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House Price Expectations, Household Indebtedness and Macroprudential Policy in a DSGE framework

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Abstract

By incorporating a data generating process for house price expectations in a standard new keynesian DSGE model, this paper differentiates between the macroeconomic impact of endogenous and exogenous sources of expectation shocks and the role of fiscal and macroprudential policy (in the absence of monetary policy) in managing these shocks in the housing market. The paper concludes that endogenous shocks pre-dominate exogenous shocks to expectations in home prices in accelerating credit growth and household indebtedness. But endogenous shocks can still be accredited with 'good housing booms' tag as they raise the ability to pay-off rising debt significantly. In terms of policy, the paper finds that loan-to-value ratios score over payment to income ratios as a potent macroprudential instrument to manage housing market dynamics as constraint switching is limited in case of LTV because of an expectations sensitive factor market. Macroprudential instruments set as a function of household debt to GDP ratio reinforce the transmission channels and turn out to be counterproductive in case of endogenous shocks but effective in managing exogenous shocks. The paper also finds that property tax can be potential instrument to arrest rising home prices but it works effectively in coordination with other policies. We also show that endogenous refinancing decisions of households can be effectively used as a channel for transmission of monetary and macroprudential policy through timely coordination of two policies.

JEL.*E30,E44,E50.*
Keywords. Expectations, Macroprudential Measures, Loan-to-value, Payment-to-income, Monetary Policy, Housing tax, DSGE.

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1 Introduction

Household indebtedness is a significant source of financial stability risk. And the potential risk aggravates if the accumulated debt is largely concentrated in the real estate which exhibits boom-bust behaviour. At lower levels of growth, higher debt may be a potential growth booster because expectations of higher future income will drive borrowings to smooth consumption and investments in non-financial assets. However, it can be a source of financial vulnerability and amplify as well as prolong even small negative shocks when stock of private debt is large (Arcand, Berkes and Panizza, 2015; Sahay and others, 2015). Furthermore, household indebtedness remains a seminal area of analysis because it can affect monetary policy responsiveness (Gelos et al; 2019). So far it is understood that excessive household debt arises due to exuberance shocks on house price expectations, which drive a wedge between the actual and the underlying fundamental value of houses (Alpanda and Zubairy, 2016). But it is intriguing whether exuberance shocks are completely exogenous or also driven by endogenous factors too. For example, expectations driven by productivity increases in the economy might have a more salubrious impact on the economy because it is accompanied by a potential increase in ability to service debt. On the other hand, exogenous shocks to expectations may take the economy away from fundamentals leading to boom-bust behaviour.

This paper explores the relationship between household indebtedness and home price expectations in a new keynesian DSGE model calibrated to Slovakia. Housing prices in Slovakia has been growing at a faster pace than implied by fundamentals in recent times. As per the residential property price index of the National Bank of Slovakia (NBS), the index has more than doubled between 2002 and 2020. While a run-up to spiralling prices was witnessed prior to the Global Financial Crises (2006-2008) when the housing prices recorded an average growth of 20.8 per cent, a similar spike was noticed during the pandemic period (2020-2021) when residential prices registered an average growth of 15.3 per cent. At the same time, as per OECD, household debt as a percentage of net disposable income in Slovakia has increased from 40.9 per cent in 2002 to 81.6 per cent in 2020. The IMF's Global Debt database reports that household debt, loans and debt securities as a percentage of GDP in Slovakia has increased from 5.7 per cent to 43.6 per cent during this period. In other words, household debt and property prices have moved in tandem with each other during 2002-2020.

Furthermore, what appears to be a potential source of challenge to financial stability and inspires anxiety between the above-mentioned relationship between household debt and property prices are some risky loan practices observed by Slovak banking system up until now. Until macroprudential instruments were brought in 2016, four out of every five loans was granted to households with high debt to income ratios, a process akin to financial inclusion in developing countries. While higher financial inclusion can have positive effects on long term growth, the relationship between household debt and long term growth is more elusive (GFSR, 2017). Even after macroprudential regulation became a potential instrument, the share of new loans with an LTV ratio of higher than 80 per cent rose from 42.0 per cent at end-2014 to 49.0 per cent at end 2016 (IMF, 2018)[1]. The banks loan portfolio is largely sustained by net income from loans to residents, bulk of which is generated from lending to households. Although banking sector as a whole is well capitalized, the smaller banks have relatively low capital buffers and may be exposed to risks. In sum, rising household debt could be a matter of concern because it raises the probability of tail responses in economic activity.

We construct a new keynesian DSGE model with nominal rigidities, housing frictions and household debt tailored to Slovakia. We lay down the data generating process of household's home price expectations formation with an aim to study the macroeconomic effects of endogenous and exogenous shocks to expectations on household debt. Conditional on the source of expectations, in the absence of monetary policy as a potential instrument, we evaluate the effectiveness of fiscal and macroprudential policy in managing the impact of expectations shocks originating in the housing sector. We assume that economic agents form expectations that move procyclically with output and anticyclically with interest rate. Besides, expectations are also perturbed by an exogenous component which we refer to as 'exuberance shock'. We hypothesise that

[1]The LTV ratio for new loans has subsequently declined to 17.2 per cent in 2020Q2 (IMF staff report, text Figure 7, p.15)

while the shocks to fundamental component give rise to 'good housing booms', the exuberance shock induces 'bad housing booms' to coin a term analogous to Gorton and Ordonez (2019). We find that the key to understanding the differences between two types of shocks is to appreciate the operation of two principal channels in addition to the traditional channels of transmission of shocks. First, the expectations channel working through expectations augmented labor supply schedule. The marginal utility loss from sacrificing a unit of leisure increases with the declining shadow price of the borrowing constraint as expected prices go up on account of an additional unit of labor supply. In other words, with the rise in anticipated wealth effect from housing as expected home prices rise on account of overall productivity increase in the economy, households tend to offer less labor. The second channel complementing the first is the constraint switching effect of Greenwald (2016). Greenwald (2016) explained that when two constraints (LTV and PTI) are simultaneously in operation, relative to a borrower constrained by PTI, a borrower constrained by LTV is willing to pay a premium for additional housing because it enables it to obtain a larger loan. But in the absence of monetary policy as a policy instrument, unlike Greenwald (2016), changes in the PTI limits come through changes in labor supply in our paper such that an increase in labor supply relaxes the PTI limits making LTV appear more restrictive. More borrowers then become willing to pay the premium for housing leading to rise in housing investment and expected home prices. The rising home prices endogenously loosens LTV limits increasing credit growth in the economy. In addition, since households refinance a fraction of existing loans each period, an additional channel of transmission opens up which enables the transmission of monetary and macroprudential policy.

There are four major findings of the paper. Our first finding is with respect to the nature and underlying transmission channels of endogenous and exogenous expectation shock. The presence of output in the expectations term allows for a periodical feedback from changes in output into expectations which makes endogenous shock permanent in nature unlike the exogenous shock. A 25 basis point rise in technology shock and a 25 basis point rise in exogenous shock has an imperfect pass-through into expectations, raising it by 0.7 bps and 15 bps, respectively. The endogenous shock leads to the heating up of the housing market reflected in rising expected home prices coupled with higher housing investment as a result of a predominating constraint switching effect. Endogenous technology shocks trigger an expansionary process in the economy with higher output, consumption, credit growth and growth in nominal debt. Contradistinctively, under exogenous shock to expectation, only expected home prices rise significantly without a concomitant rise in housing investment. Without a simultaneous surge in labor market fundamentals, expectations effect alone drives the transmission channel under exogenous shock. In sharp contrast to endogenous shock scenario, the desired level of housing investment is lower than the amount of available loans that borrowers can obtain. Consequently, langrange multipliers on LTV constraint decline significantly, raising the marginal utility loss from sacrifice of unit leisure. In the absence of wage income effect, labor supply contracts and output decelerates under exogenous shock. However, the results of the baseline model are reversed in the medium run when we allow for a linear feedback rule in the macroprudential policy where LTV and PTI varies with household debt levels.

Our second finding emanates from the policy simulations. We find that a contractionary LTV policy stands out as the most potent instrument in managing endogenous expectation shocks. A 10 bps contraction in LTV weakens the constraint switching effect and restricts the growth in housing investment, actual home prices, credit and nominal debt at levels lower than the baseline. The performance of the competing policies with respect to exogenous expectation shock management is precisely close to each other. LTV tightening produces at least as good results as LTV and PTI tightening together. However, the impact of LTV tightening sets in very late in case of endogenous shocks as compared to exogenous shocks.

The third finding of the paper relates to the effect of property tax. We find that rising property taxes effectively reduces optimal demand for housing and moderates the impact of expected home prices on actual home prices. But although property taxes has the intended impact in terms of cooling down the housing market, the impact of fiscal policy changes is felt across the board resulting in lower output, inflationary economy and lower debt servicing capacity of the borrowing household.

The fourth finding of the paper is that in an economy with endogenous macroprudential policy coupled with endogenous refinancing decision monetary and macroprudential policy work at cross purposes. Under endogenous expectation shocks, borrowers reduce their refinancing rate in response to the higher debt levels. Consequently, the transmission from policy rates to home mortgage rates is rendered weak leading to higher credit growth and growth in nominal debt. Contrarily, monetary policy is effective in managing exogenous shocks. Exogenous shock lowers debt levels which trigger rise in refinancing rate which leads to greater pass through of policy interest rates to mortgage rates increasing the share of adjustable rate mortgages. This results in lowering of credit growth, nominal debt and output in the economy.

The paper is organised in the following manner. Section 2 takes stock of the prominent features of Slovakian Housing market. Section 3 covers the the relevant literature. Section 4 describes the model and section 5 produces the calibration. Section 6 presents the results and section 7 concludes.

2 Housing Market in Slovakia

Slovakia has the third highest home ownership rates amongst EU nations with over 90 per cent of the population owning houses (Kubas, 2018). Demand for home ownership has expanded with the rise in incomes coupled with the development of a demographic structure skewed towards greater concentration of the economically active population capable of servicing mortgage debt. Between 2015-2021, average nominal wages have recorded a growth of 4.6 per cent, surpassing the productivity growth of the economy. Further, relaxation of entry norms for foreign workers have led to the expansion of the labor force and inflow of Slovakian expatriates adding to the demand for housing. There is considerable evidence in the literature that the relationship between labor market and housing market runs in both directions. Employment and migration increases in regions where homes become affordable (Sika and Vidova, 2017).

