Loan to value ratios and housing prices. Evidence from Central and Eastern Europe

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Preface

I can admit that writing this master's thesis has already been a success for me because I have had an opportunity to work with and learn from a professor who is a real professional in his field. My greatest gratitude goes to my supervisor Asbjørn Rødseth for the help in planning my thesis, long-lasting and comprehensive discussions, very helpful comments and ideas. I really appreciate the time he has devoted to the supervision of my thesis.

I also wish to thank Ragnar Nymoen who was always able to find time for small discussions, who responded to every e-mail sent to him. He helped me to solve some estimation issues and better understand the output received in OxMetrics.

Finally, I would like to thank my parents for invaluable support and especially my mother's attempts to understand the mechanism of the financial accelerator and its relation to the loan-to-value (LTV) ratio. Last but not least, thanks to Domas for the motivation and encouragement.

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1   Introduction and summary

The recent financial crisis has shown that little time is needed for upheavals in financial markets to affect real economy. What started as a subprime mortgage crisis in one country ended up as an economic recession in the majority of modern world countries. Because of financial innovations, financial system has become more and more interconnected and complex. This has caused the expansion of the systematic risk (Rubio and Carasco – Gallego, 2014). The preexisted tools designed to manage the systematic risk and prevent contagion effect failed during the recent financial crisis. This situation induced discussions about the necessity to establish macroprudential policy and appropriate tools designed to limit the contagion effect and economic volatility by both national central banks and international institutions such as the International Monetary Fund (IMF) and The Bank for International Settlements (BIS).

In the last few years, the loan-to-value (LTV) ratio has been at the center of discussions about macroprudential policy. The Basel Committee on the Global Financial System named LTV ratio as one of the possible tools to achieve financial stability (Lambertini et al, 2013). According to the IMF, the introduction of limits on LTV ratio should mitigate *"risks generated by strong credit growth and credit-driven asset price inflation"* (Lim et al. 2011). A survey conducted by the IMF in 2013, shows that 52 per cent of analyzed countries (24 out of 46) had already limits on LTV ratio, 30 per cent of countries (14 out of 46) had both limits on LTV and on the debt-to-income (DTI) ratios (IMF, 2013). The number of countries that introduced limits on LTV ratios increased significantly in the aftermath of the recent financial crisis: six countries introduced limits on LTV ratios in 2010, three - in 2011 and two - in 2012 (IMF, 2013). An earlier survey of the IMF also finds that limits on LTV ratio together with other instruments aimed at credit growth (DTI and reserve requirements) are adjusted most frequently in such a way that they give a larger countercyclical impact (Lim et al. 2011).

The existing limits on LTV ratio provide basis for the analysis of financial accelerator mechanism, since those limits should constrain households and affect their optimal choice of housing. By the use of econometric methods, OxMetrics software packages and a panel of nine Central-Eastern Europe countries (CEE-9), this thesis analyzes the effect of existing limits on LTV ratio on housing prices and, at the same time, it looks for evidence of the existing financial accelerator mechanism in CEE-9 countries over 2006q1 to 2014q1 period.

However, the performed analysis has showed that longer time series would be beneficial for empirical tests presented in section 4. The selected countries provide a great opportunity to test the existence of financial accelerator mechanism, because the cross-country variation in both LTV ratios and real housing prices seems to be high (see table 3.1 and figure 3.2), especially in the period after financial crisis. The first part of empirical analysis is based on Almeida el al. (2006) work, who have analyzed 26 OECD countries (OECD-26). This part also includes comparison of the results obtained by analyzing two different sets of countries. However, we have decided to go a step further and include the long-term dynamics in the analysis.

The main reason why financial accelerator effect is possible with household spending is that households finance their spending by borrowing. In contrast to firms, households have no possibility to rise funds by issuing shares or bonds. They have fewer external finance alternatives. The use of property as a collateral for housing loans increases the risk of spill-over effects between housing prices and households' ability to borrow. A positive shock to household income increases demand for housing. Since supply of housing seems to be inelastic in the short-run, housing prices increase. The growth in housing prices leads to the increase in borrower's collateral value, which in turn decreases the external finance premium. This decrease further affects supply and demand of housing.

I have found evidence supporting the hypothesis of existing financial accelerator mechanism when collateral constraint binds in the Central-Eastern European (CEE-9) countries over 2006q1 to 2014q1 period. When compared to the results presented by Almeida et al. (2006) I have found that the effect of a change in household income when we interact it with existing limits on LTV ratio seems to be similar in CEE-9 and OECD-26 countries. The analysis including the long-run dynamics (equilibrium correction model (ECM) for housing prices) supports the hypothesis of existing financial accelerator mechanism when collateral constraint binds in CEE-9 countries as well. In order to test, whether the proposed (ECM) specification for housing price dynamics is better than the one used by Almeida et al. (2006), I have asked authors for the data set they used. Unfortunately, I have got an answer from the authors that they no longer have this data.

By analyzing the long-run relationship between housing prices, household income and limits on LTV ratio, I have found no cointegrating relationship between these variables. However, the results obtained by estimating ECM for housing prices suggest that changes in limits on

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LTV ratio have a long-run effect on housing prices but the magnitude of this effect appears to be small. Based on the results presented by the dynamic simulations, I have found that higher maximum LTV ratio is associated with higher real housing price volatility. More accurate and reliable results would have been obtained, if I had had a longer time series in my panel data set. The sample used in this analysis in most cases covers only one boom and bust cycle.

The organization of thesis is as follows; Section 2 discusses the theory of financial accelerator mechanism and limits on LTV ratio. In line with the theory we present a small survey of empirical contributions. Section 3 describes the data. Section 4 presents the results of empirical tests used in testing the theory presented in the previous section. This section is divided in two subsections. The first subsection is devoted to comparison of the results obtained by analyzing CEE-9 countries to the results presented by Almeida et al. (2006) for OECD-26 countries. The second subsection lays out the extension to housing price equations proposed by Almeida et al. (2006). Section 5 introduces dynamic simulations based on the results presented in the previous section. Section 6 concludes.

2 The theory of financial accelerator and limits on the loan-to-value (LTV) ratio

This section presents literature review on the financial accelerator mechanism and use of limits on the loan-to-value (LTV) ratio as a macroprudential tool. This review contains both the theoretical knowledge and the empirical findings for the existence of the financial accelerator mechanism and effects of existing limits on LTV ratio on housing prices and other macroeconomic variables. The section ends with a presentation of a two-period model for a constrained housing demand.

2.1 The mechanism of financial accelerator

Bernanke and Gertler (1989) show how small economic shocks can have significant and persistent effects on real economy because of financial market frictions. Existing market imperfections (coming from asymmetric information or moral hazard) create a link between households' (and firms') financial health, borrowing capacity and credit in circulation and, hence, economic activity. Bernanke (2007) argues that the existence of this inverse relationship *"creates a channel through which otherwise short-lived economic shocks may have long-lasting effects"*. According to Ćorić (2011), economic disturbances, which can induce the financial accelerator effect, include all shocks that cause: changes in the value of borrowers' liquid assets (such as, a change in productivity, decrease in foreign demand, etc.); changes in the value of borrowers' illiquid assets (that can arise due to a change in asset prices, in interest rate, etc.); change in borrowers' outstanding obligations (that can also be caused by the changes in interest rate).

