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The Believe or not to Believe: Monetary Policy and Trends in House Prices

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To believe or not to believe: monetary policy and the trend in house prices *

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Abstract

House prices are usually characterized by periods of long-lasting growth that lead to uncertainty concerning their sustainability (i.e. whether house prices will eventually fall). This uncertainty is of special importance for central banks: the reversals in house prices are often associated with a credit crunch and a long-lasting and painful recession. Furthermore, monetary policy - incorrectly assessing the sustainability of house prices - may further amplify the impact of house prices on the economy. In order to analyze the costs of this mistake I compare the performance of two policy rules that are optimal under extreme assumptions: 1. there is a housing shock that leads to the persistent deviations of house prices from the long-run trend and 2. there is no such a shock and house prices deviate from the trend only due to the impact of other shocks. I show that the central bank minimizing these costs should act as if the growth in house prices is temporary. If the central bank incorrectly assumes that growth in house prices is sustainable it conducts too loose monetary policy that significantly increases fluctuations of output gap and inflation.

JEL: E32, E52, E58

Keywords: monetary policy, asset prices, model uncertainty, robust control

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1 Introduction

The role of house prices in monetary policy has been widely discussed by both central bankers and academics during recent years. House prices are usually characterized by periods of long-lasting growth and housing booms that are associated with rapid credit growth (as housing is usually bought with credit and it serves often as collateral; see e.g.: Borio and Lowe, 2002). Furthermore, housing is an asset owned by the significant share of households (see: Cecchetti, 2008). Thus, it is an important item in household balance sheet. It is also of high importance for monetary authorities, as bursting of a housing bubble may destabilize the economy leading to a credit crunch, dramatic drop in consumption and investment, and - as a result - a long-lasting and painful recession. The importance of house prices for monetary policy is reflected in an interesting stream of literature which investigates optimal response of monetary policy to asset prices (see e.g. Bernanke and Gertler, 2001; Borio and Lowe, 2002; Cecchetti, 2008; Gilchrist and Leahy, 2002).

Although the consensus among the central banks seems to move towards treating house prices as an indicator of imbalances in financial market, even recent experience gained during the financial crisis did not provide central bankers and researchers with a satisfactory answer to the very fundamental question: whether persistently growing house prices will eventually fall. This issue is associated with uncertainty concerning the assessment of the extent to which house prices deviate from the long-run trend. Depending on information set and the central banks' beliefs, the trend can be perceived in a variety of ways leading do different assessment of the deviations from it (see Figure 1 that presents different trends and deviations from them for house prices in the US depending on the information set and filtering procedure). This assessment is crucial for thinking about monetary policy in a business cycle, as it is assummed that the central bank can impact only the cyclical fluctuations in the economic activity.

A long-lasting growth in house prices often rises a question whether it is sustainable which is usually a bone of contention for both researchers and central bankers. Neither statistical methods nor proxies for so called fundamental value of house prices help to resolve this disagreement because housing boom enthusiasts usually find “good reasons” for the price growth. In this paper I would like to investigate how the central bank can cope with uncertainty concerning sustainability of house prices and the filtering of the trend.

I consider two models, both built on Iacoviello (2005) but different with respect to one assumption. In the first one, the autoregressive housing shock drives house prices away from the trend. While they can stay away from the trend for some time, they eventually return to it. I refer to this pattern as an “unsustainable growth in house prices”. In the second model there is no housing shock. Therofere, house prices are close to the trend, although they can deviate from it driven by other shocks. I describe this situation as a “sustainable growth in house prices".

I contribute to the literature by analyzing the effectiveness of monetary policy rules under two different assumptions on the sustainability of house prices. This - to best of my knowledge - has not been done yet. Although many articles deal with the problem how the central bank should react to house prices, they spend relatively little time on investigating effectiveness of alternative policies.

I find the optimal policy rule in each model in order to find the best central bank behavior when growth in house prices is sustainable (there is no housing shock) and when it is not (there is the housing shock). Then, I compare the effectiveness of both rules in each model by looking at loss function value of "correct" (optimal in this model) and "incorrect" (optimal in another model) policy rule in both cases treating a difference between them as a cost of incorrect assumption on house price sustainability. In technical terms this approach is similar to Orphanides and Williams (2009); Taylor and Williams (2010); Levin et al. (2003); Leitemo and Soderstrom (2005). In particular, Levin et al. (2006) perform similar exercise of switching off one shock in the economy in order to prove the robustness of their optimal monetary policy rule[1].

I show that the optimal policy rule from the model with four shocks is more robust to changes in the model specification. It means that if the central bank cares about worst-case scenario it should act as if the growth in house prices is temporary. This outcome results mainly from the incorrect interest rate response to housing shock when the central bank does not expect it. On the other hand, incorrectly assuming housing shock presence, central bank does a relatively good job responding to other shocks.