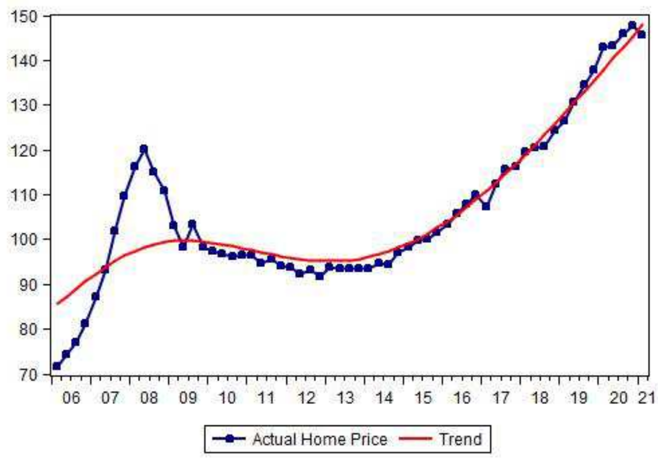
Rising demand has been aided by a favourable property tax policy environment and an underdeveloped rental market adverse to long term rentals. Real estate transfers in

Slovakia are effectively tax free as gifts and inheritance of property is not taxed. Since 2011, capital gains on sale of real estate are tax free after five years of ownership. Tax rates on immovable property is the only property tax levied in Slovakia and the tax rates are inelastic with respect to market value of properties. The rental market, constituting only 10 per cent of the housing market, has failed to provide an alternative to home ownership. The current rental rules favour short term rentals depriving tenants of long term stability and predictability. This has further accelerated demand for own houses.

Other forms of non-fiscal support to the sector include interest subsidies on mortgage loan for young people, premium on new deposits and favourable loan terms for low income households. In fact, the low interest rate regime which is in place for a while depressed long-term yields which added fuel to the demand for housing. Competitive pressure on financial institutions in the face of low interest rate margins and favourable loan contractual terms were sundry other demand propelling factors. Another major development is the growing share of refinancing of existing loans (exceeds 50 per cent in 2021) in Slovakia which has accelerated in recent years owing to prevailing low interest rate regime coupled with cap on regulatory fees on refinancing.This has helped to sustain a higher household debt in the economy. Supply constraints like restrictions on urban land use and a sluggish issue of construction permits has restrained supply response resulting in sharp spike in housing prices (Harvan et al, 2015). Of late, housing prices have deviated away from fundamentals which is a cause for concern (Fig. 1). It points towards growth of factors not integrated with the fundamental conditions in labor and financial markets that may be driving the real estate market.

Anticipating possible heating up of the housing and credit market, the NBS has undertaken some pre-emptive measures since 2014, prominent amongst which is the introduction of macroprudential measures. NBS introduced borrower based measures in 2014 prompted by growing risks and imbalances in the household credit market (IMF, 2018). NBS Recommendation No.1/2014 issued on October 7, 2014 imposed strict restrictions on the share of new real estate loans with an LTV ratio between 90 per cent and 100 per cent and rationalised collateral appraisal, verification of customer

Figure 1: Housing Prices in Slovakia



income and loan refinancing norms. During 2016, imbalances in the housing sector and vulnerabilities among mortgage lenders were rising which prompted a revision of the macroprudential policy structure. Debt service to income ratio became binding and share of loans availing LTV between 80 to 90 per cent was restricted to 40 per cent. The second revision in macropruential policy measures was brought about in 2018 to stem the growth in household indebtedness. While the share of loans with LTV exceeding 80 per cent was limited to 20 per cent, debt to income ratio was limited to 8.

We assessed the effectiveness of various macroprudential measures in managing the risks in the housing sector using a simple empirical model. We segregated the impact of macroprudential measures tightening and loosening phases on output and credit under endogenous and exogenous shock to expectations using non-linear local projections method for the period 2012Q1 to 2020Q1. To do this, we first identified the exogenous and endogenous component to expectations using a simple regression analysis. We created the expected property price series by applying the rate of growth of inflationary expectations on slovakian property price schedule. We then regressed the resulting series on past expectations and nominal GDP of Slovakia. We refer the residuals of this regression as the exogenous component of property price expectations, while the expected series after netting out residuals is referred to as the endogenous component. Based on available information, we also created a categorical series for LTV movements. LTV was tightened by NBS in the last quarter of 2014. Hence we assigned a value of 1 to the LTV series for the period 2014Q4 to 2018Q2. During 2018Q3, NBS tightened LTV and hence we assigned a value of 2 to the series for the period 2018Q3 to 2020Q1. The macroprudential series constitutes the switching variable in the local projections model.

We find that under exogenous shock, LTV tightening effectively restricts credit and output growth both in the short and medium run. But under endogenous shock, while credit is effectively controlled by LTV tightening in the short run, output comes under restriction only during the medium term. We repeated the exercise with a Klacso's (2022) composite borrower macroprudential measure index. The composite index reflects changes in all the three major macroprudential measures in operation in Slovakia today namely the LTV ratio, Debt to Income ratio and Debt service to income ratio. Since all the three have been changed synchronously in recent times, the composite measure is a more meaningful index as compared to single instrument index. Klacso (2022) provides three borrower based composite measures based on the quantification of weights assigned to each instrument in the composite series viz., (i) equal weights; (ii) weights based on share of new businesses close to the respective limits; and (iii) weights based on stringency of limits in terms of their impact of volume of new businesses. We found that there was no change in the results from the single instrument case with any of the optional indices.[2].

3 Relevant Literature

Our work is related to different strands of the literature. A large literature has focussed on exploring the driving forces behind housing market prices (Copozza et al 2002, Grimes and Aitken, 2010, Dura, Muelbauer and Murphy, 2011 and Agnello and

[2]Due to space constraint, we do not include the impulse response graphs pertaining to the Klacso's (2022) composite series in the paper. But the results are available on request

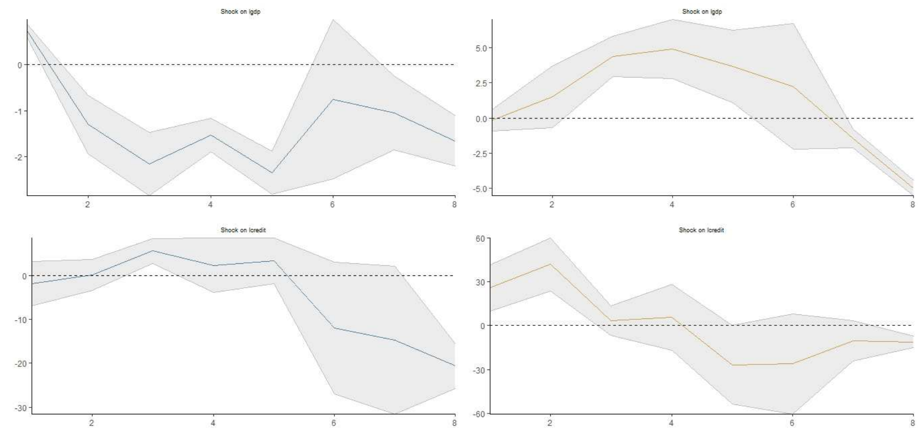


Figure 2: Response to Endogenous Shock under LTV Phases: LTV Loosening (Left Hand side graph); LTV Tightening (Right Hand side graph)

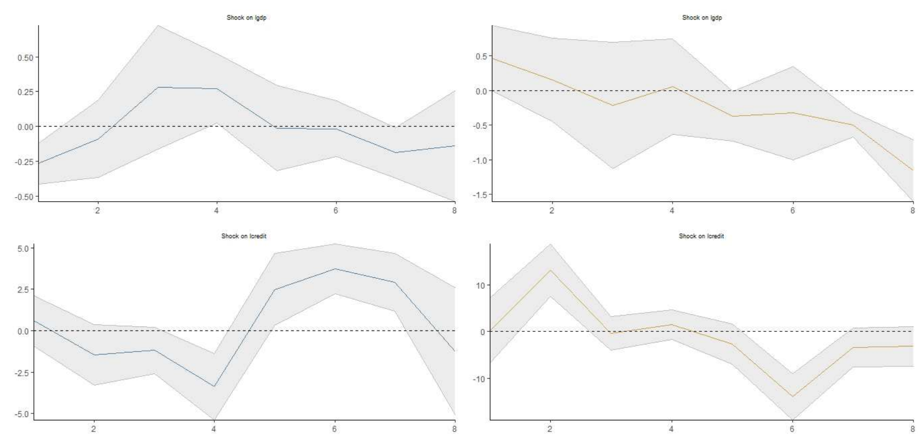


Figure 3: Response to Exogenous Shock under LTV Phases: LTV Loosening (Left Hand side graph); LTV Tightening (Right Hand side graph)

Schuknecht, 2011), the relation between housing markets, household wealth and debt (Campbell and Cocco, 2005, Mian and Sufi, 2016) and impact of household debt on future GDP and probability of banking crises (Jorda, Schularik and Taylor, 2016, Mian, Sufi and Verner 2017). The literature finds a strong relationship between house price changes and household indebtedness. In Australia, a USD 1000 increase in house value is associated with a USD 240 increase in household debt among home owners. Using data for Sweden, Turk (2015) observed that price of housing is the main driver of secular trend in household debt over the long run. Disney et al (2010) elaborate this economic relationship in a case study for UK. They show that exogenous increases in home equity value enable changes in the composition of debt. Rising value of housing equity enable them to substitute cheaper secured debt for unsecured debt. The reduction in price at which households's borrow on the margin, may lead them to increase overall borrowing and raise their expenditure on durable goods.

