

THE EMPIRICAL IMPORTANCE OF HABIT FORMATION IN DSGE MODELS: A BAYESIAN INVESTIGATION FOR POLISH ECONOMY

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Abstract

In this paper I present the small scale DSGE model of staggered wage and price contracts with internal habit formation, where the utility from a current consumption is affected by the level of the consumer's own past consumption. Internal habit formation seems to be a reasonable compromise between catching up with the Joneses, where the reference level of consumption is given by the consumption of representative agent and deep habits. In order to assess the empirical importance of habit formation I estimate and compare using Bayesian techniques two variants of DSGE model: one with habit formation and the other without habit formation. The estimation and comparison is based on quarterly data for Polish economy. The results suggest that model with habit formation is clearly favored by the data. However, obtained Bayes factor seems to be very low in comparison to results for other economies. Comparison of impulse response functions shows that introduction of habit formation has rather limited impact on propagation mechanisms. Moreover, obtained posteriors seem to be stable between these models.

Keywords: Habit formation, Bayesian model comparison, DSGE models

Introduction

Habit formation in consumption is a widely used real friction in the dynamic stochastic general equilibrium models (DSGE). Historically, it was introduced by Abel [1990] and Constantinides [1990] to explain the equity premium puzzle, identified by Mehra and Prescott [1985], which cannot be solved using standard time-separable utility function and reasonable calibration of discount factor and relative risk aversion parameter. Introduction of habit formation to modern DSGE models was proposed by Christiano, Eichenbaum and Evans [2005]. It causes that model is able to generate hump-shaped response of consumption to various shocks that is more comparable to the results obtained from VAR models. Moreover, works by Smets and Wouters [2007] and Adolfson et. al. [2007] confirm that introduction of habit formation improves model fit to the data.

This paper presents the small scale DSGE model with internal habit formation, where the utility from a current consumption is affected by the level of the consumer's own past consumption. Internal habit formation seems to be a reasonable compromise between catching up with the Joneses, where the reference level of consumption is given by the consumption of representative agent and deep habits, proposed by Ravn, Schmitt-Grohe and Uribe [2006]. Moreover, following Erceg, Henderson and Levine [2000], I introduce price and wage rigidities in the spirit of Calvo [1983] to the model. The works by Rabanal and Rubio-Ramirez [2005; 2008] and Kuchta [2014] confirm the empirical importance of sticky wages assumption.

In order to assess the empirical importance of habit formation the model is estimated in two variants: one with habit formation and the other without habit formation using

Bayesian techniques. Next, the Bayesian model comparison is applied. The estimation and comparison are based on quarterly data for Polish economy. The results suggest that model with habit formation is clearly favored by the data. However, obtained Bayes factor seems to be very low in comparison to results for other economies. Moreover, obtained posteriors seem to be stable between these models.

The remainder of the paper is organized as follows. In the next section the theoretical model is derived and described. The third section contains a short description of estimation and comparison methods. The obtained results are presented in section forth. Finally, the last section presents some conclusions.

Model

The final good (Y_t) is produced by a perfectly competitive, representative firm, which combines a continuum of intermediate goods, indexed by $j \in [0;1]$, using the following technology [Dixit, Stiglitz, 1977]:

$$Y_t = \left[\int_0^1 (Y_t^j)^{\frac{1}{1+\tau_p}} dj \right]^{1+\tau_p} \quad (1)$$

where $\tau_p > 0$ is parameter, that govern the mark-up of the intermediate-goods firm, and Y_t^j represents the input of intermediate good j . The perfectly competitive firm takes its output price (P_t) and its input prices (P_t^j) as given and seeks to maximize profits. The profit maximization problem implies following optimal demand for the inputs:

$$Y_t^j = \left(\frac{P_t^j}{P_t} \right)^{-\frac{1+\tau_p}{\tau_p}} Y_t \quad (2)$$

where the output price has the form of:

$$P_t = \left[\int_0^1 (P_t^j)^{-\frac{1}{\tau_p}} dj \right]^{-\tau_p} \quad (3)$$