Aoki et al. (2004) describe the financial accelerator effect on household spending in the following manner: a positive shock to economic activity increases housing prices, this leads to the growth in borrowers' collateral value, this growth in turn decreases the external finance premium, which boosts housing investments and consumption. According to Borio and Lowe (2002), increasing housing and property prices combined with a rapid growth of credit *"increase the probability of an episode of financial instability"*. If hypothesis about the presence of financial accelerator is correct, then we should expect that changes in the value of

housing will affect household borrowing and spending by somewhat more than in a benchmark case where only wealth effect is at work (Bernanke, 2007).

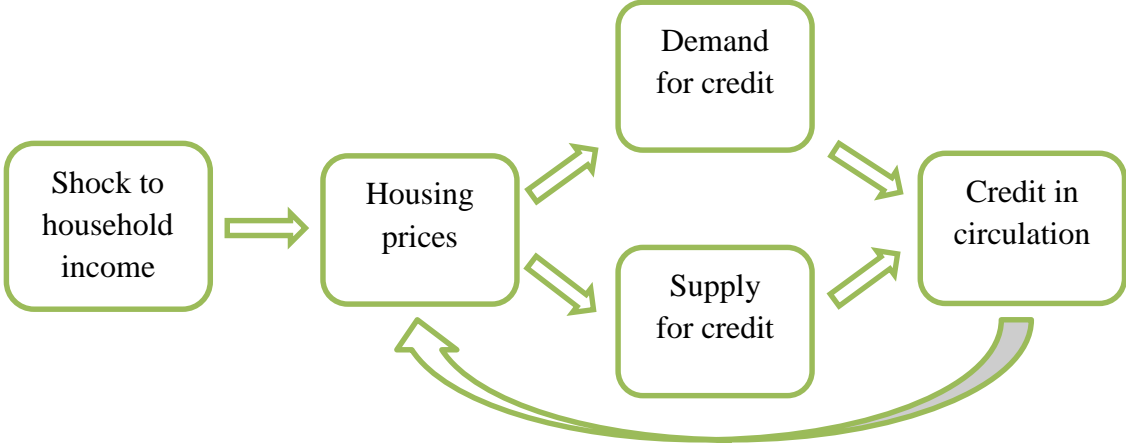**Figure 2.1. Relationship between housing prices and credit market**

Figure 2.1 presents the simultaneity aspect of the relationship between housing and credit markets. After a positive income shock, the demand for housing increases. The increased demand raises the price of housing, which in turn increases households' borrowing capacity. The increased borrowing capacity stimulates the raise in housing demand thus amplifying the initial increase in housing prices. The supply side of credit is affected through increased values' of banks' assets. As the value of collateral raises, likelihood of defaults on existing loans diminishes. In this way, banks' assets become less risky and may encourage banks to expend lending to households. Finally, changes in the credit market result in increased borrowing to households that put an upward pressure on housing prices.

So far, we have discussed the effect of increased housing prices only from demand side. Based on economic theory, increased supply of housing should slow down the growth of housing prices in case of a positive shock to household income. According to Tobin Q (Tobin, 1969) theory of housing, investment in housing is equal to the ratio of market price of existing houses (p_t) to its replacement value (w_t) raised to the power of elasticity of supply (η).

$$I_t = \left(\frac{p_t}{w_t}\right)^{\eta}$$ (2.1)

According to Anundsen (2013), the replacement value can be proxied by the sum of construction and land costs.

The increase in housing prices raise Tobin Q for residential investments via increase in the value of housing relative to its replacement value (construction costs) (Tobin, 1969). This increase further depends on the elasticity of housing supply. According to equation 2.1, a positive income shock will result in higher housing prices in countries with less elastic housing supply. Anundsen (2013) argues that supply elasticity depends on several factors, including land availability and regulatory constraints on housing construction. Countries that differ in regulatory framework and extent of restrictions on housing construction should face different damping in growth of housing prices after a positive income shock, other factors ceteris paribus.

Several recent studies find evidence that supports the theory of financial accelerator mechanism. At the moment, there is no perfect method to empirically test whether financial accelerator is at work. Researchers use many different techniques to test the hypothesis of the presence of financial accelerator mechanism. This section continues by presenting some most interesting techniques and findings in recent academic literature.

Anundsen and Jansen (2013) use a structural vector equilibrium correction model over the period 1986q2-2008q4 to analyze the relationship between housing prices and credit in Norway. They find that there is a two-way interaction in the long-run, meaning that an increase in housing prices lead to credit expansion, which further puts an upward pressure on housing prices. By using dynamic simulations, they show that when supply side of housing market is included into the model, the effects of shocks are dampened. They also conclude that the mechanism of financial accelerator is present in the Norwegian economy.

Kamber and Thoenissen (2012) use a relatively standard new Keynesian model with financial frictions and calibration that is quite standard in literature to show that with financial accelerator, the effect of changes in financial markets have a stronger impact on real economy. According to their model, an unanticipated 100 basis point decrease in nominal interest rate with pure inflation targeting rule, causes more than 8 percent increase in investment with the financial accelerator mechanism at work, and a 6 percent increase without financial accelerator. The effect on output (GDP) is much smaller. With financial accelerator, output increases more than 2.5 percent, without financial accelerator, it increases by 2.3 percent. This indicates that investment is more responsive to the monetary policy shocks than output.

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Gilchrist and Zakrajsek (2012) show that in response to an exogenous increase in financial bond premium, the net worth position of nonfinancial sector deteriorates significantly, real economic activity slows appreciably, while both the short- and longer-term risk-free rates decline noticeably. Gilchrist and Zakrajsek (2012) concludes that "*financial disruptions appear to be able to account for a substantial fraction of fluctuations in real economy activity during these last three recessions (1990 recession, burst of the tech bubble in 2001 and financial crisis in 2008)*".

Findings in recent studies support the theoretical framework of the financial accelerator mechanism proposed by Bernanke et al. (1999). However, methods used in testing the hypothesis of the presence of financial accelerator mechanism require improvement and further development.

2.2 Use of limits on LTV ratio as a macroprudential tool

The recent financial crisis increased researchers' interest in limits on LTV ratios and other macroprudential tools. We could divide existing studies on LTV ratios into two groups. One group of researchers (Walentin (2014), Lin (2014)) uses DSGE models in their analysis. Others (Wong et al. (2011), Lim et al. (2011), Almeida et al. (2006)) use econometric methods to discuss the relationship between limits on LTV ratios and other macroeconomic variables (housing prices, mortgage credit growth). Empirical results on the effect of LTV ratios on financial stability are rather mixed.

Almeida et al. (2006) find that "*housing prices as well as demand for new mortgages are more sensitive to income shocks in countries with higher LTV ratios*", using international variation in maximum LTV ratios. They claim that these results are consistent with the dynamics of a collateral-based financial accelerator in household spending. They also find that "*the empirical relationship between LTV ratios and income sensitivities is stronger in countries where housing prices are low relative to household income*". Almeida et al. (2006) argue that these results further support the existence of the financial accelerator mechanism behind the observed cross-country differences in income sensitivities, because when housing is more expensive, it is more likely that the income constraint is binding instead of the collateral constraint.