Further, the relationship between housing price and indebtedness is found to be state dependant. House price increases are associated with larger increases in total indebtedness for home owners with higher initial LTV ratios. Mian and Sufi (2014) find that the impact of housing wealth gain on spending varies across income groups. Low income households liquefy home equity when house prices increase and increase spending significantly. High income households are generally unresponsive to housing wealth gains. The entire effect of housing wealth on spending is through the borrowing. Atalay, Barrett, Edwards and Yu (2020) uphold the evidence of rising house prices pushing household debt. The wealth effect is stronger for moderately leveraged households and weaker for households that have encountered adverse income and employment shocks. Kostalova (2019) explored the driving forces of household debt in Slovakia using quarterly data over the period 2006-2018. She found that domestic household consumption, house prices and GDP growth for Germany are significant determinants of household debt in Slovakia.

Most of the literature centering on housing as collateral looks at the role of monetary and macroprudential policies and their interactions in managing the boom-bust cycles in the housing market. This is largely because macroprudential tools operate through variables that play a key role in the transmission of monetary policy and vice versa (Angeloni, Neri and Panetta, 2010). Greenwald (2016) highlighted the interaction of two macroprudential instruments, the payment to income ratio and the loan-to-value ratio in the mortgage channel of transmission. He documented the presence of a 'constraint switching effect' whereby a relaxation in the payment to income constraint alone, say via a reduction in interest rates, reinforces the relaxation of LTV constraint amplifying credit growth and debt escalation in the model. Alpanda and Zubairy (2016) show that tightening in mortgage interest deduction and regulatory loan-to-value (LTV) are the most effective and least costly in reducing household debt, followed by increasing property taxes and monetary tightening. Turdaliev and Zhang (2019) show that using monetary policy as a tool to restrain household debt is welfare reducing as it increases inflation volatility, while macroprudential policies like lowering LTV ratios increases borrower's welfare.

One central difference between the above-mentioned papers and our paper is that the former papers consider that boom-bust cycles in the real estate market are triggered by house price changes. Expectations are not explicitly modelled in these papers although expectations are naturally built into these models via the borrowing constraints namely the LTV, DTI and PTI constraints. Contrastingly, our paper explicitly models the housing price expectations and distinguishes between the impact of endogenous or fundamental shocks and exogenous shocks to expectations. This enables us to shed light on how the housing sector may lead to both good booms and bad booms. A paper close to ours in terms of this basic idea is Lambertini, Mendicino and Punzi (2010). However, they build the idea of expectations on the news shock mechanism where public signals of future fundamentals cause business cycle fluctuations. Thus at time t, agents receive a signal about future macroeconomic condition at time t+n. If the expected movement is not realized, busts follow. Understandably, their paper do not completely endogenize expectations which is a characteristic feature of our paper. It is important to mention here that the bulk of the literature on expectations driven business cycles have used news shocks to represent expectations (Christiano et al, Jaimovich and Rebelo, Walentin 2014)). Gomes and Mendicino (2012) make this distinction between news shocks and expectations very clear. They extended Iacoviello and Neri (2010)'s model of housing market to include news shocks. They found news shocks account for a sizeable variability of house prices and other macro-variables over the business cycle. In that sense, our paper is also related to the literature on expectations driven business cycles where expectations are not triggered by the housing market.

3.1 Model

The economy consists of a continuum of savers and borrowers. The savers are patient individuals that derive their income from the interest proceeds of domestic assets viz., bank deposits and risk-free bonds. The borrowing households consume, supply labor services, acquire housing assets and borrow from banks against their house as collateral. The economic agents are differentiated by their degree of impatience which is reflected in the discount factors. There also exist a continuum of perfectly competitive and capitalised banks which issue deposit liabilities that are subscribed by savers. The bank provides collateralised loans to borrowing households against their accumulated housing stock.

3.2 Savers

The representative saving household maximises expected utility which depends on current individual and lagged aggregate consumption (c_t^p) and housing services (h_t^p). The savers do not participate in the labor market.

$$E_0\sum_{t=0}^{\infty}\beta_p^t[log(c_t^p(i) - a_p c_{t-1}^p)) + \xi_1 log(h_t^p)]$$

The parameter a_p in the utility function measures the external and group-specific habit formation in consumption and ξ_1 measures the weightage of housing services in the savers utility function. The household chooses consumption, amount of deposits and housing services subject to the following budget constraint.

$$
\begin{aligned}
c_t^p + d_t + q_t i_t^{hp} + B_t + \tau_t^h q_t h_t^p \leq \frac{R_{t-1}^d d_{t-1}}{\pi_t} + \\
\frac{R_{t-1} B_{t-1}}{\pi_t} - \frac{\psi_1}{2}(B_t - \bar{B}^2) - \frac{\psi_1}{2}(d_t - \bar{d}^2) + tr_t^p + \Pi_t^b + \Pi_t^f
\end{aligned}
\tag{1}
$$

where c_t^p and i_t^{hp} denote consumption and housing investment by saving households. B_t and d_t denote the real value of domestic government bonds and bank deposits, respectively. R_t and R_t^d are the gross interest rates on domestic bonds and deposits, respectively; π_t is the gross inflation rate; q_t is actual market price of housing and τ_t^h is the per unit property tax imposed by the government on housing. δ^h is the depreciation rate of housing. We also introduce portfolio adjustment costs so that bonds and deposits can be treated as imperfect substitutes. Although marginal, the risk profile of bonds and bank deposits can be differentiated. Besides, this facilitates to pin down the equilibrium dynamics of optimal holdings. The parameters ψ_1 and ψ_2 measure the size of the portfolio adjustment costs for bonds and deposits, respectively. $\bar{B}$ and $\bar{d}$ denotes the steady state holdings of bonds and deposits, respectively. The household thus allocates his interest income earned from domestic bond market and bank deposits (d) and lump-sum transfers from the government (tr), dividends from the banking sector (Π^b) and profits from the firms (Π^f) into consumption expenditure, investment in the housing services, bank deposits, bonds next period and tax payments on income earned and property owned. The housing market evolves as under

$$
h_t^p = (1 - \delta^h) h_{t-1}^p + i_t^{hp} + 0.5\kappa^{hp} (\frac{i_t^{hp}}{i_{t-1}^{hp}} - 1)^2 i_t^{hp}
$$

where housing stock today depends on undepreciated housing stock last period and fresh investment flows. The savers also incur housing investment adjustment costs. The first order conditions with respect to housing services leads to the optimal housing choice equation given as in Equation (2)

$$\frac{\xi_1}{h_t^p} = \lambda_t^p \tau_t^h q_t - \beta^p \mu_{t+1}^{hp}(1-\delta^h)q_{t+1} + \mu_t^{hp} \tag{2}$$

where λ_t^p is the langrange multiplier with respect to the budget constraint and μ_t^{hp} is the langrange multipleir with respect to the housing evolution equation. Equation 2 is the housing demand function for savers which depicts the inverse relationship between housing demand and housing prices. The optimal choice of domestic bond and bank deposits lead to the following two intertemporal Euler equations, respectively.

$$1 + \psi_1(B_t - \bar{B}) = \beta^p E_t(\frac{\lambda_{t+1}}{\lambda_t}\frac{R_t}{1+\pi_{t+1}}) \tag{3}$$

$$1 + \psi_2(d_t - \bar{d}) = \beta^p E_t(\frac{\lambda_{t+1}}{\lambda_t}\frac{R_t^d}{1+\pi_{t+1}}) \tag{4}$$

Without portfolio adjustment costs the two assets are perfect substitutes and their returns are equal. But with active portfolio adjustment costs, the assets are imperfect substitutes and the above two equations (3 and 4) represent the downward sloping demand curves of bonds and deposits, respectively.

3.3 Borrowers

The representative borrower maximizes the lifetime expected utility which allows for superficial habit consumption as in the savers and depends on current individual and lagged aggregate consumption (c_t^i), labor supplied to the intermediate good producers, (n_t) for which they are paid real wages (w_t) and utility for acquisition of the housing services, h_t^i.

$$E_0 \sum_{t=0}^{\infty} \beta_i^t [(log(c_t^i(i) - a_i c_{t-1}^i) - \epsilon_t^{l,i}\frac{n_t^{(1+\theta)}}{1+\theta} + \xi_2 log(h_t^i)]$$

The borrower accumulates housing (h^i_t) for twin benefits. One, to benefit from the changes in the value of the immobile asset (wealth effect). And two, to obtain collateralised loans (L_t) from the bank against the housing stock. The housing market evolves as

$$h^i_t = (1-\delta^h)h^i_{t-1} + i^{hi}_t + 0.5\kappa^{hi}(\frac{i^{hi}_t}{i^{hi}_{t-1}} - 1)^2 i^{hi}_t$$

The borrower distributes his income earned from supplying labor services and proceeds from the secured loan from the bank ((L_t)) on consumption, payment of income tax at the rate (τ^w_t), payment of property tax at the rate of (τ^h_t), payment of principal and interest on mortgage debt (D_t) and investment into housing stock for the next period. His lifetime budget constraint is given as

$$c^i_t + \tau^h_t q_t h_t + \tau^w_t w_t l_t + q_t i^{hi}_t + (R^m_t + \kappa)\frac{D_{t-1}}{\pi_t} \leq L_t(i) + w^i_t n^i_t$$

The borrower is not able to return the entire amount of loans borrowed in period t in period t+1. As a result the borrower accumulates debt. The debt of the borrowing household evolves as

$$\frac{D_t(i)}{P_t} = (1-\kappa)\frac{D_{t-1}(i)}{P_t} + \frac{L_t(i)}{P_t}$$

where κ is the share of loans amortized. Amortization requirements imply that the borrower cannot re-optimize the total mortgage debt stock as he has to carry forward the unpaid mortgage principal (Chen and Columba, 2016). Also new housing loans carry a fixed interest rate R^F_t and a fraction Φ of existing loans are refinanced each period at the rate of R^F_t. Thus as Φ tends to 1, the economy tends more towards adjustable rate mortgages. The effective interest evolution equation in our paper closely resembles Alpanda and Zubairy (2014).

$$R^m_t(i) = (1-\Phi)(1-\frac{L_t(i)}{D_t(i)})R^m_{t-1}(i) + [\frac{L_t(i)}{D_t(i)} + \Phi(1-\frac{L_t(i)}{D_t(i)})]R^F_t$$

We start by assuming that Φ is exogenous and constant. This assumption restricts the power of monetary policy to impact household debt. But later we relax this assumption and make Φ a function of loan-to-value ratio such that refinancing activity and the share of adjustable rate mortgages depend on the stance of central bank macroprudential policy.