Each intermediate good j is produced by a monopolistically competitive firm j using the following technology with a constant return to scale:

$$Y_t^j = \varepsilon_t^a L_t^j \quad (4)$$

where L_t^j is the labor input and ε_t^a represents productivity shock, which it is assumed to be identical to each firm and follow a first order autoregressive process of the form:

$$\ln \varepsilon_t^a = \rho_a \ln \varepsilon_{t-1}^a + \eta_t^a; \quad \eta_t^a \sim iid N(0; \sigma_a^2) \quad (5)$$

where $\rho_a \in (0;1)$ is autoregressive parameter. Linear relationship between input of labor and output causes that real total cost is also linear, which means that real marginal cost (RMC_t^j) is independent of output and directly related with real wage (w_t) and productivity shock:

$$RMC_t = \frac{w_t}{\varepsilon_t^a} \quad (6)$$

Each intermediate-goods producing firm has some monopolistic power on the market, which causes that each of them can choose the price of produced goods. It is assumed that price-setting mechanism is governed by Calvo scheme. In each period there is set of a randomly chosen firms, with the measure $1 - \theta_p \in (0;1)$, which can set price optimally. Rest of firms leave the price unchanged. Calvo scheme implies that price of output (3) evolve according to:

$$P_t = \left[(1 - \theta_p) (P_t^*)^{-\frac{1}{\tau_p}} + \theta_p (P_{t-1})^{-\frac{1}{\tau_p}} \right]^{-\tau_p} \quad (7)$$

where $\theta_p \in (0;1)$ is parameter of price rigidities and P_t^* is optimally chosen price, set in period t . In this period each firm that can choose price optimally, set it to maximize the stream of expected profits:

$$E_t \left\{ \sum_{\tau=0}^{\infty} (\beta \theta_p)^\tau \frac{\lambda_{t+\tau}}{\lambda_t} \left(\frac{P_t^*}{P_{t+\tau}} - RMC_{t+\tau} \right) Y_{t+\tau} \right\} \quad (8)$$

subject to the demand constraint (2), where $\beta \frac{\lambda_{t+\tau}}{\lambda_t}$ is marginal rate of substitution between period $t + \tau$ and t , and it is used the fact that in the present of linear production technology marginal cost is equal to average cost, if fixed costs are zero. The first order condition of the firm is given by:

$$E_t \left\{ \sum_{\tau=0}^{\infty} (\beta \theta_p)^\tau \frac{\lambda_{t+\tau}}{\lambda_t} Y_{t+\tau}^* \left((1 + \tau_p) RMC_{t+\tau} - \frac{P_t^*}{P_{t+\tau}} \right) \right\} = 0 \quad (9)$$

It is assumed that economy is populated by continuum of monopolistically competitive households, indexed by $i \in [0;1]$. Each household supplies a differentiated and imperfect substitute labor service and derives utility from consumption (C_t^i) and disutility from hours worked (L_t^i):

$$\sum_{\tau=0}^{\infty} \beta^\tau E_t \left\{ \varepsilon_{t+\tau}^b \left[\ln(C_{t+\tau}^i - h C_{t+\tau-1}^i) - \varepsilon_{t+\tau}^l \frac{(L_{t+\tau}^i)^{1+\delta_i}}{1+\delta_i} \right] \right\} \quad (10)$$

where $h \in (0;1)$ is parameter of internal habit formation, $\delta_i > 0$ represents the inverse of the elasticity of labor supply, ε_t^b and ε_t^l denote preference shock and labor supply shock, respectively. It is assumed that each of them follow a first-order autoregressive process of the form:

$$\ln \varepsilon_t^b = \rho_b \ln \varepsilon_{t-1}^b + \eta_t^b; \eta_t^b \sim iid N(0; \sigma_b^2) \quad (11)$$

$$\ln \varepsilon_t^l = \rho_l \ln \varepsilon_{t-1}^l + \eta_t^l; \eta_t^l \sim iid N(0; \sigma_b^2) \quad (12)$$

where $\rho_b \in (0;1)$ and $\rho_l \in (0;1)$ are autoregressive parameters.

The intertemporal budget constraint has the form:

$$\frac{B_t^i}{R_t P_t} + C_t^i = \frac{B_{t-1}^i}{P_t} + w_t^i L_t^i + D_t^i + d_t \quad (13)$$

where B_t^i represents the amount of one-period riskless bonds purchased in period t , R_t is the gross nominal interest rate, w_t^i is real wage, D_t^i is the household's net real income from participating in state-contingent securities at time t and d_t represents the shares in the intermediate firm's profits.