Similar uncertainty, but with respect to other crucial macroeconomic variables (e.g. GDP, interest rate, exchange rate), has already been studied in the literature. The most pronounced of these variables is the output gap. Since it can be interpreted as the measure of demand pressure in the economy, it is crucial in assessing the inflationary pressure in the economy. The uncertainty surrounding the output gap and its consequences are confirmed by a number of studies (see e.g. Orphanides et al., 2000,McCallum, 2001 Rudebusch, 2001, Drew and Hunt, 2000, and Billi, 2012). In particular, Orphanides et al. (2000) find that the current estimates of historical output gap and the real time estimates show significant differences in the United States in 1966Q1 - 1994Q4 with mean error equal to 3.2 p.p. (underestimation of real-time output gaps) and root mean squared error equal to 4.2 p.p. The consequences of output gap uncertainty for monetary policy were found to be pronounced. Smets (2002) shows that output gap uncertainty reduces the response of the Taylor rule to the current estimated output gap relative to the current inflation. It may partially explain why the estimated coefficients in the Taylor rule are usually lower than those obtained from optimal

[1] However, they estimate their model so they do not recalibrate parameters in the economy. In my simulation I do it in order to keep similar variances of output and inflation in both versions of the model.

control exercises. Output gap uncertainty led some economists to either advise nominal GDP targeting (see e.g. Rudebusch, 2002), or look for policy rules that are robust to different types of uncertainty stemming from i.a.: model, parameter estimation and data, or try to model uncertainty itself (Onatski and Williams, 2003).

Other examples of variables that lead to model uncertainty include interest rates (with respect to their deviations from the natural level) and exchange rate (w.r.t. the steady state value). Leitemo and Soderstrom (2005) investigated different optimized Taylor rules in models with different mechanisms of exchange rate determination showing that the Taylor rule may suffice to stabilize a small open economy in which there is uncertainty about deviations from UIP/PPP or equilibrium exchange rate is uncertain. Edge et al. (2010), in turn, found that both the natural level of output and the natural interest rate are the important sources of uncertainty.

The rest of the paper is structured as follows. Section 2 briefly presents the model and Section 3 describes calibration and optimization of the policy rule. Results of the simulations are presented in Section 4, whereas Section 5 concludes.

2 The Model

In the simulations I apply a medium-scale DSGE model with a housing sector building on the important work of Iacoviello (2005). Housing serves as a collateral for credit constrained (CC) households and entrepreneurs. The CC mechanism establishes an important channel through which house prices influence borrowing, wealth, and - as a result - also the allocation of resources in the economy.

The economy is populated by patient and impatient households as well as by entrepreneurs. There are also retailers that serve introduction of nominal stickiness and the central bank that optimizes its policy rule with respect to a loss function.

Households purchase consumption goods and housing as well as provide labor input. Entrepreneurs spend on consumption goods and produce intermediate goods using technology, labor, capital, and housing. These intermediate goods are differentiated at no cost and sold to aggregators by retailers who act in monopolistically competitive market with time-dependent sticky prices. This step of production is introduced in order to motivate time-varying stickiness of prices and is a common feature in New-Keynesian models. Aggregators combine differentiated intermediary goods into one final good. As it was mentioned, there is also the monetary authority which conducts monetary policy following the interest rate rule.

The model was estimated in Iacoviello (2005)with the following US data: GDP, inflation, housing prices and interest rates. There are four shocks in the model: technology, mark-up, housing preferences and interest rate. The model is log-linearized around the steady state.

The following subsections briefly introduce main agents, their objectives and constraints that are important from the point of view of understanding the results[2].

2.1 Patient Households

Patient households discount future with the factor β', calibrated so that they save in an equilibrium. The representative patient household maximizes lifetime utility:

$$E_0 \sum_{t=0}^{\infty} (\beta')^t \left[\ln c_t^{'} + j_t \ln h_t^{'} + \chi \ln \frac{M_t^{'}}{P_t} - \frac{L_t^{'\eta}}{\eta} \right] \tag{1}$$

deciding on consumption[3] $c_t^{'}$, housing $h_t^{'}$ (that have a real price equal to q_t), real money balance $\frac{M_t}{P_t}^{'}$ and labor supply $L_t^{'}$ (receiving real wage $w_t^{'}$). Furthermore, they can borrow $b_{t-1}^{'}$ at the nominal interest rate, where R_{t-1} denotes the nominal lending interest rate. π_t denotes gross inflation rate in period t. Patient households face the housing preference shock j_t, that follows an AR(1) process. They own retail firms in this economy and receive stream of dividends $\Pi_t^{'}$ (it is assumed that only patient households own firms). They also receive lump sum transfers $T_t^{'}$. As a result, they are restricted by the following budget constraint (in real terms):

$$c_t^{'} + q_t(h_t^{'} - h_{t-1}^{'}) + \frac{R_{t-1}}{\pi_t} b_{t-1}^{'} + \frac{M_t^{''} - M_{t-1}^{''}}{P_t} = b_t^{'} + L_t^{'} w_t^{'} + \Pi_t^{'} + T_t^{'} \tag{2}$$

2.2 Impatient Households

Impatient households - in contrast to patient ones - borrow using housing as collateral. Their discount factor is lower than that of patient ones, $\beta^{''} < \beta^{'}$, so that the collateral constraint is binding. The representative impatient household maximizes:

$$E_0 \sum_{t=0}^{\infty} \beta^{''t} \left[\ln c_t^{''} + j_t \ln h_t^{''} + \chi \ln \frac{M_t^{''}}{P_t} - \frac{L_t^{''\eta}}{\eta} \right] \tag{3}$$

subject to the flow of funds:

$$c_t^{''} + q_t(h_t^{''} - h_{t-1}^{''}) + \frac{R_{t-1}}{\pi_t} b_{t-1}^{''} + \frac{M_t^{''} - M_{t-1}^{''}}{P_t} = b_t^{''} + L_t^{''} w_t^{''} + T_t^{''} \tag{4}$$

and the borrowing constraint:

[2] For more details of the model see Iacoviello (2005)

[3] Note that variables with prime ($'$) denote the variables for patient households, the variables with double-prime ($''$) denote variables for impatient households, while variables without any of these notations refer to entrepreneurs.

$$b_t^{''} \leq m^{''} E_t(q_{t+1} h_t^{''} \pi_{t+1}/R_t) \tag{5}$$

where $m^{''}$ denotes LTV ratio for the impatient household. The model is calibrated so that the household always hits the constraint, so that inequality 5 becomes equality.