Nevertheless, the borrower's loan eligibility is restricted by two criteria - the loan to value ratio (LTV) and the payment to income ratio (PTI), both enforced by the banks. The LTV ratio (ϕ^{LTV}) on a loan is the ratio of the face value of the loan at origination to the expected value of the underlying housing collateral (Greenwald, 2016). By setting a cap on the LTV ratio, the lender reduces the probability that the property will not be worth enough to cover the balance on the loan in case of default. For example, a typical LTV limit of 80 per cent means the lender imposes a haircut of 20 per cent on the value of collateral so as to allow the property to fall in value by up to 20 per cent without becoming "underwater." Another simple way of interpreting it is to see it as a down payment requirement of 20 per cent for the house buyer. Hence a decline in the LTV ratio implying a larger haircut and a higher downpayment by the borrower from their purses should be construed as a contractionary signal in the economy as it should ideally reduce demand for loans and contract consumption and output.

$$R_t^m(i)L_t(i) \leq \phi_t^{LTV} E_t[q_{t+1}^e h_t \pi_{t+1}]$$

where q_t^e is the expected home price. A similar criteria that limits loan demand is the payment to income ratio of ϕ_t^{PTI}. Mathematically, this constraint can be expressed as

$$L_t(i) \leq \phi_t^{PTI} E_t[\frac{(1+\pi_{t+1})w_{t+1}l_t}{\kappa + r_t}]$$

Both these constraints assume additional significance as they naturally embed expectation channels within it. For given LTV and PTI ratio, loan demand goes up in anticipation of higher housing prices and higher wages. We elaborate more on this below.

To begin with, we assume that the regulatory variables ϕ_t^{LTV} and ϕ_t^{PTI} observe an AR(1) process .

$$\phi_t^{LTV} = (1-\rho_{ltv})\phi^{\bar{LTV}} + \rho_{ltv}\phi_{t-1}^{LTV} + \eta_t^{ltv}$$

$$\phi_t^{PTI} = (1-\rho_{pti})\phi^{\bar{PTI}} + \rho_{pti}\phi_{t-1}^{PTI} + \eta_t^{pti}$$

But later we allow for a rule based LTV and PTI. Particularly, we make macroprudential policy countercyclical with respect to the total debt stock such that whenever debt rises above average levels, the banks reduce these ratios to contract loan supply.

The household maximizes lifetime utility with respect to consumption (c_t^i, labor (n_t), housing (h_t^i), loans (L_t), debt (D_t) and effective interest rate (R_t^m) subject to the budget constraint, LTV and PTI borrowing constraints. The first order condition with respect to labor yields the labor supply function which is a critical result that is central to our understanding of the macroprudential instrument dynamics.

$$n_t^\theta = \lambda_t^i(1-\tau_t^w)w_t + \mu_t^{pti}\phi_t^{pti}E_t(\frac{\pi_{t+1}w_{t+1}}{\kappa+r_t}) + \underbrace{(1-\rho)\mu_t^{ltv}\phi_t^{ltv}h_t\lambda_t Ae^{z_t} + \beta^i\rho(1-\rho)\mu_{t+1}^{ltv}\phi_{t+1}^{ltv}h_{t+1}\lambda_t Ae^{z_{t+1}}} \tag{5}$$

In Equation (5), the marginal utility lost in supplying one unit of labor is compensated by the rise in wages net of income taxes, the shadow gain from the relaxation of the PTI constraint due to increase in labor supply and shadow gain from the relaxation of LTV constraint due to increased labor supply and the consequent increase in expected home prices. Due to lagged expectations term in the expected home price evolution equation, increased labor supply yesterday will also relax the LTV constraint. The last term in the labor supply equation is the discounted shadow gain from the relaxation of the LTV constraint on account of pass-through of past labor supply increases.

The first order condition with respect to housing shows that the marginal cost of purchasing a unit of housing today equals the marginal utility gains from housing services and the shadow gain from the relaxation of the LTV borrowing constraint owing to rise in the level of housing net of the consumption equivalent lost due to payment of property taxes to the government. The cost is also dampened by the discounted value of the increased housing wealth tomorrow in consumption equivalent terms. The equation shows that actual home prices are driven by expectations but also by various fundamental factors like inflation in the economy. They can also be influenced by various policy measures such as property taxes and loan to value ratio.

$$q_t = \frac{\xi_t^h}{\tau_t^h \lambda_t^i h_t^i} + \frac{\mu_t^{ltv} \phi_t^{ltv} q_{t+1}^e \pi_{t+1}}{\tau_t^h \lambda_t^i} + \beta^i \frac{\mu_{t+1}^{h,i}(1-\delta^h)}{\tau_t^h} - \frac{\mu_t^{h,i}}{\tau_t^h}$$

A simple algebraic manipulation of the equation also highlights the seminal guiding forces of the housing price formation process. Home prices can be expressed as an autoregressive process

$$q_t = Aq_{t-1} + \underbrace{B(q_{t+1}^e - q_t^e)}_{\text{increment in expectations}} + \underbrace{C(q_t^e - q_{t-1})}_{\text{bubble/prediction error}} + \beta^i \frac{\mu_{t+1}^{h,i}(1-\delta^h)}{\tau_t^h} - \frac{\mu_t^{h,i}}{\tau_t^h} + \frac{\xi_t^h}{\tau_t^h \lambda_t^i h_t^i}$$

where A = B = C = $\frac{\mu_t^{ltv} \phi_t^{ltv} q_{t+1}^e \pi_{t+1}}{\tau_t^h \lambda_t^i}$. The reorganised equation suggests that current home prices rise with increment in expectations and the self induced bubble in past expectations formation. Thus actual prices may deviate from the fundamentals due to expectation accretion and increase in the bubble term. But it can be brought back to equilibrium with increase in taxes and lower loan to value ratios.

3.4 Labor Market

The labor market is similar in spirit to Gerali and Neri (2012). There exists a continuum of labor types. The labor union sets nominal wages for workers of its labor type by maximizing a weighted average of its members utility subject to a constant elasticity of demand schedule and quadratic adjustment costs with indexation ι to a weighted average of lagged and steady state inflation as in the following equation .

$$\text{E\_}0\beta^i[U_{c_i}[\frac{W_t(m)}{P_t}n_t(i,m) - \frac{\kappa^w}{2}(\frac{W_t(m)}{W_{t-1}(m)-\pi_{t-1}^{\iota}\bar{\pi}^{1-\iota}})^2\frac{W_t}{P_t}] - \frac{n_t(i,m)^{1+\theta}}{1+\theta}]$$

The union charges each household lump-sum fees to cover adjustment costs. In a symmetric equillibrium, labor choice for each single household is given by the following non-linear wage phillips curve ensuing from the first order conditions of the above optimisation process.

$$\kappa_\omega(\pi_t^w - \pi_{t-1}^{\iota}\bar{pi}^{1-\iota})\pi_t^w = \beta^i E_t[\frac{\lambda_{t+1}^i}{\lambda_t^i}\kappa_\omega(\pi_{t+1}^w)]$$

The demand for labor services emerges from a perfectly competitive labor packer who assembles them into CES composite labor input to be supplied to be supplied to intermediate goods producers. The labor packer solves the following optimisation process.

$$Max.\ (\int_0^1 n_t(m)^{\frac{\epsilon^n-1}{\epsilon^n}}dm)^{\frac{\epsilon^n}{(\epsilon^n-1)}}$$

s.t $\int_0^1 W_t(m)n_t(m)dm \leq \bar{V}$

for a given level of wage bill $\bar{V}$. The FOCs give rise to demand function for differentiated labor supply.

$$n_t(m) = (\frac{W_t(m)}{W_t})n_t$$

where W_t is aggregate wage rate.

3.5 Housing Market

Housing serves as a collateral for the borrowing agents to obtain a secured loan from the bank. However, when the agent does not payoff the entire amount of the loan next period, the bank does not sell off his house to recover the unpaid part of the loan. The collateral sell-off is not triggered because there is no default on the loan but only delayed payment of the loan. This design is intuitive. Non-payment of the loan for a period does not trigger a sell-off of the collateral because even sell-off has a cost including setting up of auction, redistribution of the proceeds amongst stakeholders and sundry other legal proceedings. The cost is high in countries where property rights are not well laid out. The Bank rather prefers to categorise the non-yielding asset as non-performing, sub-standard and later doubtful before resorting to sell-off as a last-resort practice. During this life-cycle of the asset, the bank makes provisions against the probable loss which increases progressively with the length of non-payment period. Thus the bank bears the interim cost of accumulated NPAs and this cost is factored into the price of the loan.

In sum, the role of housing is to act as a catalyst for financial acceleration. When housing prices rise, given the loan to value ratio set by the regulator, the borrowers eligibility of the loan rises.