Lim et al. (2011) use a simultaneous equation setup to capture the feedback between growth of housing prices and financial stability. They use mortgage market structures as potential drivers. When estimating seemingly unrelated regressions, they control for housing finance characteristics that include a predominant interest rate type, maximum observed LTV ratio and an ordinal measure of government participation. This analysis covers 36 countries during two episodes, the boom (2004-2007) and the bust (2008-2009). In contrast to Almeida et al. (2006), this analysis rejects the importance of maximum LTV ratios in explaining crisis outcomes or pre-crisis boom. Moreover, the Lim et al. (2011) claims that maximum *"observed LTV ratios explain neither the depth of the house price downturn nor the increase in loan losses during the crisis"*. However, when their sample includes only advanced economies and estimation period is prolonged from 1980 to 2010, they find some evidence that LTV ratios could explain house price movements.

IMF (2011) finds evidence that prevailing contract types for mortgages play a significant role in an amplification mechanism. The presence of flexible rate contracts amplify fluctuations in housing prices, which are caused by changes in GDP growth. The IMF argues that it might be possible that flexible rate contracts appear more affordable for prospect borrower, although it makes the borrower more exposed to interest rate risk. IMF (2011) extends its analysis by including a government participation variable. The IMF considers both the composite index of government participation and specific dimensions. The analysis performed by the IMF suggests that government participation in a form of subsidies to first-time buyers, tax deductibility of capital gains on housing and government provision of guarantees or mortgage loans amplify the boom and exacerbate the bust. All these findings note negative, unintended consequences of government participation in the housing finance market.

In order to analyze the effectiveness and drawbacks of the limits on LTV ratios, Wong et al. (2011) use econometric analysis of panel data covering 13 countries. Based on empirical results and Hong Kong's experience, they find maximum LTV ratios to be effective in reducing systematic risk stemming from fluctuations in property markets. Results of their estimation show that using LTV ratios as a macroprudential tool enhances financial stability by diminishing the probability of mortgage default with respect to property price shocks. They also consider negative impact on liquidity (increased liquidity constraints) on homebuyers that follow the decrease in limits on LTV ratios. Wong et al. (2011) find empirical evidence that mortgage insurance programmes (MIP) are able to diminish negative

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consequences of increased liquidity constraint without affecting the effectiveness of the tool. In line with this finding, they recommend that potential liquidity constraints on households should not be treated as a major drawback leading to rejection of LTV limits as a tool for mitigating systematic risk stemming from property price shocks.

Rubio and Carasco – Gallego (2014) use a DSGE model with housing and collateral constraints in order to find a macroprudential rule for LTV ratio that would respond to credit growth. They find that when both the macroprudential rule for LTV ratio and a traditional Taylor rule for monetary policy are used, the stability of financial system and welfare of agents improves, especially in the case of a non-coordinated game (i.e. when both policies act in a non-coordinated way). However, they find that there is a trade-off in case of a non-coordinated game between heterogeneous agents. According to their DSGE model, in case of a positive technology or housing demand shock, based on the macroprudential rule for LTV, responsible authorities should decrease the limits on LTV ratios in order to moderate credit boom. Rubio and Carasco – Gallego (2014) conclude that by acting in this way the ultimate goal – financial stability – can be achieved.

By using a DSGE model with collateral constraints and two sectors (housing and goods), Walentin (2014) quantifies the effects of recent changes in maximum LTV ratios for mortgages in Sweden on the monetary transmission mechanism. His results support previous findings that the use of housing as collateral for loans amplifies the effects of housing demand and monetary policy shocks. According to Walentin (2014), consumption of constrained households is positively related to the increase in net worth. If monetary policy or housing demand shocks move housing prices and other macroeconomic variables (e.g. interest rate, GDP or consumption) in the same direction, then existing collateral constraints amplify these shocks. When shocks move macroeconomic variables in the opposite direction, the effect on the variable is dampened due to collateral constraints. Because housing demand and monetary policy shocks move macroeconomic variables used in the analysis of Walentin (2014) in the same direction, existing limits on LTV ratios amplify these shocks. The author concludes with a recommendation *"to take into account the effects of housing-related collateral constraints and their changing nature",* if we want to comprehend the monetary transmission mechanism.

Lambertini et al. (2013) address the issue of judgmental adjustment of limits on LTV ratios rather than a use of the rule. In order to analyze the optimal monetary and macroprudential policy, they use a model that allows boom-bust periods in housing price and growth of credit

and consists of two types of agents Borrowers and Savers. Their key finding is that both optimal interest rate rule, which takes into account the growth of credit, and maximum LTV ratio rule, which contains countercyclical response to credit growth, are Pareto improving relative to benchmark policy. In addition, both rules contribute to reduction in volatility of credit growth and housing prices without affecting volatility of inflation. The analysis of the optimal monetary and macroprudential policy suggests that there exists a trade-off between heterogeneous agents when both rules are implemented. The optimal policy for the Borrowers includes LTV ratio rule that reacts in a countercyclical manner to changes in credit growth, however, a constant LTV ratio is optimal for the Savers. To sum up, findings presented by Lambertini et al. (2013) suggest that the policy, which accounts for a variation of financial variables, is socially optimal.

Lin (2013) uses a monetary general equilibrium model, which allows for a collateral default, contains a banking sector, production and heterogeneous agents, in order to analyze optimal LTV ratio. According to her analysis, low LTV ratios that eliminate the possibility of default lead to a lower credit volume, which has negative implications on social welfare. The author argues that higher LTV ratios contribute to consumption smoothing of both types of agents (creditor and debtor) and diminish the total expected consumption of the borrower because increased demand for credit increases cost of borrowing as well. Lin (2013) finds that the optimal LTV ratio should allow for the possibility of default.

Some empirical evidence on the relationship between limits on LTV ratio and other macroeconomic variables are mixed (IMF (2011), Almeida et al. (2006)). According to IMF (2011), it might be because the limits on LTV ratios do not present the borrowing constraint on households in some emerging economies. However, the overview of empirical literature supports the existence of positive relationship between LTV ratios, housing prices and growth of credit. Moreover, most of the authors find limits on LTV ratios to be an effective macroprudential tool. Although it might be too early to evaluate the effectiveness of limits on LTV ratios implemented in recent years, according to the IMF, countries that have been using limits on LTV ratios for a longer time period saw it an *"effective way of dealing with real estate booms"*. To sum up, the IMF claims that limits on both LTV and DTI could be beneficial tools for sustaining financial stability by dampening credit and house price growth.

The presence of limits on LTV ratios provides a basis for existence of the financial accelerator mechanism. As it was discussed earlier, both positive and negative shocks to households'

income or net worth affect their borrowing capacity, which, in turn, affects housing prices. The degree of amplification is increasing in LTV ratios, which means, that for a given change in housing prices, the change in constrained households' net worth and demand is increasing in LTV ratios as well. According to Walentin (2014), a significant increase in the limits on LTV ratio "*implies substantial amplification of certain shocks on both housing and the macroeconomy more generally*".