The household chooses the amount of consumption goods and one-period riskless bonds to maximize (10) subject to (13). The first order conditions are given by:

$$\lambda_t^i = \beta E_t \left\{ \lambda_{t+1}^i \frac{R_t}{\pi_{t+1}} \right\} \quad (14)$$

under transversality condition:

$$\lim_{t \rightarrow \infty} \beta^t \lambda_t^i B_t^i = 0 \quad (15)$$

where:

$$\lambda_t^i = \frac{\varepsilon_t^b}{C_t^i - hC_{t-1}^i} - \beta h E_t \left\{ \frac{\varepsilon_{t+1}^b}{C_{t+1}^i - hC_t^i} \right\} \quad (16)$$

is the marginal utility of consumption. Moreover in the model without habit formation ($h = 0$) the marginal utility of consumption is reduced to:

$$\lambda_t^i = \frac{\varepsilon_t^b}{C_t^i} \quad (17)$$

It is assumed that there are labor agencies which aggregate heterogeneous, individual for each household, labor services in a homogenous input factor using following technology:

$$L_t = \left[\int_0^1 (L_t^i)^{\frac{1}{1+\tau_w}} di \right]^{1+\tau_w} \quad (18)$$

where: $\tau_w > 0$ represents the household's mark up. Labor agency tends to maximize profits and chooses labor input taking its prices as a given. Optimal demand for an individual labor has the form of:

$$L_{t+s}^i = \left(\frac{W_t^i}{W_{t+s}} \right)^{\frac{1+\tau_w}{\tau_w}} L_{t+s} \quad (19)$$

where: W_t^i represents individual nominal wage of household and

$$W_t = \left[\int_0^1 (W_t^i)^{\frac{1}{\tau_w}} di \right]^{-\tau_w} \quad (20)$$

is an index of nominal wage.

It is assumed that each household has some monopolistic power and can choose nominal wage. Similarly to the price-setting mechanism, the wage-setting mechanism is governed by Calvo scheme. In each period a set of randomly chosen households can choose their wage optimally, to maximize (10) subject to (13) and (19), whereas rest of the households leaves their nominal wage unchanged. Introduction of sticky wages in the spirit of Calvo implies that nominal wage evolve according to:

$$W_t = \left[\theta_w (W_{t-1})^{\frac{1}{\tau_w}} + (1 - \theta_w) (W_t^*)^{\frac{1}{\tau_w}} \right]^{-\tau_w} \quad (21)$$

where: W_t^* is the optimal nominal wage, which is given by the first order condition of the form:

$$\sum_{s=0}^{\infty} (\beta \theta_w)^s E_t \left\{ L_{t+s}^* \left[(1 + \tau_w) MUL_{t+s}^* - \lambda_{t+s}^i \frac{W_t^*}{P_{t+\tau}} \right] \right\} = 0 \quad (22)$$

where: L_t^* and MUL_t^* are the labor demand and marginal disutility of labor at this wage, respectively.

The equilibrium conditions at the labor market and the market of intermediate goods imply that:

$$\frac{1}{\Delta_p} \int_0^1 Y_t^j dj = Y_t \quad (23)$$

$$\frac{1}{\Delta_w} \int_0^1 L_t^i di = L_t \quad (24)$$

where: $\int_0^1 Y_t^j dj$ represents aggregate supply of intermediate goods, $\int_0^1 L_t^i di$ is aggregate supply

of labor services, $\Delta_t^p \equiv \int_0^1 \left(\frac{P_t^j}{P_t}\right)^{-\frac{1+\tau_p}{\tau_p}} dj \geq 1$ and $\Delta_t^w \equiv \int_0^1 \left(\frac{W_t^i}{W_t}\right)^{-\frac{1+\tau_w}{\tau_w}} di \geq 1$ measure the ineffective

price and wage dispersions in the economy, respectively [see: Yun, 1996; Christiano, Trabandt, Walentin, 2010]. Moreover, the equilibrium condition at the final goods market is given by:

$$Y_t = C_t \quad (25)$$

In considered model the gross nominal interest rate is controlled by the Central Bank, which chooses its level according to Taylor rule [1993] of the form:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\left(\frac{\pi_t}{\pi}\right)^{\phi_\pi} \left(\frac{Y_t}{Y}\right)^{\phi_y} \right]^{(1-\rho_R)} \exp(\eta_t^R); \quad \eta_t^R \sim iid N(0; \sigma_R^2) \quad (26)$$

where: variables without time subscript denote its levels in steady state and $\rho \in (0;1)$ is the smoothing parameter, ϕ_π and ϕ_y are the long-run responses of the monetary authority to deviation of inflation and output from their steady state values.