The housing market is assumed to be inhabited by a continuum of two types of agents - the optimists and the pessimists. A fraction λ of the economic agents are optimists who expect housing prices to increase (q^h), while the residual $1-\lambda$ are pessimists who expect housing prices to decline (q^l). Optimism or optimistic expectations which may be denoted by λ is assumed to evolve procyclically with respect to the business cycle and anticyclically with respect to monetary policy. such that

$$\lambda_t = \bar{\lambda}^{1-\chi} * \lambda_{t-1}^{\chi} e^{-(R_t-\bar{R})} e^{y_t-\bar{y}} \epsilon_t^{\lambda}$$

where $\bar{\lambda}$ is the steady state share of optimists in the population. So with a productivity shock, more people turn optimists about the economic environment and start expecting higher housing prices. Contrarily, with tightening of monetary policy, optimism dampens and more people start feeling pessimistic about the economic environment and consequently expect housing prices to go down. The ϵ_t^{λ} is an exogenous shock to expectations representing exuberance about the housing market whereby the number of optimists changes abruptly. The parameter χ ensures that the spike in expectations is gradual and not immediate. The time series of higher housing price and lower housing price evolve as an AR(1) process such as

$$q_t^h = \rho^{qh} q_{t-1}^h + (1-\rho^{qh})\bar{q^h} + (1-\rho^{qh})(\omega_h (y_{t-1}-\bar{y}) + \omega_h^2 (y_{t-2}-\bar{y}) + \omega_h^3 (y_{t-3}-\bar{y})$$

$$q_t^l = \rho^{ql} q_{t-1}^l + (1-\rho^{ql})\bar{q^l} - (1-\rho^{qh})(\omega_l (y_{t-1}-\bar{y}) + \omega_l^2 (y_{t-2}-\bar{y}) + \omega_l^3 (y_{t-3}-\bar{y})$$

where ω_h and ω_l are the weights on the lagged deviations of output from steady state output. The higher average price evolves as a positive function of weighted average of the deviations of output of the last three quarters from steady state output. The lower average price evolves as a negative function of weighted average of the deviations of output of the last three quarters from steady state output. The expected housing price at time t+1, q_{t+1}^e then evolves as a convex combination of the last period's expectations and the current expectations based on information at time t, λ_t, q_t^h and q_t^l.

$$q_{t+1}^e = \rho q_t^e + (1-\rho)(\lambda_t q_t^h + (1-\lambda_t) q_t^l)$$

3.6 Banks

There exists a perfectly competitive banking system which combines deposit liabilities and bank capital to issue loans. The bank pays a cost whenever the actual capital to loan ratio deviates from the regulatory prescribed target of ν^b. We assume that the cost function is quadratic in nature.

In sum, the bank's objective is to maximise the proceeds from the interest and principal payment on loans net of outgoings on interest payment on deposits and quadratic capital cost as given by the expression in.

$$E_0 \sum \Lambda_{0,t}^P [(R_{t-1}^m + \kappa)\frac{D_{t-1}(i)}{P_t} - R_t^d d_t(i) - L_t(i) + d_t(i) - \Delta k_t(i)^b - \mu^k (\frac{k_t(i)^b}{L_t(i)} - \nu^b)^2 k_t(i)^b$$

The bank accumulates capital with a view to meet bank regulatory norms to provide a buffer against the temporary default on the loans which adds to the non-performing assets pool. Unlike most other papers (Gerali and Neri, 2010), we assume that capital is a choice variable for the bank. The bank capital has to be revised each period in proportion to the required provisions against the accumulating NPAs. The bank capital thus evolves as

$$k_{t+1}^b = (1-\delta_k)k_t^b + \omega npa_t$$

where ω is the multiplier on NPAs created each period indicating the provisions that need to be set aside on bad loans by regulatory requirement. Since most of the banks in Slovakia are controlled by foreign entities (mainly banking groups in Austria, Italy and Belgium), we assume that capital is accumulated through the parent bank such that capital supplied k^s is given by

$$k_t^s = \bar{k^s}\Gamma_t$$

where Γ_t is a risk premium which rises with the sovereign debt of the country such that

$$\Gamma_t = e^{-\tilde{k}(B_t-\bar{B}})e^{\gamma_t}$$

where γ_t is an exogenous shock to risk premium. Further, all bad loans do not automatically turn into NPAs at once. The NPA pool is constantly adjusted due to definitional changes as well as some previous period NPAs becoming standard loans as the borrower pays off the principal and interest. We introduce three features into the law of motion of NPAs to capture the above dynamics. First, we assume that a fraction f of the bad loans each period turn into NPAs. Secondly, a fraction δ^w of NPAs is written off each period. Further, we impose a quadratic cost of adjustment of previous period NPAs with the current period NPAs due to changes in the definition of NPAs from time to time. The NPA equation then evolves as

$$npa_t(i) = (1-\delta^w)npa_{t-1}(i) + f(1-\kappa)L_t(i) + k^n(1-\frac{npa_t(i)}{npa_{t-1}(i)})^2 npa_t(i)$$

where k^n is adjustment cost factor. The fraction δ^w of NPAs that is written off follows a stochastic process. This is introduced to understand the costs of writing off of loans from time to time.

By repeated use of the balance sheet constraint in the objective function, the latter reduces to

$$(R^m_{t-1}+\kappa)D_{t-1}(i) - (1+r^d_t)L_{t-1}(i) + r^d_t k_{t-1}(i) - 0.5kk^b(\frac{k_t(i)^b}{L_t}(i) - \nu^b)^2 k_t(i)^b$$

The resulting objective function is maximised with respect to L_t, k^b_t and npa_t's subject to the laws of motion of bank capital and NPAs. The first order conditions after differentiating the objective function with respect to bank capital (k^b) yields the deposit interest rate setting equation.

$$R^d_t = 1 + \frac{1}{\beta^p}[\varsigma^k_t + \varkappa(\frac{k^b_t(i)}{L_t(i)} - \nu^b)(\frac{k^b_t(i)}{L_t(i)}) + 0.5\varkappa(\frac{k_t(i)^b}{L_t(i)} - \nu^b)] - \varsigma^k_{t+1}(1-\delta^k)$$

Deposit rates are set by banks taking into account the leverage of banks and the future path of the shadow value of the bank capital constraint. The deposit interest rate is set as a function of the shadow value of bank capital constraint and the capital adjustment costs. Higher capital adjustment costs induce banks to attract deposits through marginal increase in deposit rates. A higher shadow value attached to the capital constraint per unit increase in the provisions implies reduced optimal bank profits as well as lower net transfer to the savers. So intuitively, the mark-up covers the costs in terms of loss in net profit transfer to savers for which the latter is compensated through higher deposit rates. Another way of looking at this equation is that depositor's are compensated for the provision of liquidity that guarantees banking stability.

Rearranging the equation from the first order condition with respect to loans (L_t) yields the lending rate setting equation given as

$$R_t^m = R_t^d - \frac{1}{\beta^p}[\varkappa(\frac{k_t^b(i)}{L_t(i)} - \nu^b)(\frac{k_t^b(i)}{L_t(i)})^2] - [\mu_t^n f(1 - \kappa)] - \kappa \quad (6)$$

Lending rates are linked to the deposit rate, cost of NPA accretion and the leverage of the banks. Evidently, there is complete pass-through of the cost of funds to the bank customer. Banks pay a cost when capital to asset ratio moves away from the prescribed norm and bad loans add to the NPA pool thereby reducing bank profits. The optimal choice for banks is to choose a level of loans such that marginal cost of reducing capital to asset ratio and the marginal cost of adding bad assets to the NPA pool equals the interest rate spread.

The bank also fixes the rate of provisioning taking into account the expected future path of NPA adjustment costs.

$$\begin{aligned}\mu_t^k \omega = \varsigma_t^n(1 - 0.5k^n(1 - \frac{npa_t}{npa_{t-1}})^2 - k^n(1 - \frac{npa_t}{npa_{t-1}}(\frac{npa_t}{npa_{t-1}}))) \\ + \beta^p E_t \varsigma_{t+1}^n(-(1 - \delta_{t+1}^w) + k^n(1 - \frac{npa_{t+1}}{npa_t})(\frac{npa_{t+1}}{npa_t})) \quad (7)\end{aligned}$$

Hence given the macroprudential tools at a point in time, optimistic expectations about the housing market will fuel higher credit off-take against housing as a collateral which in turn would trigger larger accumulation of NPAs due to delayed repayment of loans. Unless all NPAs are written off which is implausible, a larger pool of NPAs is likely to cascade into larger future NPA adjustment costs. According to the above equation, the rate of provisioning of capital for banks depends on the path of shadow cost of NPA accretion net of NPA adjustment cost and discounted present value of shadow cost of NPA accretion net of writing off of NPAs for the banks.

4 Pricing

Each monopolistic firm faces a quadratic cost of adjusting nominal prices a la Rotemberg (1982). The i-th firm will set the price so as to maximise the present discounted value of future profits given as.

$$E_t \Sigma Q_{t,t+j}[P_{t+j}(i)Y_{t+j}(i) - w_{t+j}l_{t+j}(i) - \frac{\aleph}{2}(\frac{P_{t+j}(i)}{P_{t+j-1}(i)} - 1)^2 Y_{t+j}]$$

subject to the demand function $y_t(i) = (\frac{P_t(i)}{P_t})^{-\epsilon}$, where Q is the stochastic discount factor. The firm thus maximises over the Langrangean function.

$$L_t = E_t \Sigma Q_{t,t+j}[P_{t+j}(i)Y_{t+j}(i) - w_{t+j}l_{t+j}(i) - \frac{\aleph}{2}(\frac{P_{t+j}(i)}{P_{t+j-1}(i)} - 1)^2 Y_{t+j}] - mc_{t+j}(i)(Y_{t+j}(i) - Al_{t+j}(i))$$

First order conditions with respect to $P_t(i)$ and $l_t(i)$ after applying symmetry since all firms face the same optimisation problem are given as:

$$Y_t - \epsilon Y_t + \epsilon \frac{mc_t}{P_t} Y_t - \aleph(\pi_t - 1)\pi_t Y_t + \aleph E_t Q_{t,t+1}(\pi_{t+1} - 1) Y_{t+1}\pi_{t+1}^2$$

$$mc_t = \frac{w}{A}$$

5 Government

The Government spends the proceeds of taxes earned and bonds sold on provision of transfers and interest payments on bonds.

$$\tau_{w,t} w_t l_t + \tau_{h,t} q_t h_t + \tau_{c,t} R_t^d d_t + B_t \leq tr_t + B_{t-1}(1 + r_t)$$

For setting up of income and property tax equation, we follow Fernandez et al (2015).

$$\tau_t^w - \bar{\tau^w} = \rho_w(\tau_{t-1}^w - \bar{\tau_w}) + \phi_{w,y}(y_{t-1} - \bar{y}) + \phi_{w,b}(\frac{B_{t-1}}{y_{t-1}} - \frac{B}{y})$$

$$\tau_t^h - \bar{\tau^h} = \rho_h(\tau_{t-1}^h - \bar{\tau_h}) + \phi_{h,y}(y_{t-1} - \bar{y}) + \phi_{h,b}(\frac{B_{t-1}}{y_{t-1}} - \frac{B}{y})$$

where τ_t^w and τ_t^h are the mean of the income and property tax rate, respectively. B_t is public debt and y_t is output. The equations allow for two channels of feedback, one from business cycle and the other from debt to output ratio.