2.3 A model for constrained housing demand

The framework of a two-period model for constrained housing demand derived in this section is based on Almeida et al. (2002). Note that this model is a part of the draft presented by Almeida et al. in 2002, but not of the later journal version presented by Almeida et al. in 2006.

It is crucial for this model that households, who are willing to borrow for purchasing a house, are constrained by existing limits on the amount they can borrow. This amount is typically limited to a particular proportion of value of the house they already own or are willing to buy. This proportion is called the loan-to-value ratio (LTV). Existing limits on LTV ratio leads to a credit quantity constraint (Almeida et al. 2002). Imposing limits on LTV ratio, we allow an amplification mechanism to take place in the collateral based spending cycle. The theory behind this overlaps with the one presented in previous subsections. When we model the relationship between limits on LTV ratio and income sensitivity of housing demand, we are able to test directly endogenous mechanism underlying financial accelerator. If financial accelerator is present, then the effect of positive shocks to household income should be amplified by increased households' borrowing capacity associated with higher maximum LTV ratio.

The purpose of this subsection is to model collateral and income constraints in housing demand and to analyze how small changes in housing demand affect housing prices. Assume that there are only two periods (t_1, t_2) and two goods in the economy, housing (H) and food (Z_1 and Z_2). Z_1 is food consumption in period one and Z_2 is food consumption in period two. The price of housing (P) is measured in units of food. Food costs the same in both periods; however, a representative household has a discount rate (β) for food consumption in the second period. The household buys housing at the beginning of period one; however, food is

purchased at the time period in which it is consumed. The household is endowed with lifetime income, $Y_1 + Y_2$, and seeks to maximize lifetime utility, subject to a budget constraint.

We introduce two borrowing constraints that limits household's choice of housing. However, only one of these constraints can bind at a time. In period one, the representative household cannot borrow directly against future income Y_2, meaning that it is required to have a collateral in order to get a mortgage (B_1) in period one. The representative household can borrow up to a particular proportion of housing value. Due to existing limits on borrowing, a "credit quantity (or collateral) constraint" exists in this economy:

$$B_1 \leq \lambda PH, \text{ where } \lambda \in [0;1] \tag{2.2}$$

In line with the forthcoming empirical analysis, we call parameter λ a maximum loan-to-value ratio (LTV). Higher value of λ makes it easier for the household to raise the amount of money needed for house purchase. To keep the model as simple as possible, assume that the household pays no interest rate premium when it borrows according to inequality (2.2).

The other borrowing constraint, which we introduce in this economy, is called an "income constraint". According to this constraint, the representative household cannot incur housing expenditures associated with the mortgage contract that are higher than a certain fraction of its yearly income. We can express this constraint as:

$$B_1 \leq kY_1 \text{ , where } k \in [0; 1] \tag{2.3}$$

k presents the amount of housing expenditure-to-future income ratio that cannot be exceeded by the household. Almeida et al. (2002) use Y_2 instead of Y_1 in equation (2.3). However, we believe that it is more rational for banks to focus on Y_1 since banks know it with certainty and it is a good predictor of income in the next period. This constraint means that, by paying back a debt in period two (t_2), the household cannot exceed a certain share of its income in period one (t_1).

Now we need to model a condition that determines if the representative household is borrowing constrained. If the maximum amount the household can borrow (B_1) is less than what is needed to finance the optimal unconstrained housing demand ($H^U(P)$), then the household is constrained. Let the maximum amount the representative household can borrow B_1^{max} be defined by

$$B_1^{max} = min[\lambda PH^U(P), kY_1] \tag{2.4}$$

According to the assumptions described above, the household is constrained if:

$$PH^U(P) > Y_1 + B_1^{max} \tag{2.5}$$

Meaning that if:

(i) $B_1^{max} \leq \lambda PH^U(P)$, the household is collateral constrained,

(ii) $B_1^{max} \leq kY_1$, the household is income constrained.

Based on eq. (2.4) we can find a condition for a binding income constraint:

$$\frac{k}{\lambda} < \frac{PH}{Y_1} \tag{2.6}$$

This condition implies that the income constraint is binding if the value of housing is high, relative to the income, or the maximum LTV ratio is high, relative to the ratio of maximum amount of housing expenditures associated with the mortgage contract to the yearly income.

Note that each of these constraints contain a *policy* variable k or λ. By changing these variables, authorities can affect the maximum amount of mortgage debt the household is allowed to have.

The optimal unconstrained demand for housing

When the representative household is not borrowing constrained, it maximizes its utility function:

$$\max U = \{\alpha \ln(H) + (1 - \alpha)\ln(Z_1) + \beta \ln(Z_2)\} \tag{2.7}$$

subject to a period-by-period budget constraint:

$$(i) \ B_1 = Z_1 + PH - Y_1 \text{ and}$$

$$(ii) \ B_2 = Z_2 + B_1 - Y_2 = 0 \tag{2.8}$$

In (ii) we have used an assumption that there is no residual value of the house, $B_2 = 0$.

After inserting (i) in (ii), we can derive a lifetime budget constraint:

$$Z_1 + PH + Z_2 = Y_1 + Y_2 \tag{2.9}$$

The representative household finds the optimal demand for housing based on the following first order conditions:

$$\text{w. r. t. H: } \frac{\alpha}{H} = \gamma P, \tag{2.10}$$

$$\text{w. r. t. } Z_1: \frac{1-\alpha}{Z_1} = \gamma, \tag{2.11}$$

$$\text{w. r. t. } Z_2: \frac{\beta}{Z_2} = \gamma, \tag{2.12}$$

where γ is the Lagrange multiplier for the lifetime budget constraint.

Based on the first order conditions, we can construct expressions for Z_1 and Z_2 and insert these expressions into the lifetime budget constraint (eq. (2.9)):

$$Z_1 = \frac{1-\alpha}{\gamma} = \frac{(1-\alpha)}{\alpha} PH \tag{2.13}$$

$$Z_2 = \frac{\beta}{\gamma} = \frac{\beta}{\alpha} PH \tag{2.14}$$

$$\frac{(1-\alpha)}{\alpha} PH + PH + \frac{\beta}{\alpha} PH = Y_1 + Y_2 \tag{2.15}$$

The optimal unconstrained housing demand (as a function of housing price) is given by:

$$H^U(P) = \frac{\alpha}{(\alpha+(1-\alpha)+\beta)} \frac{(Y_1+Y_2)}{P} \tag{2.16}$$

The optimal amount of housing is proportional to lifetime income. The proportionality factor is equal to $\frac{\alpha}{1+\beta}$ and it is determined by the weights put on commodities in the utility function. If the representative household appreciates consumption of housing more than consumption of food in period one (α is higher), then the optimal amount of housing is higher. If the representative household appreciates consumption of food more in period two (β is higher), then optimal amount of housing is lower.

The optimal constrained demand for housing

When the representative household is borrowing constrained, it maximizes its utility function (eq. (2.6)), subject to lifetime budget constraint (eq. (2.9)) and one of the borrowing constraints described by eq. (2.2) and (2.3). According to eq. (2.4), stricter constraint is binding.