2.3 Entrepreneurs

Entrepreneurs run firms, do not work, and they possess housing. They choose capital, housing, and labor that are used in a production process, as well as their consumption, which is their source of utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t \ln c_t \tag{6}$$

They produce an intermediate homogenous good using technology, labor, capital and housing:

$$Y_t = A_t K_{t-1}^{\mu} h_{t-1}^{\nu} L_t^{'\alpha(1-\mu-\nu)} L_t^{''(1-\alpha)(1-\mu-\nu)} \tag{7}$$

where A_t measures productivity and follows an $AR(1)$ process, α measures the relative share of patient and impatient households in total population, K_t denotes capital that depreciates at rate δ and is created at the end of period t. Parameters μ and ν are the shares of - respectively - capital and housing in the production. Both capital and housing are subject to the quadratic adjustment costs.

Furthermore, entrepreneurs are constrained by flow of funds equation:

$$\frac{Y_t}{X_t} + b_t = c_t + q_t(h_t - h_{t-1}) + \frac{R_{t-1} b_{t-1}}{\pi_t} + w_t^{'} L_t^{'} + w_t^{''} L_t^{''} + I_t \tag{8}$$

where $X_t = \frac{P_t}{P_t^w}$ is a markup of final over intermediate goods and I_t is an investment. Similarly, to impatient households, entrepreneurs face also collateral constraint:

$$b_t \leq m E_t(q_{t+1} h_t \pi_{t+1}/R_t) \tag{9}$$

Entrepreneurs are also more impatient than patient households ($\beta < \beta'$) which forces them to borrow using their housing as collateral (instead of accumulating wealth to become self-financed and make CC non-binding).

2.4 Retailers and aggregator

There is a continuum of retailers $z \in [0; 1]$ who purchase from entrepreneurs homogenous intermediate goods Y_t at the price P_t^w in a competitive market. Retailers, in turn, mark these goods at no cost and sell them as $Y_t(z)$ at the price $P_t(z)$ to an aggregator. Each retailer chooses his price as an optimal one taking into account the demand curve (reflecting his relative price to an average price in the economy) and the probability of changing the price equals to $1-\theta$. Goods marked by retailers are imperfect substitutes and are combined into one final good by the aggregator. He uses the Dixit-Stiglitz aggregator characterized by the elasticity of substitution $\epsilon > 1$.

Combining the optimal price setting mechanism and the time-dependent price stickiness leads to the New Keynesian Philips (NKP) curve that is a subject to mark-up shock. After log-linearization around the steady state the NKP takes a form:

$$\hat{\pi}_t = \beta\hat{\pi}_{t+1} - \kappa\hat{X}_t + \hat{u}_t \tag{10}$$

where hats denote log-deviations from the steady-state, $\pi_t = \frac{P_t}{P_{t-1}}$ and u_t follows an AR(1) process.

2.5 The central bank

The central bank is assumed to conduct monetary policy according to the standard backward-looking Taylor rule that includes also house prices. The inclusion of additional potential response of monetary policy to house prices is motivated by their special role in the economy and interest of this paper. If the central bank cares about potential mistake it can make with respect to the assessment of house prices, it should also at least be able to use the information provided by these prices (see: Iacoviello (2005)).

$$\frac{R_t}{R} = \Big(\frac{R_{t-1}}{R}\Big)^{\gamma_R}\Big(\Big(\frac{\pi_{t-1}}{\pi}\Big)^{(1+\gamma_\pi)}\Big(\frac{y_{t-1}}{\tilde{y}}\Big)^{\gamma_y}\Big)^{(1-\gamma_R)}\Big(\frac{q_{t-1}}{q}\Big)^{\gamma_Q}\exp\big(\hat{e_{R,t}}\big) \tag{11}$$

where$e_{R,t}$ are i.i.d. normal innovations.

3 Calibration and Optimization

Model is calibrated in two versions that reflect the uncertainty concerning the sustainability of house prices: whether the growth is unsustainable (and can be described as a persistent shock) or it is permanent (and house prices are close to the trend):

1. Model with the housing shock assumes that growth in house prices is temporary and reflects persistent housing shock, i.e. house prices significantly deviate from the trend and their growth is unsustainable. This version is essentially identical to the Iacoviello (2005) model[4]. It includes 4 types of shocks: productivity, mark-up, housing preference

[4]The only slight difference is an additional parameter R_Q attached to past house prices in the Taylor

and interest rate. As the variance decomposition (Table 1) shows, the the housing preference shock is almost entirely responsible for changes in house prices.

2. Model without the housing shock. In this version the housing preference shock is switched off. It implies that house prices deviate from the trend due to endogenous response to remaining 3 shocks in the model. It implies that house prices are very close to the trend (as the housing preference shock was a main driver of house prices). Therefore, in this model I interpret growth in house prices as sustainable.

In more technical terms, two models I use differ in two dimensions. Firstly, some parameters must have different values to reflect whether house prices deviate from the trend or not. The detailed explanation of calibration is presented in Subsection 3.1. Secondly, they differ with respect to the parameters in the policy rule. Obtaining optimal policy rules is crucial in order to assess the costs of inappropriate monetary policy in both variants of the model[5]. In Section 3.2 I describe the optimization procedure and analyze its results.