6 Central Bank

Slovakia has moved into the monetary union since 2012 and hence the interest rate is given exogenously. We use a simple interest rate rule similar to Vybraska et al (2019).

$$1 + r_t = (1 + r^*)\epsilon_t^m$$

where r^* is the foreign interest rate and ϵ_t^m is an exogenous shock to monetary policy.

7 Market Closing

Equilibrium in the housing market is given as

$$h_t^p + h_t^i = \bar{h}$$

Equilibrium in the goods market is given by the resource constraint

$$Y_t = C_t + q_t(h_t - (1 - \delta^h) * h_{t-1}) + Adjustment\ \ Costs$$

where $C_t = c_t^p + c_t^i$ is aggregate consumption and Y_t is aggregate output in the economy.

8 Calibration

Calibration of parameters for the Slovakian economy is a challenge given the limitations of the dataset and country specific studies. We hence take cues from various euro area studies, some DSGE models constructed for the Slovak economy by the NBS and various other studies to calibrate parameters of the model. The depreciation rate of bank capital is fixed at 0.1049 in line with Gerali et al (2010), while the depreciation rate of the housing is set at 0.01 as per Iacoviello and Neri (2013). The inverse of frisch elasticity is set at 1.5 in accordance with Gerali et al (2010). The income tax rate ($\tau_{w,t}$) in Slovakia is set at 19 per cent per annum. The land tax rate ($\tau_{h,t}$) in the economy is very low. This works out to a quarterly gross rate of close to 1.0 per cent. The amortization rate (κ) is set at 0.033 years in sync with the steady state value of new loan to debt ratio. The percentage of NPAs written off works out to 2.8 percent. Total loans to GDP ratio is on average 17.7 per cent, while NPAs, on average is 9.9 per cent of GDP. The rate of provisioning in the bank is fixed at 1.9 per cent in tune with the steady state value of depreciated capital per unit of NPAs created each period. The proportion of bad loans turning to NPAs each period is fixed at 1.7 per cent to match the written off NPAs per unit of bad loans.

The discount factor of savings households is set at 0.984 which varies inversely to the gross policy interest rate and that of borrowing households is fixed at 0.975 in line with Gerali and Neri (2010). The lending rate is set as the sum of deposit rate and discounted value of non-performing loans net of the amortization rate as obtained from the first order condition of the bank profit maximisation problem. The steady state deposit rate is set at 1.02 per cent which is equivalent to a mark-up over the policy interest rate net of the discounted present value of un-depreciated bank capital. The LTV ratio is fixed at 0.78 from the financial stability report and payment to income ratio at 0.123. The elasticity of labor demand is set at 7, while elasticity of substitution in the good market is fixed at 1.08.

Table 1: Calibrated Parameters

β^p	Discount Factor of Savers	0.984
β^i	Discount Factor of Borrowers	0.975
κ	Amortization ratio	0.033
θ	Inverse of Frisch Elasticity	1.5
$\tilde{\theta}$	Borrower's Credibility Measure	exp(2.6)
δ^k	Depreciation Rate of Bank Capital	0.1049
δ^h	Depreciation Rate of Housing Stock	0.01
ω	Rate of bank provisioning (\frac\deltak̂*\nub̂(1-\kappa))	0.019
f	Multiplier on bad loans in NPA Law of motion	0.017
δ^w	Rate of writing off of NPAs	0.029
Ξ_1	Weightage of Housing Service in Savers Utility	0.01
Ξ_2	Weightage of Housing Service in Borrowers Utility	0.01
a^p	Degree of Habit Formation in Savers' Consumption	0.4
a^i	Degree of Habit Formation in Borrowers' Consumption	0.8
ψ_1	Size of Portfolio Adjustment Costs w.r.t Bonds	0.01
ψ_2	Size of Portfolio Adjustment Costs w.r.t Deposits	0.01
κ^{hp}	Investment Adjustment Cost parameter (Savers Housing Inv.)	0.5
κ^{hi}	Investment Adjustment Cost parameter (Borrowers Housing Inv.)	0.5
Φ	Rate of Refinancing	0.55

Table 2: Steady State Values

k$\hat{b}$/L	Bank Capital to Assets Ratio	0.17
L/Y	Household Loan to GDP ratio	0.18
D/Y	Household Debt to GDP Ratio	0.50
d/Y	Bank Deposits to GDP ratio	0.15
$\phi^{\bar{ltv}}$	Loan to Value Ratio	0.78
$\phi\bar{\Theta}dti$	Payment to Income ratio	0.12
n	labor Supply	0.33
B	Domestic Bonds net supply	0
npa	NPA to GDP ratio	0.09
f	Multiplier on bad loans in NPA Law of motion	0.017
R$\hat{d}$	Deposit Rate	1.01625
\bar\tau$\hat{w}$	Steady State Income tax rate	0.19
\bar\tau$\hat{h}$	Steady State gross housing tax rate	1\bar\tau$\hat{h}$
Steady State interest income tax rate	0.25	

9 Results

The model envisages three sources of perturbation to expectations. The productivity channel, the interest rate channel and the exuberance channel which encompasses a purely stochastic source of shock to expectations. These three different cases enable us to distinguish between a 'good boom' and a 'bad boom'. Slovakia being in the Euro area does not possess an independant monetary policy. Hence, interest rates is not an internal source of fluctuation in expectations about the housing market unlike productivity and exuberance channels. There are two major channels of transmission of the shocks viz., expectations effect and constraint switching effect. We show below that expectations driven by productivity advances have a salubrious impact on the economy as compared to the case of expectations driven by exuberance shocks.

9.1 Endogenous vs Exogenous Shocks to Expectations Formation

A positive productivity shock has a direct positive impact on output and the labor market. Higher output accelerates optimism about the housing market causing expected home prices to rise. The presence of output in the expectations term allows for a regular feedback from changing output and interest rates into expectations. This makes technology shock appear like a permanent shock to expectations. A 25 basis point rise in technology shock, raises peak optimistic expectations by 0.7 basis points and expected home prices by 0.3 basis points. Optimistic expectations contributes close to 0.24 basis points to the hike in expected prices, while the residual spike in expected prices may be attributed to lagged expectations. Exuberance or exogenous shocks to expectations, almost replicates the economy under productivity shock, but significantly higher in terms of the magnitude of the impact on expected home prices. A 25 bps exogenous shock to expectations directly raises expectations by 15 bps on impact, implying imperfect pass-through due to lagged expectations. This leads to 7 bps rise in expected home prices.

Under endogenous shock the constraint switching effect pre-dominates the expectations effect. The positive productivity shock generates demand for labour which accelerates real wages. Labor supply rises in response to the shock leading to relaxation of the PTI constraint. As a result, borrowers become willing to pay a premium on housing driving up demand for housing and housing investment. However, the expansionary impact on actual home prices is dampened by the endogenous increase in property taxes which are an increasing function of income. The switching effect completely dominates the expectations effect as the cumulative rise in expected home prices on account of rise in output is small and hence the resultant decline in the shadow price of the LTV constraint is not enough to accelerate the cost of labor supply. Further due to productivity shock, the wage income effect on labor supply is significantly high causing labor supply to go up consistently. As a result labor supply and output go up under endogenous shocks to expectations formation. Credit market expands and both nominal and real debt grows considerably as inflation falls owing to positive supply response. Because of rising output and wages, ability to service debt increases significantly under endogenous shock to expectations (Figure 19).

Contrarily, under exogenous shock, the expectations effect dominates the constraint switching effect which is almost non-existent in this case. Because of the relatively large increase in expected home prices, the desired level of housing investment is lower than the available loan that households can take out. Thus the langrange multiplier on the LTV borrowing constraint declines significantly. Observing the inter-temporal condition on labor supply, this implies that the shadow gain from the relaxation of the LTV borrowing constraint due to increase in expected prices from an additional unit of labor supply is decreasing raising the marginal utility loss from sacrifice of a unit of leisure. In other words, the large increase in expected home prices accelerates expected wealth from home ownership which reduces labor supply. Intuitively, for households who do not own homes, higher expected home prices in a region may lead to migration of labor to regions with jobs as well as locally affordable homes. [3] Thus labor supply falls gradually moderating output in the economy under exogenous shock. The decline in output coupled with contraction in labor market squeezes households ability to service debt leading to a 'bad boom'. However, the phrase 'bad boom' has to be taken with a pinch of salt. The economy with exogenous shock performs better than the economy under endogenous shocks on some measures. The real debt is higher under exogenous shock in the short run but declines faster over the medium run. Banking soundness significantly improves under exogenous shock due to steadily declining NPAs. The significant contraction in credit demand in the medium run restricts the growth of bad assets in the economy under exogenous shock.

[3] Migration might be easier for the unskilled population. In that case, the differentiation of skilled and unskilled labor force would be a good addition to the model. We keep this topic aside for future research.

9.2 Policy Management

9.2.1 Macroprudential Policies

In order to get at the appropriate policy response to manage shocks to expectations, we compare the response of macro variables to endogenous and exogenous shocks under varying levels of macroprudential instruments. We create four scenarios. One, tight LTV ratio where central bank reduces loan to value ratio by 10 basis points from 0.78 to 0.68. Two, a tight payment to income ratio whereby we have a lower household debt with higher amortization as we double the amortization rate from 0.033 to 0.06. Three, we tighten both LTV and PTI constraints together. Fourth, is the baseline with LTV at 0.78 and amortization rate at 0.033.