When household is income constrained ($B_1^{max} \leq kY_1$), then the optimal demand for housing is found by optimizing the utility function with respect to Z_1 after inserting for H and Z_2 from lifetime budget and income constraints:

$$\max U = \alpha \ln \left(\frac{Y_1(1+k)-Z_1}{P} \right) + (1-\alpha)ln(Z_{1)} + \beta\ln(Y_2 - kY_1) \qquad (2.17)$$

Since it is better for the representative household to consume more than less, we have that $B_1^{max} = kY_1$ in the optimum.

After inserting the expression for Z_1 into the condition for binding income constraint (we insert an expression for B_1^{max} taken from eq. (2.5) into the binding income constraint), we can derive the optimal demand for housing when the representative household is income constrained:

$$H^I(P) = \frac{Y_1(1+k)\alpha}{P} \qquad (2.18)$$

In this case, the optimal amount of housing is proportional to the weight put on housing in the utility function and the policy variable k that determines the maximum amount of the mortgage debt the household is allowed to have.

When the household is collateral constrained ($B_1^{max} \leq \lambda PH^U(P)$), it buys less housing and borrows less in period one. As a result, the household is able to consume more in period two. The marginal utility of housing increases since the amount of available housing decreases. This leads to the cut in food consumption in period one, since the household is motivated to save more in order to buy more housing. By having some extra savings, the household is able to get much housing due to existing proportionality between mortgage debt and the value of housing. The optimal demand for housing, when household is collateral constrained, depends both on weights put on the goods in the utility function and on LTV ratio.

In order to analyze and compare the effect of a small change in current income on housing demand (suppose that housing prices do not change at the same time) in borrowing constrained and unconstrained cases, we take derivative of the optimal demand for housing with respect to current income Y_1:

$$\frac{\partial H^U}{\partial Y_1} = \frac{\alpha}{P(1+\beta)} \leq \frac{\partial H^I}{\partial Y_1} = \frac{\alpha(1+k)}{P} \tag{2.19}$$

This inequality shows that when there is a small increase in current income, demand for housing increases more when the household is income constrained. When collateral constraint binds, an increase in income will be spent in period one on both food and housing. The amount that is spent on housing will be supplemented by borrowing up to a new limit. Assuming that the household is collateral constrained, we can infer that the household's demand for housing will be more sensitive to changes in its current income, if this household is facing higher maximum LTV (λ) ratio.

Empirical implications

When "translating" this theoretical model into the empirical one, we face one major problem – housing demand is not directly observable in the countries we are going to analyze in the next sections. Following Almeida et al. (2006) we pick a real housing price index as a proxy for housing demand. However, in order to transform implications of this theoretical model with housing demand to the empirical model with housing price index, we need to assume some degree of housing supply rigidity. Indeed, this assumption is highly realistic for the Central Eastern Europe countries that had a planned economy up to the 1990's. The gap between supply and demand of housing in the 2000's was still considerable. The average number of rooms per person in CEE-9 countries ranges from 1.1. (in most cases) to 1.5, meanwhile the average number of rooms in EU-15 countries[1] is 1.8 (Eurostat). Moreover, the construction sector in these countries remained highly regulated by the state (Doing business, 2014). Therefore, it is reasonable to assume that changes in housing price index may approximate changes in housing demand.

Based on Almeida et al. (2002), we can show how changes in current income affect housing prices when supply of housing is perfectly inelastic, meaning that supply of housing is

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[1] The term EU-15 refers to the 15 Member States of the European Union as of December 31, 2013.

constant in the short-run. In this case, a change in demand should lead to a change in housing prices, not to the stock of housing, since it is fixed in the short-run.

In order to analyze and compare the effect of a small change in current income on housing prices when the representative household is not borrowing constrained and when it faces both budget and income constraints , we take derivative of the inverse demand function, assuming that H is a constant, with respect to current income Y_1:

$$\frac{\partial P^U}{\partial Y_1} = \frac{\alpha}{(1+\beta)} \le \frac{\partial P^I}{\partial Y_1} = (1+k)\alpha \tag{2.20}$$

In eq. (2.20), P^U represents the price level when the household is not borrowing constrained, P^I stands for the price level when income constraint binds. According to eq. (2.20), we can affirm that housing price sensitivity to changes in current income is higher when the income constraint binds. Since equations (2.19) and (2.20) are proportional to each other with a constant factor (1/P), we can conclude, that when housing supply is sufficiently inelastic, the properties of the model, which we have derived using housing demand, remain the same when we use housing prices instead.

In the long-run, high housing prices should induce investment in housing and supply of housing should increase. The long-run effect of an increase in housing demand on housing prices should be smaller than the short-run effect. However, the long-run effect depends on housing supply elasticity. When the household is collateral constrained, an increase in housing prices raises the amount the household can borrow. This in turn increases demand for housing and puts an upward pressure on housing prices.

According to Almeida et al. (2002), another possible challenge in the empirical analysis is a possibility of a strong autocorrelation of income. In this case, the comparison between borrowing constrained and unconstrained household becomes more complicated. This can be shown by introducing an autoregressive coefficient ρ into the household's income equation:

$$Y_2 = \tilde{Y}_2 + \rho Y_1 \tag{2.21}$$

where $\tilde{Y}_2$ is a stochastic component of income in period two.

Derivative of housing prices with respect to changes in current income becomes:

$$\frac{\partial P^U}{\partial Y_1} = \frac{\alpha(1+\rho)}{(1+\beta)}, \ \frac{\partial P^I}{\partial Y_1} = (1+k)\alpha \qquad (2.22)$$

When household income is autocorrelated, it is no longer possible to show that the effect of a change in current income on housing prices is always higher when the representative household faces both budget and borrowing constraints.

Lastly, it is important to test whether the changes in housing prices with respect to the household's income are not driven by the economic development. According to Almeida et al. (2002), this can come into the picture if a fraction of income spent on housing, α, increases over time. It is important to distinguish between economic and financial reasons for the increase in housing prices.

In our empirical analysis that investigates the short-run and the long-run effects of existing limits on LTV ratio on housing prices, we use country dummies in order to control for economic, cultural and behavioral changes that differ between countries. We aim to control for the cross-country differences in income sensitivities so that we could distinguish between economic and financial development.

3 Data description

We use a panel of nine Central Eastern European (CEE-9) countries to compare the effect of existing borrowing constrains in CEE-9 countries over the 2006q1 – 2014q1 period to the effect in 26 OECD countries (OECD-26) over the 1970 – 1999 period, that was estimated by Almeida et al (2006). In addition, using a panel of CEE-9 countries, this thesis tests whether the existing limits on LTV ratio have short-run or long-run effects on housing prices. We have chosen 2006q1 as a first quarter because it is the first quarter for which the official real estate price index is available for most of the countries (except for the Czech Republic, Hungary and Slovenia). Due to limited data availability of housing price index, our time series cover only one boom and bust episode.