3.1 Calibration

Before optimizing the policy rule, I recalibrate shock variances and autoregressive parameters in shock processes so that the model without the housing shock can be meaningfully compared with the model with the housing shock. I do not change other parameters as compared with Iacoviello (2005) estimation and calibration because they are believed to be so called "deep" parameters that come from the structural model and they should be robust to a policy change (Table 2). Therefore, both versions of the model share the same values of deep parameters in order to be robust to the Lucas critique[6]. My recalibration is needed as switching-off the housing shock has an impact on the volatility of other variables which is undesirable for two reasons (Table 3)[7]:

- methodological/interpretational. It would mean that in the version without the housing shock the central bank not only perceives in an alternative way (as compared with the version with housing shock) the volatility of house prices but also volatility of other observables (such as output or inflation). This would violate the logic of the exercise

rule. It is, however, close to zero.

[5]In this way I abstract from the problem that the historical Taylor rule can be associated only with one variant of the model (with or without the housing shock).

[6]It has to be noted, however, that although parameters are structural, some of them come from the estimation in Iacoviello (2005) that assumed presence of housing shock. Therefore, one can rightly argue that there is implicit assumption that the version with housing shock better represents the real world. However, one also should note that it would be difficult to estimate some parameters such as Loan to Value ratios without housing shock and others are well-established in the literature.

[7]By definition change in parameter values due to optimization implies also change in volatility of variables. Here, the description refers to the methodological appropriateness of calibration prior to optimization.

in which the central bank should observe the same world in both versions of the model (including the same observable variables: output, inflation, interest rates and housing prices) but it is meant to be unsure just about the nature of house prices.

- technical. It would complicate the comparison of mistakes made by policymakers in both scenarios (other reference values of the volatility of inflation and output that impact the value of loss function)

As switching-off the housing shock lowers the variance of output and inflation I increase the volatility of the interest rate shock to get models with comparable moments of key variables (i.e. in a sense to receive two observationally equivalent model specifications). I choose the volatility of interest rate as I suppose that the fact that the central bank believes that house prices are close to the trend should not affect the assessment of the productivity or mark-up shocks. It would rather influence the assessment of the central bank's own deviations from policy rule. Furthermore, as it turns out in robustness check, this assumption does not affect significantly the results. It allows, though, to minimize the difference in the output and inflation volatilities between model variants (see Table 4).

3.2 Monetary policy optimization

I use the Optimal Simple Rule (OSR) routine in Dynare to find an optimal monetary policy in both variants of the model[8]. As a start-point for optimization parameters in the Taylor rule I take their values from Iacoviello (2005). The appropriateness of policy rule is assessed with a standard loss function in which central bank minimizes the variance of inflation and output gap with weights of, respectively, 1 and λ:

$$L = \sigma^2_{\hat{\pi}} + \lambda \sigma^2_{\hat{y}} \tag{12}$$

The optimization, and subsequently - model simulations with suboptimal policy rules, are conducted for $\lambda \in [0; 1]$ as I look for a policy that will be robust to different λ. I take various λ as I have no prior knowledge on its appropriate value. In the literature it is frequently assumed that $\lambda = 0.5$ (see e.g. Smets (2002)), thus for illustrative purposes the impulse

[8]As the optimization is done numerically, the procedure is imperfect in the sense that it can lead to e.g. local maximum. Therefore, I improved it by using the optimized parameters as the initial value for next optimization. This procedure is repeated unless decrease in loss function is less than 0.0001 which corresponds to drop of 0.01 percentage point of inflation gap and $0.01/\lambda$ percentage points of output gap. Thanks to this procedure the results improve - it takes usually few iterations to get optimal rule, and optimal policy is robust in comparison to the case of just 1 iteration in the sense that alternative policy does not beat optimal policy as it happened without iterating OSR procedure. Furthermore, in case of this procedure I face more rarely problems with Blanchard-Kahn conditions in the simulation of model with alternative policy rule.

response functions and basic results of optimization are reported for this value. However, it has to be stressed that the main results are presented as a frontier and do not depend on λ.

3.2.1 Optimization results

Optimization significantly improves performance of monetary policy in the model as compared with the historical rule estimated in Iacoviello (2005). As shown in Table 6, relatively stronger improvement occurred in the model without the housing shock. This results from the smaller number of shocks and - consequently - trade offs that monetary policy has to face in this variant.

Table 7 presents the optimized Taylor rules in two versions of the model. In both optimized models interest rates response to output gap is stronger than in the case of historical Taylor rule. At the same time it is weaker in response to inflation. This finding is in line with the literature which can be attributed to real world uncertainty about the output gap (see Smets (2002)). It is also intuitive. If the central bank knew the structure of the economy and parameters it would be much more decisive in its actions. The side effect of stronger reaction to output gap in optimal rules is a slight increase in inflation after monetary policy shock - the unintuitive pattern that was absent in the historical rule (Figure 2)[9]. Furthermore, optimization in both versions leads to a drop in interest rate persistence.

What may seem unexpected, though, is the optimized value of parameter γ_q that describes the direct interest rate reaction to past house prices. One might expect it to be positive in the model with the housing shock and zero in the other model. As Table 7 shows in the model with the housing shock, as expected, central bank should slightly tighten monetary policy in case of higher house prices[10]. However, in the model without the housing shock, the optimal, direct response of interest rates to house prices is negative[11].