Estimation and comparison methods

In this part I present the method of estimation which is used to estimate structural parameters of the DSGE model. The procedure of estimation consists of several steps. In the first step the model is log-linearized around the deterministic steady state. Next, it is solved using perturbation method based on first order approximation of the policy and transition functions [Schmitt-Grohe, Uribe, 2004]. The solution of model can be interpreted as the transition equation in the state-space representation of the DSGE model. In the third step I use empirical time-series to construct measurement equation to obtain state-space model. In the next step the Kalman filter is used to evaluate likelihood function [see Hamilton, 1994, p. 372-409; Canova, 2007, p. 214-220]. After that, Bayes theorem is used to construct posterior distribution of parameters of interest according to the formula written below [Fernandez-Villaverde, 2010, p. 9; Kuchta 2011]:

$$p(\boldsymbol{\theta} | \mathbf{x}^T, m_i) = \frac{p(\boldsymbol{\theta} | m_i) p(\mathbf{x}^T | \boldsymbol{\theta}, m_i)}{p(\mathbf{x}^T | m_i)} \quad (27)$$

where: $p(\boldsymbol{\theta} | \mathbf{x}^T, m_i)$ represents posterior distribution for the model m_i , $p(\boldsymbol{\theta}, m_i)$ is the prior distribution, $p(\mathbf{x}^T | \boldsymbol{\theta}, m_i)$ is the likelihood function and $p(\mathbf{x}^T | m_i)$ denotes marginal density of data which is defined as [Kass, Raftery, 1995]:

$$p(\mathbf{x}^T | m_i) = \int p(\boldsymbol{\theta} | m_i) p(\mathbf{x}^T | \boldsymbol{\theta}, m_i) d\boldsymbol{\theta} \quad (28)$$

The marginal data density averages all possible likelihoods across the parameter space, using the prior as a weight. It takes into account that the size of the parameter space for different model can be different. Hence, more complicated models will not necessarily rank better than simpler models, if the extra parameters are unimportant [Rabanal, 2007, p. 924-295]. Moreover, it can be also used to compare misspecified and/or nonnested models [Fernandez-Villaverde, Rubio-Ramirez, 2004] and it is directly related to the predictive density function [Smets, Wouters, 2003, p. 1139].

In order to compare alternative DSGE models I apply posterior odds ratio of the form [Fernandez-Villaverde, Rubio-Ramirez, 2004, p. 157-158]:

$$POR_{i,j} = \frac{p(m_i) p(\mathbf{x}^T | m_i)}{p(m_j) p(\mathbf{x}^T | m_j)} \quad (29)$$

where: $\frac{p(m_i)}{p(m_j)}$ is prior odds ratio and $\frac{p(\mathbf{x}^T | m_i)}{p(\mathbf{x}^T | m_j)}$ is the Bayes factor. Due to the fact that there are any important circumstances, I assign both models the same prior probability. Moreover I adopt from Jefferson [see Kass, Raftery, 1995] that Bayes factor higher than 150 means that one of compared models is strongly favored by the data.

Estimation and comparison is based on set for a Polish economy from I quarter 1995 to IV quarter 2011 which consist of real GDP in per capita terms, real average wage, CPI and the short-run (3 month) nominal interest rate. All data were expressed as logs, seasonally adjusted and transformed in the percent deviation from steady-state using Hodrick-Prescott filter [Hodrick, Prescott, 1997].

Results

This part presents results of estimation and comparison of considered models. To obtain posterior distribution I apply Random-Walk Metropolis algorithm [see An, Schorfheide, 2007, p. 131] which consists of two chains, each of 400.000 draws. Posteriors are evaluated using only the last 100.000 draws. This ensures that the algorithm converged. Before estimation I divide parameters into two groups. First group consists of discount factor and household mark up parameter which are calibrated at the values 0.99 and 0.1, respectively. For the second group I choose prior distributions which are presented in table 1. Chosen priors ensure that possible values of parameters are consistent with economics assumption.

Results of the estimation are presented in table 1. Obtained posteriors seem to be similar in both models in spite of the fact that the estimated parameter of habit formation is statistically significant and implies high level of habits in Polish economy. According to presented results, significant level of price stickiness in Polish economy is observed. Estimate of the sticky price parameters suggests that the average duration of price is in the range of 4.3 to 10 quarters. These findings seem to be consistent with previous results for Polish economy [see Baranowski, Szafranski, 2012]. Obtained posteriors suggest also a moderate level of nominal wage stickiness. Estimate of the sticky wage parameter implies that the average duration of wage contract is found in the range of 2 to 3.7 quarters. It is quite surprising that the level of wage stickiness is much lower than the level of price stickiness, but it is consistent with other estimations of DSGE models for Polish economy [see Krajewski, 2013]. Moreover, the estimates of the parameters in Taylor rule suggest that in case of Polish economy, significant level of nominal interest rate smoothing and rather poor long-run response of the monetary authority to deviation of inflation from it steady state value are observed.