We use quarterly changes in natural logarithms (logs) of real GDP and housing prices in subsection 4.1. Real GDP is used as a proxy for household income variable. Quarterly data on seasonally and working days adjusted real GDP per capita index (2005=100) for CEE-9 countries over the 2006q1 – 2014q1 period is sourced from Eurostat statistical database. Quarterly data on the real housing price index (2010=100) for all countries, except for Poland and Bulgaria, is also taken from Eurostat statistical database. We construct a real housing price index for Poland and Bulgaria based on data taken from Macrobond search engine. We use the price per square meter of usable floor space of a residential building to construct index for Poland that should approximate the housing price index taken from Eurostat database. We deflate the price per square meter of usable floor space of a residential building before constructing the index. This index is constructed by setting the average price per square meter of usable floor space of a residential building in 2010 equal to 100. In order to construct the housing price index for Bulgaria, that should approximate the housing price index taken from Eurostat database, we use quarterly average market prices of dwellings sourced from Macrobond. Before constructing the index, we deflate average market prices by a consumer price index. The housing price index is constructed by setting average market prices of dwellings in 2010 equal to 100. The panel of CEE-9 countries is unbalanced. We have housing price data for Czech Republic only from 2008q1, Hungary and Slovenia – 2007q1. The full sample has 254 observations.

In subsection 4.2, we analyze the short-run and the long-run relationships between housing prices, household income and limits on LTV ratio. In this subsection, we also try to find a

better proxy (than the real GDP per capita) for household income. We use a seasonally and working days adjusted index (2005=100) of a real final consumption expenditure of households as a proxy for household income in the construction of an equilibrium correction model (ECM). We also compare the results of the ECM when we use both real GDP and household consumption expenditure as a proxy for household income. The quarterly data for household consumption expenditure is taken from Eurostat statistical database.

In section 4, we use inflation rate and real interest rate as explanatory variables. The inflation rate is the change in harmonized index of consumer prices for the current quarter taken from Eurostat database. Since we have either monthly or annual data, quarterly data was constructed by taking the sum of monthly change of rate of harmonized index of consumer prices of the corresponding three months. Real interest rate is the nominal long-term interest rate on government benchmark yield, from Eurostat database, minus inflation rate in the same period for all the countries except for Estonia. Estonia does not have suitable long-term government bonds available on the financial markets. We use interest rate on the lending for house purchasing with maturities over five years sourced from Macrobond search engine to approximate government benchmark yield. We are aware that these interest rates are subject to different credit risk than government bonds. We deflate this interest rate in the same manner as we do with the government benchmark yield.

Since part of the thesis includes comparison of the results derived for CEE-9 countries with the results presented by Almeida et al. (2006) for OECD-26 countries, we tried to find and use closely comparable variables in the first part of the empirical analysis.

Table 3.1 presents country-level data on maximum LTV ratios over two periods. The data on maximum LTV ratios was sourced from the reports of national central banks, ECB financial stability review (2014) and IMF global stability report (2011). In some cases, it was impossible to track down the exact time when the maximum LTV ratio was changed. There was a common tendency to reduce the maximum LTV ratios after the financial crisis in the majority of the countries. Table 3.1 shows that there is a significant variation in the maximum LTV ratios in the Central Eastern Europe. This variation increases even more in the period after the financial crisis.

Table 3.1. Maximum loan-to-value ratios (LTV) country by country

Country	Max LTV ratio	
	Before financial crisis	After financial crisis
Estonia	1.0	1.0
Czech Republic	1.0	0.85
Bulgaria	0.7	0.5
Hungary	0.8	0.75
Latvia	0.9	0.8
Lithuania	0.95	0.85
Poland	1.0	0.85
Slovakia	07	1.0
Slovenia	0.7	1.0
Max	1.0	1.0
Min	0.7	0.5

Maximum LTV ratios represent the highest mortgage loan that households can get from lenders as a fraction of the value property owned. Pre-crisis period covers 2006 – 2009, after crisis period covers 2010-2014. Data source: national central banks, IMF (2011), ECB (2014).

Over the 2006q1-2014q1 period, some countries experienced a boom in the real estate sector. Real housing prices almost doubled in the Baltic countries in 2007 – 2008. In contrast to other countries (except for Poland), a period of housing price decrease in the Baltic States was soon replaced by an ongoing period of growth in housing prices. This situation might have been partly caused by the expectations concerning euro adoption in these countries (Estonia adopted euro in 2011, Latvia in 2014 and Lithuania in 2015). Other countries (Czech Republic, Hungary and Slovenia) did not face such a vast increase in housing prices. Housing price variation over time is presented in Figure 3.2. This figure shows that there have been significant cross-country differences in housing price development over 2006q1-2014q1 period. The statistics presented in Figure 3.2 support the statement that there is a high cross-section variation of housing prices in CEE-9 countries.

Figure 3.1. Real housing price index (2010 = 100) in CEE-9 countries
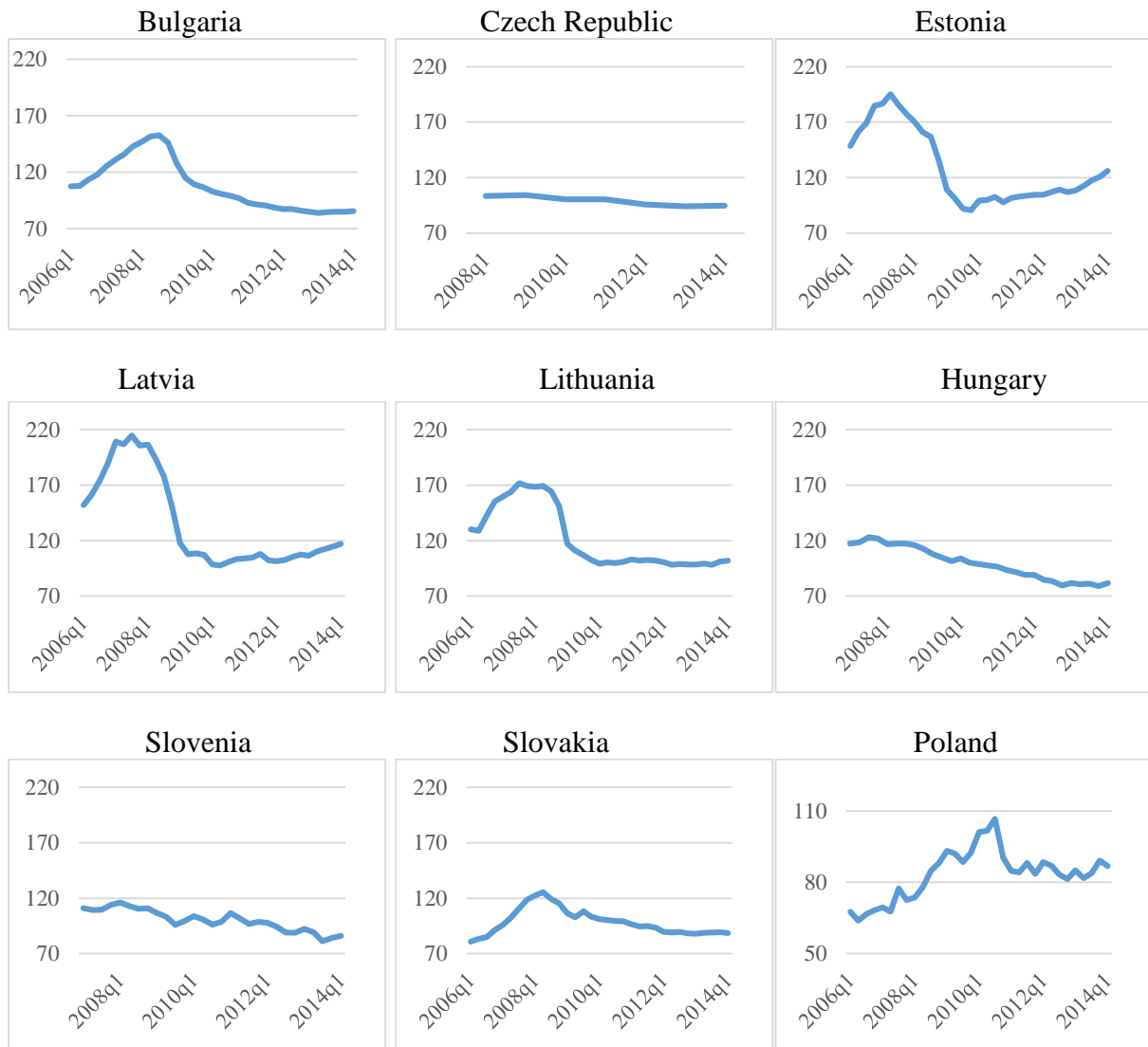
Data source: Eurostat and Macrobond.