The difference can be explained by analyzing the source of rise in house prices. In the model with the housing shock an increase in house prices usually results from positive housing shock. More desire for housing implies increase in marginal utility in housing which calls for additional purchase of housing (see Figure 3). As the result collateral constraint of impatient households loosens and they are able to consume more. At the same time, entrepreneurs sell housing substituting it with capital (i.e. with relatively cheap factor of production) that leads to increase in investment. Therefore, in the case of the model with the housing shock,

[9]It has to be notice, however, that increase in inflation is weak and it results from expectations that central bank will try to boost output in the next period after monetary tightening.

[10]In fact, interest rate response to house prices is much stronger in the model than coefficient R_q suggests. Reacting strongly to output gap in the optimized model, central bank stabilizes fluctuations of house prices. It is also notice worthy that the small additional reaction to house prices is in line with findings in the original article of Iacoviello (2005). In this article an additional reaction of the Taylor rule to house prices adds very little to its performance (as measured by the distance between inflation-output volatility frontiers).

[11]γ_q is close to zero in model with housing preference shock and negative in model without housing shock for all λ considered.

too loose monetary policy that accompanies grow in house prices would lead to consumption and investment boom.

In turn, in the model without the housing shock, increase in house prices makes housing less desired for impatient households as it becomes the relatively expensive source of utility (as compared with consumption). As impatient households sell off housing, they collateral constraint tightens that lowers their consumption potential. Therefore, the central bank relaxes collateral constraint with the lower interest rate path to achieve more stability of consumption and investment. In a sense, thanks to negative γ_q central bank fixes the inefficiency caused by collateral constraint mechanism and smooths out output gap and inflation over time (see Figure 4).

However, negative γ_q does not mean that monetary policy is "looser" in the model with three shocks than in model with four. Nor it means that negative γ_q could be straightforwardly substituted with lower γ_y. To see it, one can compare IRF to interest rate and mark-up shocks (Figure 4 and 5). In the former case house prices are strongly correlated with output gap and negative γ_q helps in stabilizing the economy. In turn, in case of mark-up shock, house prices do not change in the same direction as output gap, and lower γ_y would imply too loose policy in general[12].

4 Results. Comparison of policy rules performance

As a final step I apply the optimal Taylor rules to the other model. This allows to check how much the central bank loss increases when the bank applies the incorrect policy. The main results of the paper are summarized in Figure 6. The central bank applying policy rule that incorrectly assumes no housing preference shock in the economy makes a more costly mistake as measured by the loss function under all λ's considered in comparison with the central bank that incorrectly assumes the important role of housing shock in the economy[13]. It means that if the central bank assumes that house prices do not deviate from the trend significantly, while they do, its monetary policy brings additional volatility in the economy.

In the following subsections I elaborate on the details of this result. Firstly, I focus on the optimal policy rule from the model without the housing shock to the version with the housing shock and compare it to optimal rule in this model. Then I perform an opposite exercise.

[12] As an exercise I optimize monetary policy for every shock and find that in case of the interest rate and technology shocks γ_q is negative, whereas for mark-up and house preferences shocks it is positive. In the model without house preference shock γ_q is therefore naturally lower than in the model with four shocks.

[13] To check robustness of the results I also performed several exercises such as optimization with different initial values of parameters in the Taylor rule or simulations for different steps between λ. None of these tests did change the main result of the paper.

4.1 Model with the housing shock

Figure 7 (left panel) presents standard deviations of inflation and output gap for two Taylor rules applied in the model with the housing preference shock: the optimal rule in this model and optimal rule from the model without the housing shock. It turns out that a distance between their outcomes is significant. In extreme cases, the application of the latter rule may lead to increase in standard deviation of quarterly inflation rate by 0.4 pp. and by 1 pp. in case of output gap.

The difference between performance of these two rules is associated with their additional reaction to house prices, i.e. with parameter γ_q. As it was discussed, this parameter is significantly negative in the model without the housing shock. Applying the policy rule that is suboptimal in the model with the housing shock leads to a strong increase in the output gap volatility when the housing shock hits the economy (Figure 4). This result is intuitive - the most harmful is the shock, that monetary policy was not expecting to occur. Expectations of less restrictive policy after increase in house prices lead to the stronger growth of the output gap and inflation rate forcing the central bank to tighten monetary policy stronger in the subsequent period. This tightening is however insufficient to stabilize inflation and output gap as the central bank decreases the interest rate in response to the positive house prices gap.

4.2 Model without the housing shock

While comparing policy rules in the model without this shock, it is noteworthy that policy performance worsened much less than in the previous exercise (Figure 6). Despite some distance between policy frontiers of optimal and suboptimal rules in the model without this shock, they are close to each other (right panel of Figure 7). It means that these two rules lead to different relative volatility of output gap and inflation but the value of loss function does not change much.

Thus, in the model that does not include the housing shock, the suboptimal direct response of the central bank to house prices is of little significance. The main difference in the performance of the optimal and suboptimal rules can be seen in IRF to the interest rate shock (see Subsection 3.2.1). The suboptimal rule leads to lower investment and - as a consequence of insufficient production capacity - higher inflation that translates into higher volatility of the inflation rate.

4.3 The results under alternative Taylor rule specifications

In order to check whether the outcome depends on calibration method and/or the fact that the model without housing shock includes 3 shocks whereas the model with housing shock has an additional one, I performed the same exercise as described in Subsections 4.1 and 4.2 assuming that the Taylor rule does not include additional reaction to house prices (i.e. $\gamma_q = 0$). As Figure 8 shows, if the central bank is not allowed to additionally respond to house prices, its mistake will not be that pronounced as in left panel of Figure 7. It means that the main result of the simulation stems from the additional reaction to house prices in the Taylor rule.