Results show a clear distinction between the impacts of the macroprudential measures under endogenous and exogenous shocks in the short run and medium run, respectively (Figure 35 and Figure 51). Tightening LTV apparently stands out as the most potential instrument to manage endogenous shocks to expectations. A 10 bps contraction in LTV, directly affects the borrowing constraint of the borrower. This implies that the intended housing investment of the borrower is higher than the level of available loans they can take out. Thus when the productivity shock triggers a rise in labor demand and output relaxing the PTI constraint endogenously in the process, the impact of constraint switching effect is dampened by the presence of a lower LTV ratio. Resultingly, the strong rise in housing investment and actual home prices does not come through as in the baseline. The decline in Langrange multiplier is also lower than that under the baseline conditions indicating a tighter borrowing constraint on account of the lower LTV ratio. The rise in shadow cost is equivalent to raising the interest rate on new loans which reduces demand for credit and restricts the growth of household debt. Typical to our model, the eventual increase in shadow price, raises the marginal utility loss from sacrificing a unit of leisure inducing a lower labor supply response and pushing output below the baseline level in the medium run. In the normal course when monetary policy channel is active, the contraction in LTV is accompanied by a decline in policy rates as inflation declines with output contraction.

Figure 4: Output

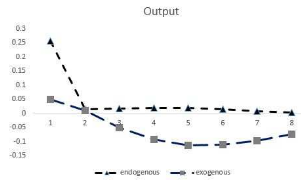


Figure 5: Consumption

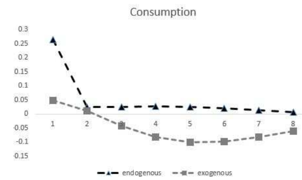


Figure 6: Inflation

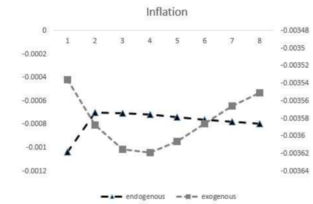


Figure 7: Labor

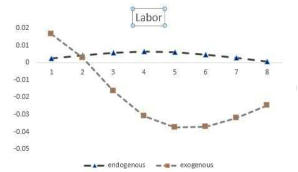


Figure 8: Home Price Expectations

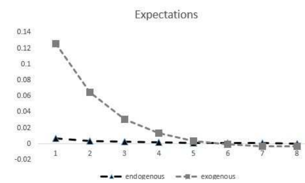


Figure 9: Expected Home Prices

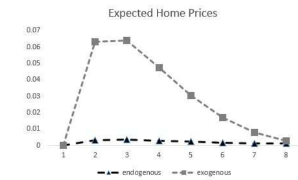


Figure 10: Actual Home Prices

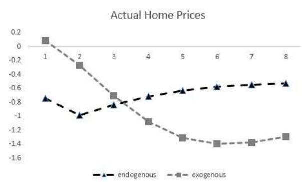


Figure 11: Nominal Debt

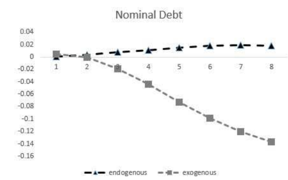


Figure 12: Credit

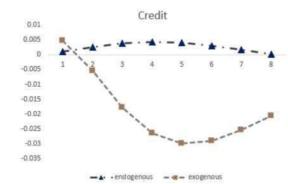


Figure 13: Debt Service

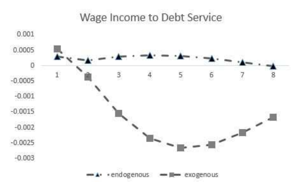


Figure 14: Lending Rate

Figure 15: Refinancing Rate

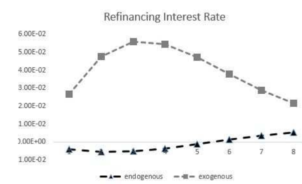


Figure 16: NPA

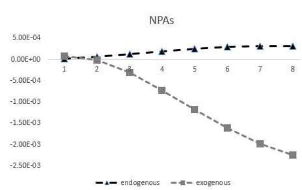


Figure 17: Real Debt

Figure 18: NPA Coverage

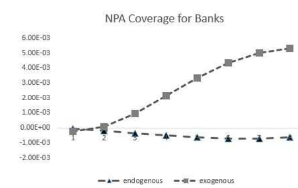


Figure 19: Response to Endogenous and Exogenous Shocks to Expectations

This tends to reverse some of the contractionary features of LTV contraction. Since policy rates cannot be independantly modified in the current model, LTV contraction dampens endogenous shocks quite high handedly in the medium run. In fact LTV tightening reduces aggregate output and inflation significantly as compared to other contractionary macroprudential policies. However, the LTV tightening does not do too well in terms of advancing debt service ability of the borrowers as compared to PTI tightening or twin policy tightening.

LTV tightening scores over other macroprudential policy measures in managing exogenous shocks also but the competition is too close in this case. Tightening both LTV and PTI is also a good option in managing exogenous shocks. Clearly, the results are in line with the empirical evidence in this regard. The impact of LTV tightening sets in relatively late in case of endogenous shocks but early in case of exogenous shocks.

9.2.2 Macroprudential Policy Reaction Function with Feedback Rule

Next we allow for a feedback rule in the macroprudential reaction function such that the central bank revises macroprudential regulatory levels with respect to changes in household debt levels relative to a steady state value. This would ensure that the policy maker is more observant about finetuning the macroprudential policy instrument around its benchmark target variable which is household indebtedness in this case. We fix LTV and PTI levels such that LTV policy declines with increasing debt levels and payment to income ratio increases with increasing debt levels reflecting contractionary macroprudential policy stance of the central bank. Mathematically, we express the feedback rules in macroprudential instruments as under:

$$\phi_t^{ltv} = {\phi_{t-1}^{ltv}}^{\rho^{ltv}} {\phi^{\bar{l}tv}}^{(1-\rho^{ltv})} e^{(-(D_t-\bar{D}))} e^{(-\eta_t^{ltv})} \tag{8}$$

$$\phi_t^{dti} = {\phi_t^{dti}}^{\rho^{dti}} {\phi^{\bar{d}ti}}^{(1-\rho^{dti})} e^{((D_t-\bar{D}))} e^{(\eta_t^{dti})}; \tag{9}$$

We find that macroprudential policy with linear feedback rules reinforce the existing channels of transmission of shocks viz., constraint switching effect and expectations effect (Figure 67). The endogenous shock to expectations triggers an expansionary process of growth which includes rise in labor demand accompanied with a rise in real wages, increase in credit offtake and consequent rise in accumulated household debt. Because of the feedback rule, rise in debt increases the PTI ratio endogenously thereby enhancing the relaxation of the PTI constraint and the consequent responsive rise in the premium borrowers' attach to housing asset further raising borrowers' housing investment under endogenous shock. The net impact of a tightening of the PTI constraint and tightening of the LTV constraint endogenously, however, has a weakening effect on labor supply. The effect is offset and overpowered by the strong wage income effect. So labor supply and hence output tends to be comparatively lower than the baseline (without feedback) scenario. In sum, feedback adds more power to the constraint switching effect, heats up the housing market, lowers output in the medium run and creates deflation in the economy. It raises real debt and weakens debt service ability of the borrower.

Figure 20: Output

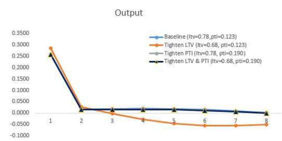


Figure 21: Consumption

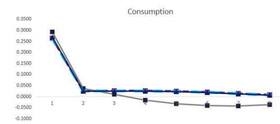


Figure 22: Inflation

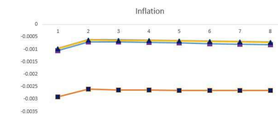


Figure 23: Labor

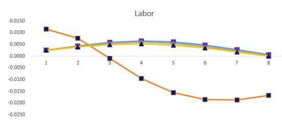


Figure 24: Home Price Expectations

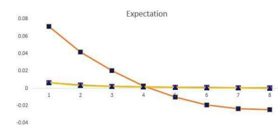


Figure 25: Expected Home Prices

Figure 26: Actual Home Prices

Figure 27: Nominal Debt

Figure 28: Credit

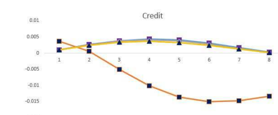


Figure 29: Debt Service

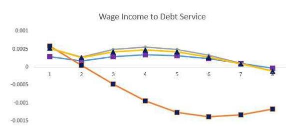


Figure 30: Lending Rate

Figure 31: Refinancing Rate

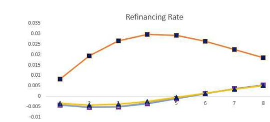


Figure 32: NPA

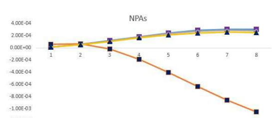


Figure 33: Real Debt

Figure 34: NPA Coverage

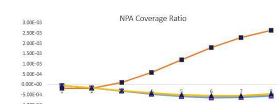


Figure 35: Policy Simulations - Response to Endogenous Shocks to Expectations

Figure 36: Output

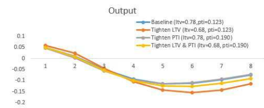


Figure 37: Consumption

Figure 38: Inflation

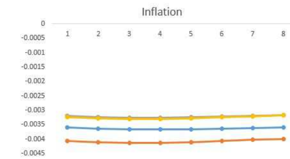


Figure 39: Labor

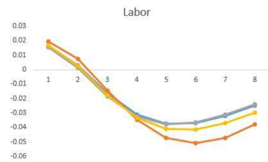


Figure 40: Home Price Expectations

Figure 41: Expected Home Prices

Figure 42: Actual Home Prices

Figure 43: Nominal Debt

Figure 44: Credit

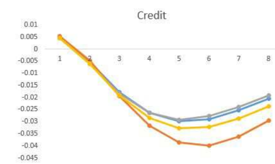


Figure 45: Debt Service

Figure 46: Lending Rate

Figure 47: Refinancing Rate

Figure 48: NPA

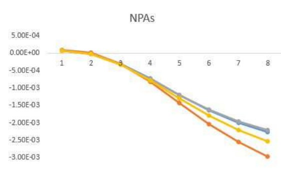


Figure 49: Real Debt

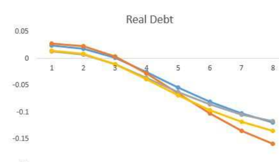


Figure 50: NPA Coverage

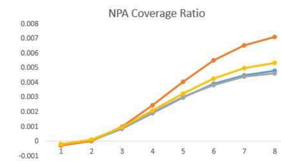


Figure 51: Policy Simulations - Response to Exogenous Shocks to Expectations

Under exogenous shocks, the sharp rise in expectations raises expected home prices. The ensuing expectations effect triggers a decline in housing investment by borrowers as they feel the virtual housing wealth effect. Both demand for fresh credit as well as accumulated debt declines. The latter leads to a countervailing increase in LTV ratio and a decline in PTI ratio, reflecting an endogenous loosening of macroprudential policy stance. While the loosening of LTV increases the shadow gains from the relaxation of the LTV constraint due to unit increase in labor supply, loosening of the PTI constraint reduces the shadow gains from the relaxation of the PTI constraint due to increased labor supply. In the absence of the wage income effect unlike during the endogenous shocks, the LTV impact overpowers the PTI impact in the medium run causing increased labor supply and output in the medium term unlike the baseline case. Lower nominal debt coupled with higher inflation leads to lower real debt. Debt service ability also exceeds baseline levels as well as levels attained under endogenous shock.