Scatter plots presented in Figure 3.3 suggest the existence of a positive relationship between maximum LTV ratios and real GDP, real housing prices and real consumption expenditure volatility. Though no causal conclusions should be made based on these simple scatter plots, it seems that countries, which have higher limits on LTV ratios, have experienced higher real GDP, real housing prices and real consumption expenditure volatility. These results are in line with the theory of imposing limits on maximum LTV ratios presented in section 2.2. In line with this theory, and based on findings presented in Figure 3.3, we may assume that the effects of a shock on macroeconomic variables are higher in those CEE-9 countries that have higher limits on LTV ratios. The degree of amplification should be increasing in maximum LTV ratios.

Figure 3.2. Volatility of key macroeconomic variables and max LTV ratios
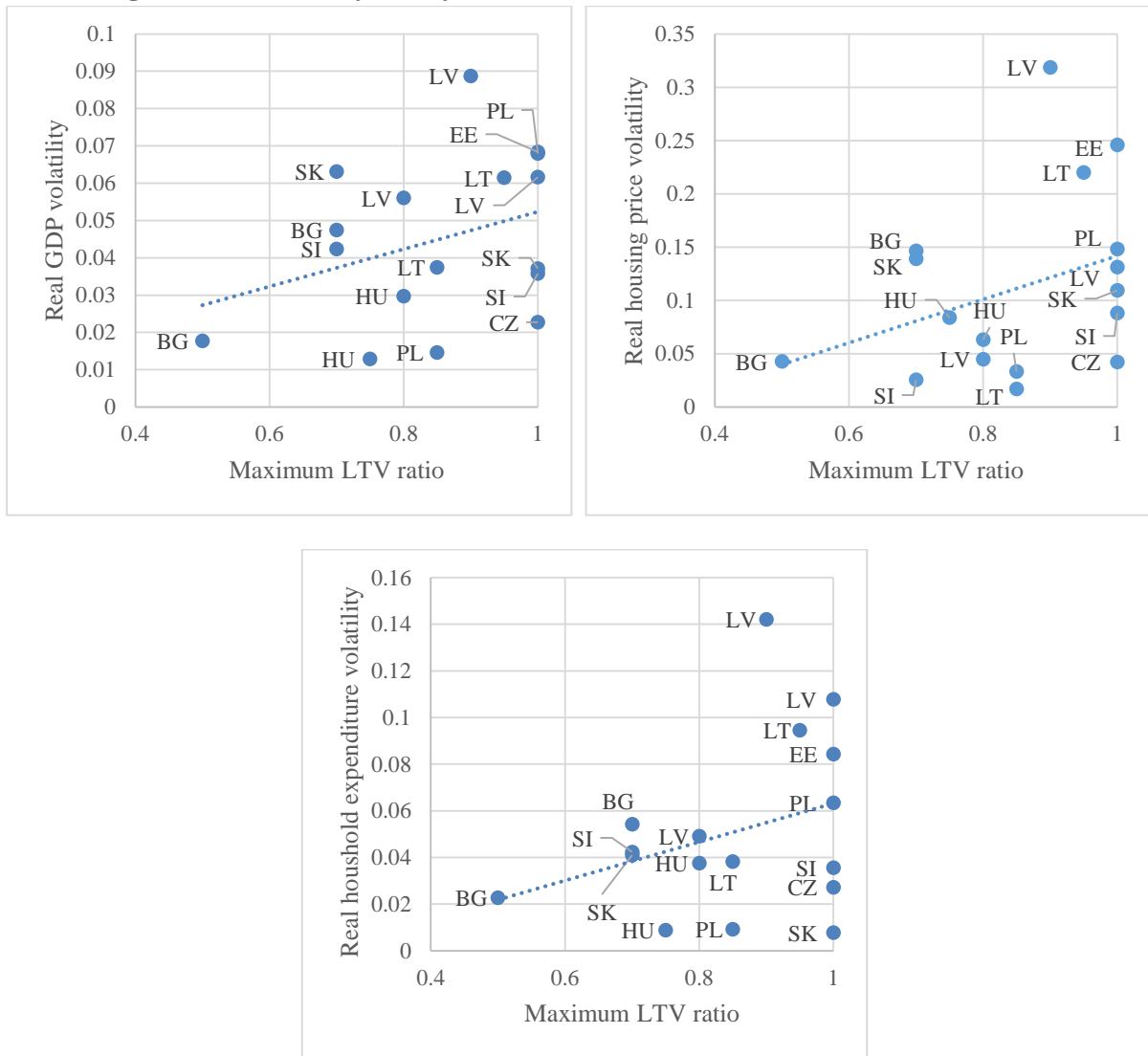
Data source: Eurostat and Macrobond. Each bubble represents maximum LTV ratio and associated volatility of macroeconomic variable. In case when countries changed existing maximum LTV ratio we calculated volatility of variables for each period (with *old* and *new* maximum LTV ratio) separately. Estimation period: 2006q1 – 2014q1.

In order to test meaningfulness of the equilibrium correction model with a multiple term (the interaction variable whose significance should prove the existence of financial accelerator mechanism) for housing prices, we wanted to estimate this model by using the data set used by Almeida et al. (2006). However, when we contacted the authors, we were told that they no longer have the data. Therefore, we were not able to perform the equilibrium correction analysis for OECD-26 countries and compare the obtained results with the results derived by analyzing CEE-9 countries.

In order to compare the results obtained by analyzing CEE-9 countries and 26 OECD countries, we use an abbreviation OECD-26 to present the results derived in the analysis of Almeida et al. (2006) for the corresponding equations in the further analysis.

4 Empirical tests

The empirical analysis presented in this section is based on the theoretical framework of Almeida et al. (2002) that was described and developed in subsection 2.3. The underlying mechanism of financial accelerator used in this section is quite intuitive: if there is a shock that increases housing prices, it should also increase households' borrowing capacity due to existing limits on the maximum LTV ratio. The increased borrowing capacity shifts out demand for housing and in turn increases housing prices. The effect of the shock to housing prices should be higher, the higher maximum LTV ratio is.