5 Conclusions

A long-lasting growth in house prices often rises a question about its sustainability which is usually a bone of contention for both researchers and central bankers. This uncertainty is of special importance for monetary policy as the reversals in house prices are often associated with a credit crunch, dramatic drop in consumption and investment, and - as a result - a long-lasting and painful recession. Furthermore, by incorrectly interpreting sustainability of house prices monetary policy may further strengthen the impact of house prices on the economy. If the central bank assumes that a rise in house prices is sustainable whereas it is not, it may further fuel a housing boom with too loose policy leading to even stronger collapse of the economy. On the other hand, if the central bank tries to counteract the growth in house prices that otherwise would have been sustainable, it decreases the welfare.

The paper investigates the optimal monetary policy when the central bank faces uncertainty about the sustainability of the growth in house prices. I assume two extreme cases and use two versions of a DSGE model to reflect this uncertainty. In the first case, the growth in house prices is temporary and is described by the persistent shock in the house prices. In the second, the growth in house prices is sustainable and can be attributed to the trend. Using optimal policy rules computed in these models I check how monetary policy performance worsens if the central bank incorrectly interprets the sustainability of the growth. Firstly, the central bank assumes that there are no significant deviations of house prices from the trend, whereas in reality these deviations occur. The second case is the opposite: the central bank incorrectly treats housing prices as determined mainly by shocks that drive them far away from the trend.

I show that the central bank is better-off if it incorrectly assumes that house prices significantly deviate from the trend, i.e. that idiosyncratic disturbances in housing market play a role. It means that if the central bank cares about worst-case scenario it should act as if the growth in house prices is temporary. This result turns out to strongly rely on inclusion of additional interest rate response to house prices in the policy rule. Therefore, the central bank that is not concerned enough about house prices - i.e. it does not include them in the Taylor rule - may be indifferent on whether house prices are close to the trend or not.

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Tables and figures

Table 1: Variance decomposition of selected variables in two variants of the model

	model with housing shock					model without housing shock			
	technology	mark-up	housing	policy		technology	mark-up	housing	policy
$\hat{y}$	1.01	9.79	26.28	62.93	$\hat{y}$	0.81	7.85	0	91.34
$\hat{\pi}$	30.33	31.80	20.86	17.01	$\hat{\pi}$	32.65	34.23	0	33.12
$\hat{q}$	3.74	1.88	89.54	4.85	$\hat{q}$	26.00	13.05	0	60.95
$\hat{r}$	10.27	10.70	6.94	72.09	$\hat{r}$	6.79	7.07	0	86.14

Table 2: Selected calibrated parameters (the same value in model with and without housing preference shock)

Description	Parameter	Value
Discounting rates:		
Patient households	β'	0.99
Impatient households	β''	0.95
Entrepreneurs	β	0.98
Preferences:		
Weight on housing services	j	0.1
Labor supply aversion	η	1.01
Factors of production:		
Patient HH wage share	α	0.64
Variable capital share	μ	0.3
Housing share	ν	0.03
Other technology parameters:		
Variable capital adjustment cost	ψ	2
Variable capital depreciation rate	δ	0.03
Housing adjustment cost	ϕ	0
Sticky prices		
Steady-states gross markup	X	1.05
Probability of not changing prices	θ	0.75
Loan-to-values		
Entrepreneur	m	0.89
Household	m''	0.55
Autocorrelation of shocks		
Technology	ρ_A	0.03
Mark-up	ρ_u	0.59
Standard deviation of shocks		
Technology	σ_A	2.24
Mark-up	σ_u	0.17

Table 3: Selected calibrated parameters (different values in model with and without housing preference shock)

Description	Parameter	model with housing shock	model without housing shock
Autocorrelation of shocks			
Housing	ρ_j	0.85	0
Standard deviation of shocks			
Monetary policy	σ_R	0.29	0.39
Housing	σ_j	24.89	0

Table 4: Standard deviation of selected variables (in terms of deviations from the trend) in two variants of the model

Description	Variable	model with housing shock	model without housing shock
Output	$\hat{y}$	1.8565	2.0723
Inflation	$\hat{\pi}$	0.4822	0.4647
Housing prices	$\hat{q}$	2.6030	0.9870
Nominal interest rates	$\hat{R}$	0.3987	0.4813

Table 5: Correlation of selected variables (in terms of deviations from the trend) in two variants of the model

		model with housing shock					model without housing shock			
Description		$\hat{y}$	$\hat{\pi}$	$\hat{q}$	$\hat{r}$		$\hat{y}$	$\hat{\pi}$	$\hat{q}$	$\hat{r}$
Output	$\hat{y}$	1.0000	-0.1224	0.3006	-0.5006	$\hat{y}$	1.0000	0.2452	0.6170	-0.7822
Inflation	$\hat{\pi}$	-0.1224	1.0000	-0.2068	-0.4473	$\hat{\pi}$	0.2452	1.0000	-0.0014	-0.5091
Housing prices	$\hat{q}$	0.3006	-0.2068	1.0000	-0.2300	$\hat{q}$	0.6170	-0.0014	1.0000	-0.8214
Real interest rates	$\hat{r}$	-0.5006	-0.4473	-0.2300	1.0000	$\hat{r}$	-0.7822	-0.5091	-0.8214	1.0000