Table 1 Estimation results

Parameter	Prior		Posterior*	
	Type	Mean (Std. errs.)	Model with habit formation	Model without habit formation
δ_l	Gamma	1.25 (0.50)	0.89 (0.31; 1.50)	0.82 (0.28; 1.38)
h	Beta	0.50 (0.20)	0.76 (0.67; 0.87)	-
θ_p	Beta	0.50 (0.20)	0.83 (0.77; 0.89)	0.84 (0.79; 0.90)
θ_w	Beta	0.50 (0.20)	0.60 (0.49; 0.69)	0.62 (0.50; 0.73)
ρ	Beta	0.50 (0.20)	0.77 (0.71; 0.83)	0.71 (0.64; 0.77)
ϕ_π	Gamma	1.50 (0.25)	1.44 (1.12; 1.77)	1.27 (1.01; 1.54)
ϕ_y	Gamma	0.125 (0.05)	0.13 (0.07; 0.20)	0.21 (0.12; 0.30)
ρ_a	Uniform	0.50 (0.29)	0.48 (0.29; 0.68)	0.48 (0.29; 0.65)
ρ_b	Uniform	0.50 (0.29)	0.09 (0.00; 0.20)	0.81 (0.70; 0.92)
ρ_l	Uniform	0.50 (0.29)	0.03 (0.00; 0.06)	0.02 (0.00; 0.06)
σ_a	Uniform	0.50 (0.29)	0.08 (0.03; 0.13)	0.09 (0.03; 0.15)
σ_l	Uniform	0.50 (0.29)	0.61 (0.30; 0.93)	0.64 (0.29; 1.00)
σ_b	Uniform	0.50 (0.29)	0.06 (0.03; 0.08)	0.02 (0.01; 0.03)
σ_r	Uniform	0.50 (0.29)	0.0026 (0.002; 0.003)	0.0028 (0.002; 0.003)
Log marginal data density			-295.54	-300.61
Bayes factor			159.17	

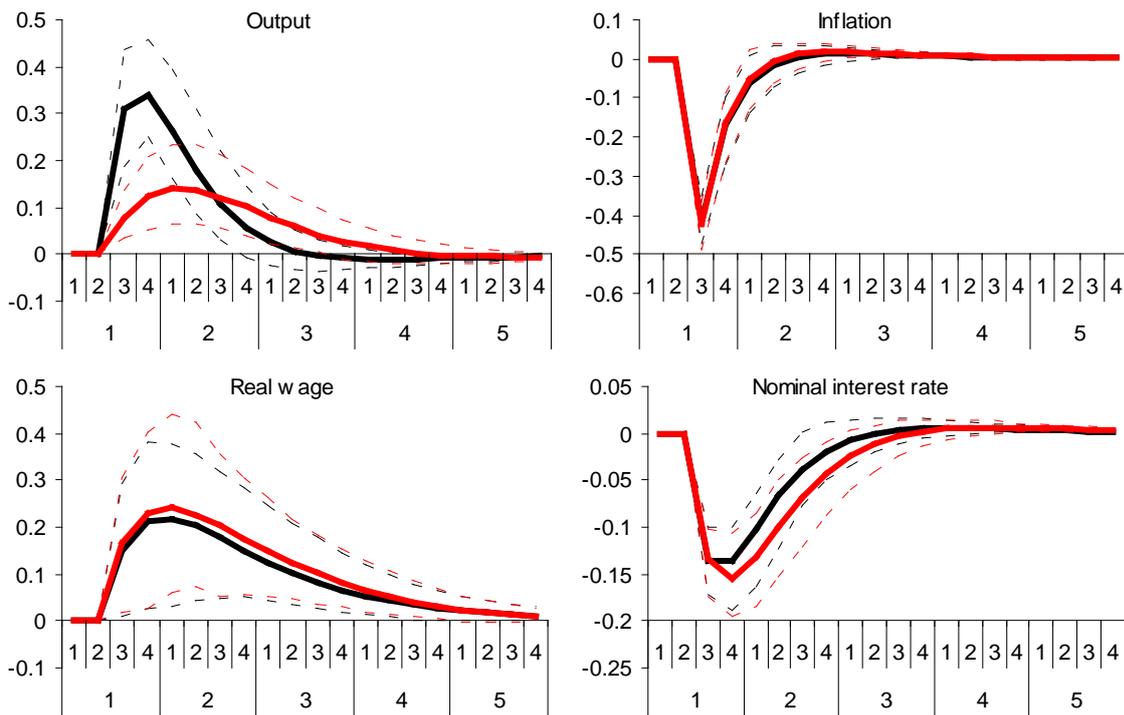
Source: own calculations in Dynare 4.2.5.