9.2.3 Role of Refinancing

If households are observant and endogenize their refinancing decision such that the refinancing rate changes with change in macroprudential policy, an additional channel of transmission is opened up that reinforces the effects of endogenous shocks but dampens exogenous shocks to expectations. Let us assume that households revise their refinancing decision using the following feedback rule:

$$\Phi_t = \bar{\Phi} e^{\phi_t^{ltv} - \phi^{\bar{ltv}}}$$

Under endogenous shocks when nominal debt goes up, LTV ratio declines by construction. If households decides to reduce their refinancing in response to lower LTV ratio, this would slow down the pass through of policy rate to the mortgage rates as the economy tends towards more fixed rate mortgages. New borrowings go up and the resulting addition to nominal debt would rise, far more than the baseline cases with feedback and without feedback detailed above. They increase consumption by borrowers and aggregate output which accelerates optimistic expectations and expected home prices.

Under exogenous shocks, on the other hand, as nominal debt declines, LTV increases raising rate of refinancing by borrowers. Higher rate of refinancing leads to greater pass through of policy rates into mortgage rates as the economy moves towards adjustable rate mortgages. Higher rates reduce demand for credit and as a result nominal debt also declines. Consumption and output fall leading to decline in induced home price expectations and expected home prices. So while endogenous macroprudential policy (LTV policy) coupled with endogenous refinancing decision hinders monetary and macroprudential policy effectiveness in managing endogenous shocks, it enhances the monetary policy effectiveness in managing exogenous shocks.

Figure 52: Output

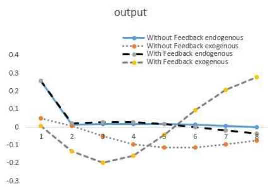


Figure 53: Consumption

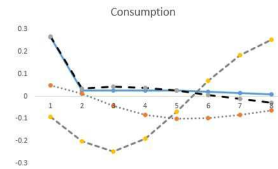


Figure 54: Inflation

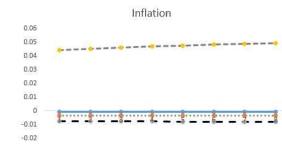


Figure 55: Labor

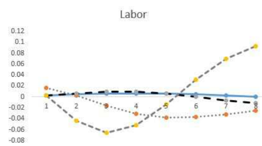


Figure 56: Home Price Expectations

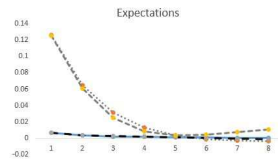


Figure 57: Expected Home Prices

Figure 58: Actual Home Prices

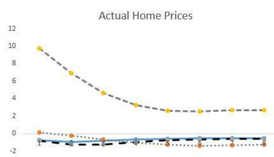


Figure 59: Nominal Debt

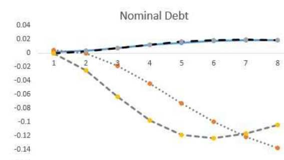


Figure 60: Credit

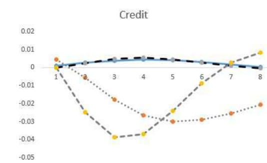


Figure 61: Debt Service

Figure 62: Lending Rate

Figure 63: Refinancing Rate

Figure 64: NPA

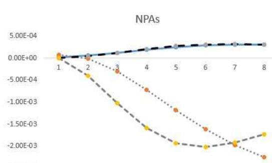


Figure 65: Real Debt

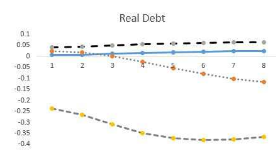


Figure 66: NPA Coverage

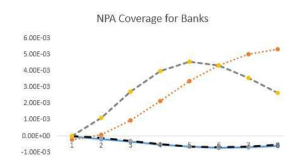


Figure 67: Response to Endogenous and Exogenous Shocks with Feedback Rule in Macroprudential Reaction Function

9.2.4 Housing Tax Shock

The housing tax shock works by moderating the impact of expected prices on actual home prices (Figure 83). A 25 bps increase in property tax rate raises the marginal cost of purchasing a unit of housing today. It reduces the optimal demand for housing and moderates the impact of expected housing prices and discounted price corrections on actual home prices. The resulting decline in housing wealth tightens the budget constraint of borrowers. Apparently, as the shadow gains from labour supply decline, borrowers also try to minimise the marginal utility loss from sacrificing leisure by reducing labor supply which then triggers a decline in output. Changing fundamentals of the economy trigger decline in home price expectations. Decline in home demand reduces demand for mortgage credit. Debt accumulation slows down and real debt declines as inflation strengthens. In sum, fiscal policy instruments impart stability to the banking system as NPAs fall and NPA coverage ratio improves. However, macroeconomic effects of fiscal policy are strong and not limited to the housing sector alone unlike macroprudential instruments. Output declines and inflation rises in the economy. Household's debt service ability and wage income to debt service ratio falls as output and wage incomes fall on account of the tax imposition.

10 Summary and Conclusion

We started with the hypothesis that housing price expectations spiral through exogenous sources and productivity increases and is a key ingredient behind rising household indebtedness. We established that although both the types of shocks trigger an expansionary process in the housing markets, endogenous shocks raise housing investment with higher expected prices, while exogenous shocks only increase home price expectations with no concomitant increase in fundamental investment in the housing sector. Under endogenous shocks, the economy witnesses an overall increase in output, labor market, credit and household debt accompanied with significant increase in debt servicing ability of the borrowing households. In sharp contrast, exogenous shocks led by pure expectation effects, raise only expected and actual housing prices with adjacent decline in other aggregate variables.

In terms of policy management of these expectation shocks, we find that fiscal policy can be potential instrument to arrest rising home prices but its impact is felt across the board in terms of lower output and higher inflation. So fiscal policy can work best in coordination with monetary policy, which in this case is not available as an independant instrument with NBS, Slovakia being in the euro area.

Our simulation results show that amongst macroprudential policies, loan-to-value ratios outsmarts all other policies and policy combinations in moderating the impact of endogenous shock to expectations. Exogenous shocks, on the other hand, can be equally managed by any contractionary macroprudential policy in general with LTV tightening having a slight advantage over other policies. Macroprudential policy with feedback with respect to household debt levels improves the management of exogenous shocks considerably. It lowers real debt and increases debt servicing ability of the borrower.

The practice of refinancing of loans can be used as a potential channel for transmission of monetary and macroprudential policy through timely coordination of two policies. If home prices are rising during rising productivity levels, it is an indication that endogenous shocks might be driving home price expectations which tend to raise

Figure 68: Output

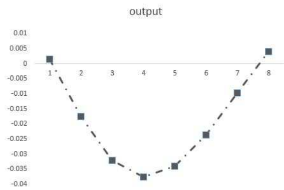


Figure 69: Consumption

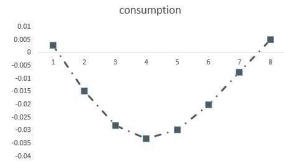


Figure 70: Inflation

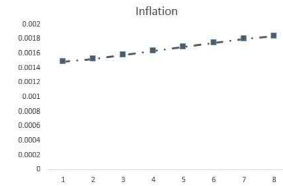


Figure 71: Labor

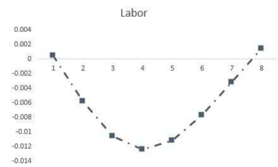


Figure 72: Home Price Expectations

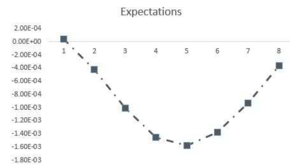


Figure 73: Expected Home Prices

Figure 74: Actual Home Prices

Figure 75: Nominal Debt

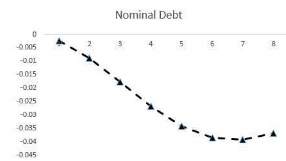


Figure 76: Credit

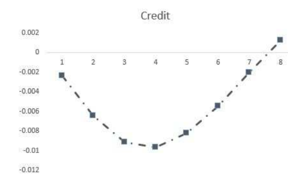


Figure 77: Debt Service

Figure 78: Lending Rate

Figure 79: Refinancing Rate

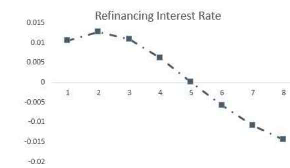


Figure 80: NPA

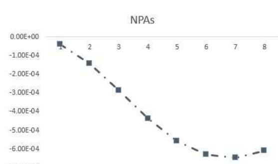


Figure 81: Real Debt

Figure 82: NPA Coverage

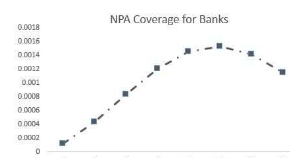


Figure 83: Response to Housing Tax Shock

indebtedness. During such times, the central bank may want to coordinate the timing of LTV policy changes internally with exogenous monetary policy decision of ECB. In that case, if ECB tightens monetary policy significantly, NBS may pursue a moderately expansionary LTV policy so that there is greater pass-through of higher policy rates into mortgage rates which will restrict credit and debt growth.

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