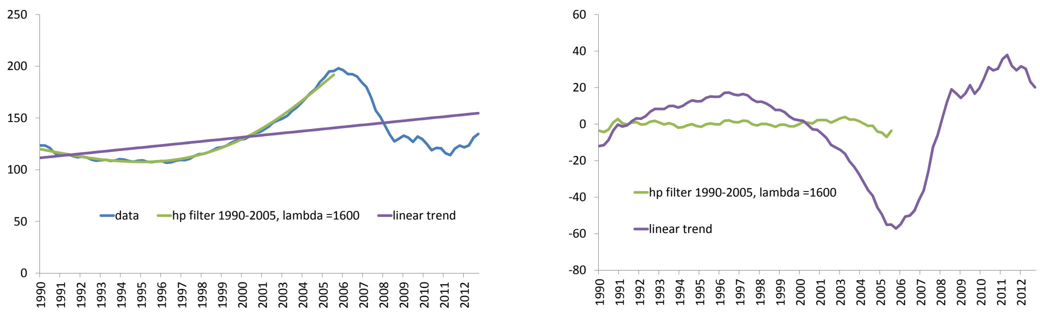
Table 6: Value of central bank loss function in two variants of optimized model

	model with housing shock	model without housing shock
before optimization	1.96	2.36
after optimization	0.62	0.27

Table 7: Value of the Taylor rule parameters in three variants of the model (original one and two optimized)

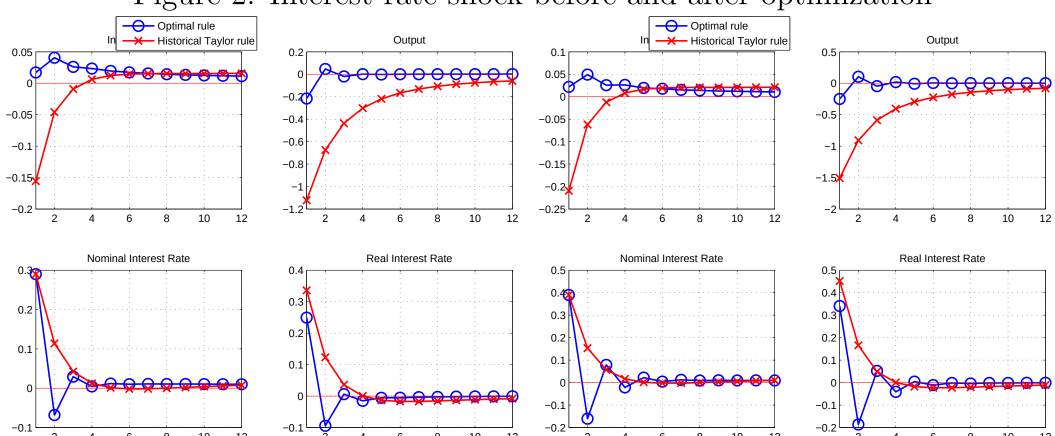
		Optimized Taylor rules	
	Taylor rule a'la Iacovello	model with housing shock	model without housing shock
γ_Y	0.13	1.28	2.50
γ_π	1.27	0.73	0.58
γ_R	0.73	0.33	0.37
γ_q	0.01	0.06	-0.30

Figure 1: Trends in house prices and deviations from them



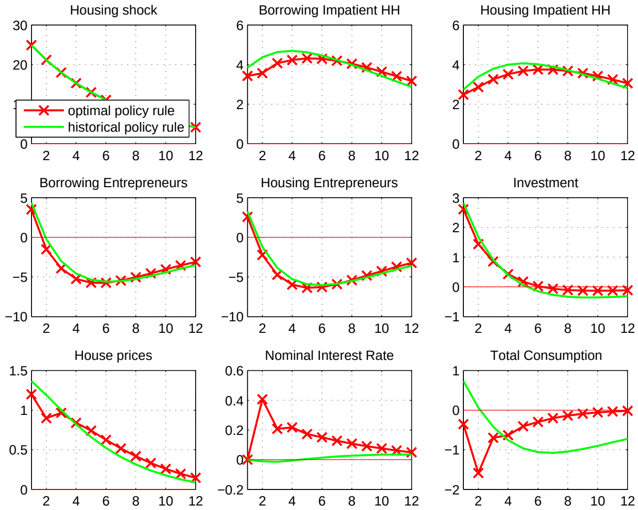
Left figure presents data on home prices and trends obtained with hp filter and linear regression. Right figure presents deviations of home prices from these trends. Data on nominal home prices comes from http://www.irrationalexuberance.com/

Figure 2: Interest rate shock before and after optimization



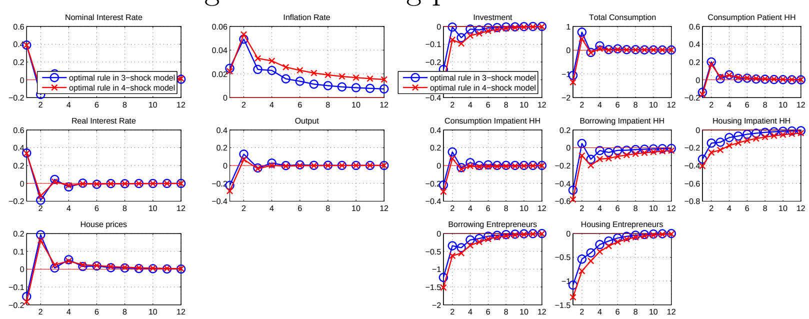
Lines with circles present IRF for models with the Taylor rule a'la Iacovello whereas lines with x - for the optimized Taylor rule. Model with housing preference shock is presented in left panel, model without this shock - in right panel.