Note:* presented values are means of the posteriors and in the parenthesis are 5th and 95th percentiles.

The draws obtained from Metropolis algorithm are also used to evaluate marginal data densities by applying the modified harmonic mean estimator. Received values together with Bayes factor which relates model with habit formation to the model without habit formation are presented in table 1. The value of Bayes factor is equal to 159. It suggests that model with habit formation is strongly favored by the data. This result is consistent with the findings for U.S. [Smets, Wouters, 2007] and euro area [Adolfson, Laseen, Linde, Villani, 2007]. However, its value seems to be very low in comparison with works by Smets, Wouters and Adolfson, Laseen, Linde and Villani. It is supposed that the low value of Bayes factor is mainly determined by the low dimension of the set of observable variables.

To evaluate impact of the introduction of habit formation to the propagation mechanism of the model of price and wage rigidities I compare impulse response functions for model with and without habit formation. I present only the responses for the output, real wage, inflation and nominal interest rate, because they are used as the observables in estimation and the explanation of their dynamics determines the results of the Bayesian comparison. Figure 1 presents selected moments (median, 5th and 95th percentile of distribution) of the posterior distributions of impulse response functions in case of temporary and positive shock in technology. The black lines represent response of the model without habit formation and the red lines – response of the model with habit formation.

Figure 1 Impulse response functions – technological shock



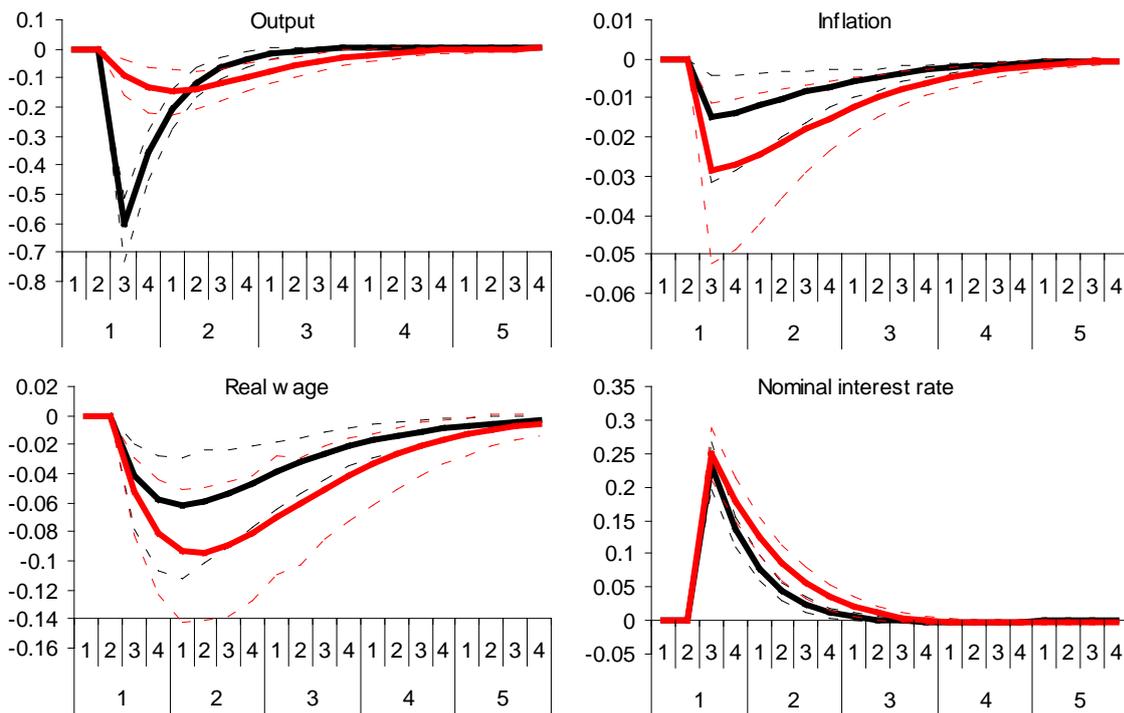
Source: own calculations in Dynare 4.2.5.

Note: black solid line – median for the model without habit formation, black dotted lines – 5th and 95th percentiles for the model without habit formation, red solid line – median for the model with habit formation, red dotted lines – 5th and 95th percentile for the model with habit formation.

