[0.4606;0.7320]	$\sigma_{\epsilon_i^*}$	0.0017	[0.0014;0.0019]
For. int. rate	ρ_{i^*}	0.6889	[0.6188;0.7621]	$\sigma_{\epsilon_{\pi^*}}$	0.0041	[0.0034;0.0048]

Table 2 Estimation results (shocks)

Table 1 also contains the posterior means and 90% highest posterior density intervals (HDPI) of the estimated parameters. The estimated value of habit parameter (0.46) is much smaller than the value estimated by Jakab and Kónya [4], 0.68. One of the reasons for this difference could be the presence of the financial crisis period in our estimation. During recessions the households do not want to or cannot afford to consume as much as in the previous periods, therefore the weight of the past consumption declines. The bargaining power of firms is estimated to be really high (0.93), as was originally expected. This means, that firms get almost all surplus generated by the filled jobs. Also employees have practically no vote when negotiating wages. Elasticity of vacancy creation is estimated relatively high with value 3.4. This means, that the vacancy creation cost function is convex, thus each additional posted vacancy costs more, than the previous. The wage and price adjustment parameters show, that it is much easier (cheaper) to change the wage. Therefore the wages adapt quicker than prices. From the two prices, it is less costly to adjust the prices of the domestically produced goods. This is probably because the importers have to take into consideration the varying exchange rates when changing the prices. The interest rate smoothing parameter in the Taylor rule is relatively small, only 0.46 and the reaction to inflation is high, 3.5. The estimations of Jakab and Kónya [4] are 0.7 and 1.53 respectively. However, this significant difference can come from the different form of the Taylor rule, since their monetary rule does not include the gap and the first difference of the output. The estimation results of the persistence

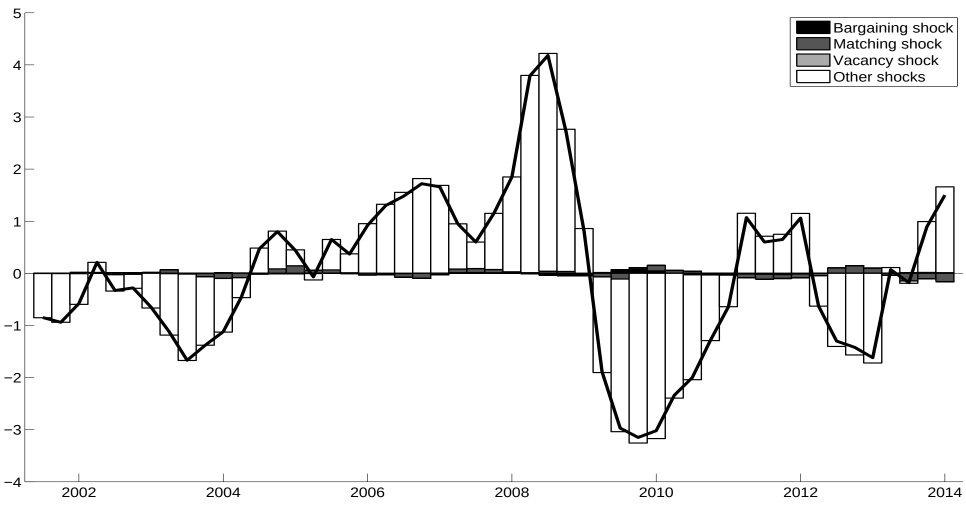

Figure 1 Variance decomposition of output

and deviation of shocks are presented in table 2. The monetary shock is the less persistent. It takes only half year for this shock to reach 10% of its initial value, while it takes more than five periods for the productivity shock to do the same. The cost-push shock is by far the most volatile. On the other hand, the volatilities of foreign shocks are the lowest.

4 Conclusion

The estimation of parameters seems to be reasonably consistent with the literature. We find rather high values of price frictions in the Hungarian economy, while the wage frictions are somewhat smaller. The model also captures the low participation rate in trade unions. Furthermore, we get similar results of the historical shock decomposition of output as Albertini et al. [1], presented in the figure 1. The model shows almost no reaction of the output to the labour market shocks. Its fluctuation is given solely by the non-labour market shocks (in the figure depicted as the sum of the *other shocks*).

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