Figure 3: Housing preference shock



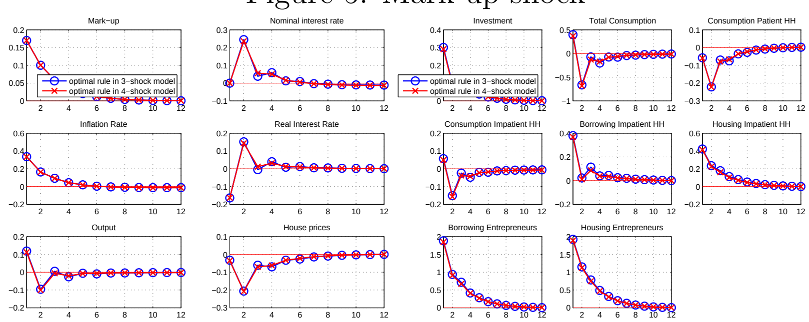
Red lines with x present IRF for model with the optimal Taylor whereas green lines IRF - for model with the historical Taylor rule (estimated in Iacoviello (2005)).

Figure 4: Housing preference shock



Lines with circles present IRF for models with the optimal Taylor rule in this model whereas lines with x - for the optimal Taylor rule from another model.

Figure 5: Mark-up shock



Lines with circles present IRF for models with the optimal Taylor rule in this model whereas lines with x - for the optimal Taylor rule from another model.

Figure 6: Difference in loss function value between suboptimal and the optimal Taylor rules in two versions of the model

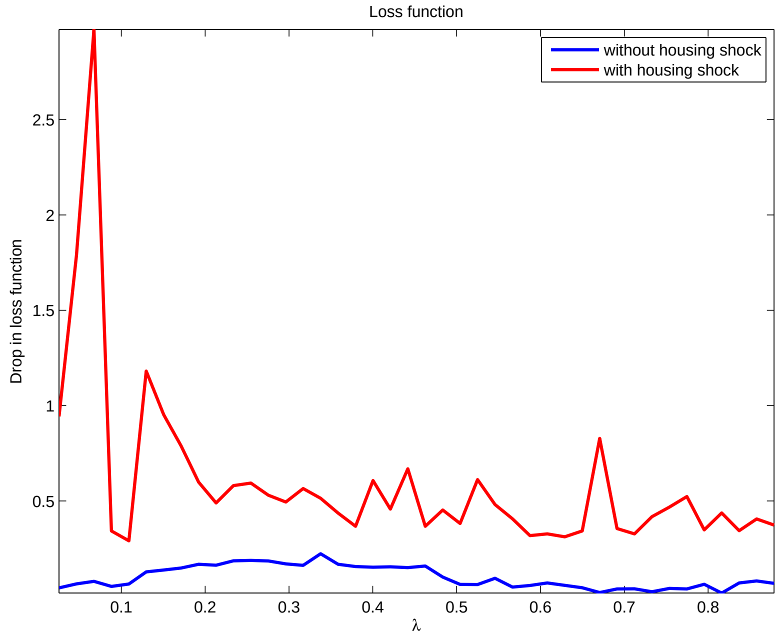


Figure 7: Volatility of inflation and output gap

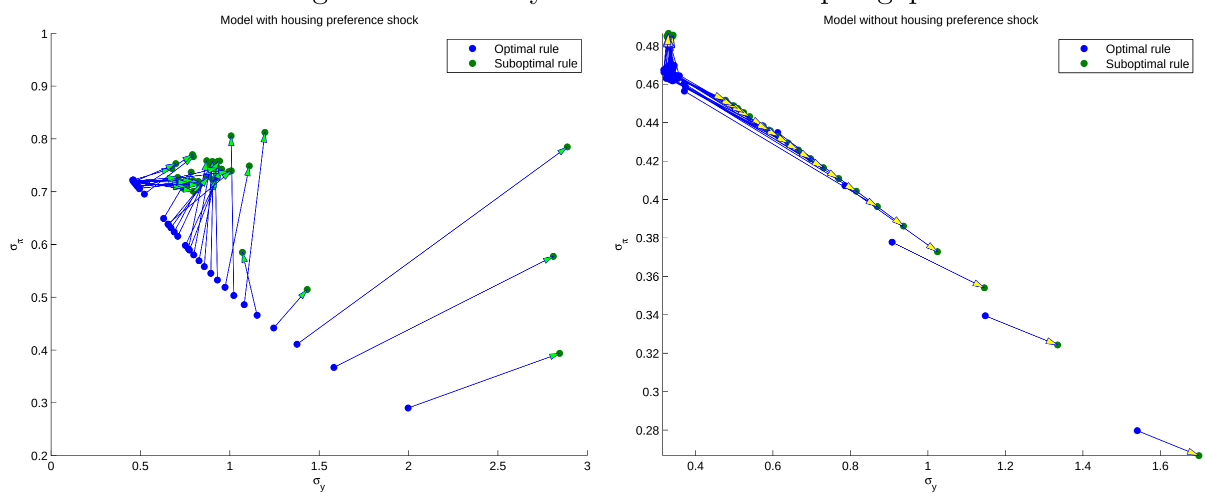


Figure 8: Volatility of inflation and output gap - model without house prices in the Taylor rule