In the theoretical model, higher level of technology increases the marginal product of labor sharply and causes that output and real wage grow. Introduction of wage and price rigidities leads to the sluggish response of real wage. As the consequence, the real wage increases through a year from the beginning of disturbance. Gradual growth of real wage results in immediate decrease of real marginal cost, because level of technology increases instantaneously. These changes cause that inflation decreases in the period of technological disturbance. The decrease of inflation despite the increase of output leads to decrease of nominal interest rate, which is consistent with Taylor rule.

Introduction of habit formation into the model of price and wage rigidities has rather small impact of the response to technological shock. It is quite surprising that obtained estimates of the reactions of inflation, real wage and nominal interest rate are similar in both models. Different response is only observed in case of output. The introduction of habit formation causes slightly more sluggish response. This arise from the fact that in case of habit formation households are interested in more spread response to changes in real income, since they are aware that if they consume more today, they should consume even more in the future, in order to remain at the same level of utility.

Figure 2 Impulse response functions – monetary policy shock



Source: own calculations in Dynare 4.2.5.

Note: black solid line – median for the model without habit formation, black dotted lines – 5th and 95th percentiles for the model without habit formation, red solid line – median for the model with habit formation, red dotted lines – 5th and 95th percentile for the model with habit formation.

Figure 2 presents selected moments (median, 5th and 95th percentile of distribution) of the posterior distributions of impulse response functions in case of temporary and positive shock in monetary policy. The black lines represent response of the model without habit formation and the red lines – response of the model with habit formation.

The appearance of monetary policy disturbance sharply raises the nominal interest rate above the steady state and thus increases its real value. Higher level of real interest rate encourages households to increase savings and reduce the consumption demand. As the consequence, fall in output is observed. Moreover, decrease of consumption demand forces firms to reduce labor demand and households to reduce their real wages. Similarly to technological shock, response of real wage is rather sluggish, because of introduction of staggered wage and price contracts. Moreover, the dynamics of real wage strongly determine the behavior of real marginal cost from a one side, and inflation from the other side. As the consequence inflation falls.

Introduction of habit formation into the model of sticky wages and prices has rather limited impact of the response to monetary policy shock. Similarly to technological shock, the main difference is observed in response of output. In the model without habit formation, the appearance of monetary policy shock results in sharp decrease of output, whereas in the model with habit formation the response of output is sluggish and hump-shaped. Moreover, the responses of real wages and inflation are stronger in the model with, than in the model without habit formation.

Conclusion

This paper evaluated the empirical importance of the introduction of habit formation into small scale DSGE model of price and wage rigidities. Habit formation implied that the utility from a current consumption is affected by the level of past consumption and led to

sluggish response of consumption to changes in real income. The analysis was based on quarterly data for Polish economy from 1995:1 to 2011:4. To assess the empirical importance of habit formation, two version of the theoretical model was estimated and compared using Bayesian techniques. Moreover, this paper presented the comparison of impulse response functions with respect to technological and monetary policy shocks.

Obtained results suggested that model with habit formation was strongly favored by the data in comparison with model without habit formation. However, estimated Bayes factor was very low in comparison with results for other economies. It was supposed that the low value of Bayes factor was mainly determined by the low dimension of the set of observable variables. This conclusion was partially supported by the results of impulse response comparison. The comparison shown that introduction of habit formation had rather limited effect on propagation mechanism of the disturbances in the model of staggered price and wage contracts. The differences were only observed in the response of output which seems to be more sluggish and hump-shaped in the model with habit formation than in the model without habit formation. This arose from the fact that in case of habit formation households were interested in more spread responses to changes in real income, since they were aware that if they consume more today, they should consume even more in the future, in order to remain at the same level of utility.

References:

- Abel A.B. [1990] “Asset Prices under Habit Formation and Catching up with the Joneses”, *The American Economic Review*, Vol. 80, No. 2., pp. 28 – 42.
- Adolfson M., Laseen S., Linde J., Villani M. [2007] “Bayesian estimation of an open economy DSGE model with incomplete pass-through”, *Journal of International Economics*, No. 72, pp. 481 – 511.
- An S., Schorfheide F. [2007] “Bayesian Analysis of DSGE Models”, *Econometric Reviews*, Vol 26, No. 2 – 4, pp. 113 – 172.
- Baranowski P., Szafranski G. [2012] “Reakcja gospodarki polskiej na szok polityki pieniężnej w małym modelu DSGE – na ile wybór metody estymacji determinuje wyniki?”, *Bank i Kredyt*, No. 43 (4), pp. 119 – 144.
- Calvo G.A. [1983] “Staggered Prices in a Utility-Maximizing Framework”, *Journal of Monetary Economics*, No. 12, pp. 383 – 398.
- Canova F. [2007] “Methods for Applied Macroeconomic Research”, *Princeton University Press*, Princeton and Oxford.
- Christiano L.J., Eichenbaum M., Evans Ch.L. [2005] “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy”, *Journal of Political Economy*, Vol. 113, No. 1, pp. 1-45.
- Christiano, Trabandt, Walentin [2010] “DSGE Models for Monetary Policy Analysis”, *NBER Working Papers Series*, No. 16074.
- Constantinides G.M. [1990] “Habit Formation: a Resolution of the Equity Premium Puzzle”, *The Journal of Political Economy*, Vol. 98, No. 3, pp. 519 – 543.
- Dixit A.K., Stiglitz J.E. [1977] “Monopolistic Competition and Optimum Product Diversity”, *The American Economic Review*, Vol. 67, No. 3, pp. 297 – 308.
- Erceg Ch.J., Henderson D.W., Levin A.T. [2000] “Optimal monetary policy with staggered wage and price contracts”, *Journal of Monetary Economics*, No. 46, pp. 281 – 313.
- Fernandez-Villaverde J. [2010] “The econometrics of DSGE models”, *SERIEs: Journal of the Spanish Economic Association*, No. 1, pp. 3 – 49.
- Fernandez-Villaverde J., Rubio-Ramirez J.F. [2004] “Comparing dynamic equilibrium models to data: a Bayesian approach”, *Journal of Econometrics*, No. 123, pp. 153 – 187.

- Hamilton J.D. [1994] „Time Series Analysis”, *Princeton University Press*, Princeton, New Jersey.
- Hodrick R.J., Prescott E.C. [1997] “Postwar U.S. Business Cycles: An Empirical Investigation”, *Journal of Money, Credit and Banking*, Vol. 29, No. 1, pp. 1 – 16.
- Kass R.E., Raftery A.E. [1995] “Bayes Factors”, *Journal of the American Statistical Association*, Vol. 90, No. 430, pp. 773 – 795.
- Krajewski P. [2013] “Oddziaływanie wydatków rządowych na rynek pracy”, *Wiadomości Statystyczne*, No. 1 (620), pp. 1 – 13.
- Kuchta Z. [2011] “Bayesian Estimation of Real Business Cycle Model: The Case of Poland”, *AD ALTA – Journal of Interdisciplinary Research*, Vol 1., pp. 59 – 64.
- Kuchta Z. [2014] “Szttywność płac nominalnych w modelach DSGE małej skali. Analiza empiryczna dla gospodarki Polski”, *mimeo*.
- Mehra R., Prescott E.C. [1985] “The Equity Premium: A Puzzle”, *Journal of Monetary Economics*, No. 15, pp. 145 – 161.
- Rabanal P. [2007] “Does inflation increase after a monetary policy tightening? Answers based on an estimated DSGE model”, *Journal of Economic Dynamics & Control*, No. 31, pp. 906 – 937.
- Rabanal P., Rubio-Ramirez R. [2005] “Comparing New Keynesian models of the business cycle: A Bayesian approach”, *Journal of Monetary Economics*, No. 52, pp. 1151 – 1166.
- Rabanal P., Rubio-Ramirez R. [2008] “Comparing new Keynesian models in the Euro area: a Bayesian approach”, *Spanish Economic Review*, No. 10, pp. 23 – 40.
- Ravn M., Schmitt-Grohe S., Uribe M. [2006] “Deep Habits”, *Review of Economic Studies*, No. 73, pp. 195-218.
- Schmitt-Grohe S., Uribe M. [2004] “Solving dynamic general equilibrium models using a second-order approximation to the policy function”, *Journal of Economic Dynamics & Control*, No. 28, pp. 755 – 775.
- Smets F., Wouters R. [2003] “An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area”, *Journal of the European Economic Association*, Vol. 1, No. 5, pp. 1123 – 1175.
- Smets F., Wouters R. [2007] “Shocks and Friction in US Business Cycles: A Bayesian DSGE Approach”, *The American Economic Review*, Vol. 97, No. 3, pp. 586 – 606.
- Taylor J.B. [1993] “Discretion versus policy rules in practice”, *Carnegie-Rochester Conference Series on Public Policy*, No. 39, pp. 195 – 214.
- Yun T. [1996] “Nominal price rigidity, money supply endogeneity, and business cycles”, *Journal of Monetary Economics*, No. 37, pp. 345 – 370.