In this section, the following hypothesis is tested: *if the financial accelerator mechanism is present and the credit quantity constraint is binding, then the income-price sensitivity should be higher in countries with higher LTV ratios.* In subsection 4.1, we compare the evidence of financial accelerator for the CEE-9 countries with the evidence presented by Almeida et al. (2006) for OECD-26 countries by performing tests for general restrictions. In subsection 4.2, we expand the existing framework by allowing for both the short-run and the long-run dynamics in the conditional equation for housing prices. We incorporate both the short-run and the long-run dynamics in our analysis by constructing an equilibrium correction model for housing prices. We complete this subsection by analyzing the long-run relationship between housing prices, household income and existing limits on maximum LTV ratio. We are aware that the analysis presented in this section might be effected by a noteworthy drawback of our data set – a rather short time series.

4.1 CEE–9 countries and OECD-26 countries compared

In this subsection, we estimate conditional equations for housing prices and compare these results with the corresponding results presented by Almeida et al. (2006). In this part of our analysis, we try to use variables that are as closely comparable as possible; however, the sample period is different.

Following Almeida et al. (2006), we start our analysis by estimating conditional equations for housing price ($\Delta Log(p_t)$) dynamics given household income($\Delta Log(y_t)$)[2]. In order to introduce the collateral constraint, we include maximum LTV ratio variable and the interaction term between maximum LTV ratio and household income variable in the analysis. The multiple term between maximum LTV ratio and household income is constructed by interacting the sum of all of included lags, besides the current GDP growth (lag 0) ($\sum_{j=0}^{2}$ $\Delta Log(y)_{t-j}$) with maximum LTV ratio variable.

$$\Delta Log(p_t) = \beta_1 \Delta Log(y_t) + \beta_2 \Delta Log(y_{t-1}) + \beta_3 \Delta Log(y_{t-2}) + \beta_4 \Delta Log(p_{t-1}) +$$
$$\beta_5 \Delta Log(p_{t-2}) + \beta_6 LTV_t + \beta_7 \sum_{j=o}^{2} \Delta Log(y_{t-j}) * LTV_t + \beta_8 dummy\ variable^3 + \varepsilon_t \quad (4.2)$$

The disturbances ε_t are assumed to be independently and identically distributed with mean zero and constant variance.

According to Almeida et al. (2006), this approach will allow us to test whether an increase in the maximum limits on LTV ratio increases the price-income sensitivity by testing whether the parameters on those interaction terms are significantly different from zero. In some conditional equations, Almeida et al. (2006) take into account only year effects, in others both year and country effects. In order to have as comparable equations as possible, we use the same specification with respect to country and year effects as Almeida et al. (2006) use.

Table 4.1 presents the main findings of this analysis. Equation (1) for CEE-9 countries finds that the multiple term ($\sum_{j=0}^{2}$ $\Delta Log(y)_{t-j}$), is indeed statistically significant at the 5% significance level and the magnitude of the coefficient appears to be similar to the corresponding coefficient for OECD-26 countries in equation (1). According to the specification tests presented in table 4.1, it seems that equation (1) for CEE-9 countries is well specified. However, goodness-of-fit graphs presented in Figure A1, suggest that there is an extreme observation, which we should take into account. In order to test whether the results presented in equation (1) for OECD-26 countries are similar to the results obtained by analyzing CEE-9 countries and, we use the test for general restrictions available in OxMetrics

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[2] In the Appendix, table A1, we present estimates for the conditional equations for housing prices without multiplication effect. Almeida et al. (2006) call those equations the benchmark empirical model for housing price dynamics and use those equations in their further analysis of the financial accelerator mechanism. We compare the results of these equations between to samples in the

[3] Dummy variable refers to both country and year dummies; the use of dummies depends on the specification of the conditional equation for housing price dynamics.

software package. The imposed restrictions correspond to the estimates obtained by Almeida et al. (2006) for each equation respectively. The test for general restrictions rejects the hypothesis that restrictions imposed on all explanatory variables except for year dummies are valid (Chi^2(7) = 4712.76 [0.0000]) in equation (1). It means that equation (1) presented in Table 4.1 differs significantly for CEE-9 and OECD-26 countries. However, when we impose restrictions on current household income ($\Delta Log(y_t)$), maximum LTV ratio and the multiple term variables ($\sum_{j=0}^{2} \Delta Log(y_{t-j})$ x LTV_t), the test fails to reject the hypothesis that imposed restrictions are valid (Chi^2(3) = 2.22928 [0.5262]). It suggests that the effects of a one unit change in current income, maximum LTV ratio and interaction term variables on housing prices seem to be similar in CEE-9 and OECD-26 countries when housing price dynamics is described by equation (1).

Equation (1) supports the hypothesis of the presence of financial accelerator mechanism in CEE-9 countries since the coefficient on interaction term is positive and significantly greater than zero at the 5% significance level. The coefficient suggests that if there is an equal change in household income, keeping everything else constant, housing prices increase more in the countries where maximum LTV ratio is higher.

When country effects are included in the specification of housing price dynamics (equation (2)), the magnitude of the coefficient for interaction term decreases and this explanatory variable becomes statistically insignificant; this result contrasts the findings presented by Almeida et al. (2006). In order to compare the effect of a change in interaction term for CEE-9 and OECD-26 countries in equation (2), we perform a test for general restrictions. This test does not reject the hypothesis that the imposed restriction is valid (Chi^2(1) = 1.08801 [0.2969]). It suggests that changes in the interaction term have the same effect on housing prices in CEE-9 and OECD-26 countries when housing price dynamics is specified by equation (2). According to the specification tests presented in table 4.1, it seems that equation (2) for CEE-9 countries is well specified. Goodness-of-fit graphs (Figure A2) for equation (2) suggest that there is an extreme observation that we should account for. Since the coefficient on a multiple term appears to be statistically insignificant in equation (2), it might be that increase in housing prices is driven by economic development instead of the collateral constraint. Compared to equation (1) (where we do not take into account country effects) the magnitude of the coefficient on multiple term in equation (2) seems to be smaller. The positive coefficient on a multiple term is still in line with the theory of the financial

accelerator mechanism, since it suggests that if there is an equal change in household income, keeping everything else constant, housing prices increase more in countries where maximum LTV ratio is higher. The magnitude of the coefficient for household income ($\Delta Log(y_t)$) seems to decrease significantly in the case of CEE-9 countries.

Table 4.1. House prices and the multiplier effect: Baseline regressions

Explanatory variables	Equation (1)		Equation (2)		Equation (3)	
	CEE-9	OECD-26	CEE-9	OECD-26	CEE-9	OECD-26
$\Delta Log(y_t)$	-1.015	-0.787	-0.189	-0.622	-1.335	-0.273
	(-0.99)	(-1.31)	(-0.20)	(-1.00)	(-1.05)	(-0.42)
$\Delta Log(y_{t-1})$	-1.405	1.174	-0.533	1.029	-1.571	0.132
	(-1.30)	(1.11)	(-0.56)	(1.03)	(-1.28)	(0.17)
$\Delta Log(y_{t-2})$	-1.818	-0.470	-0.977	-0.199	-2.029	0.504
	(-1.94)*	(-0.62)	(-1.13)	(-0.24)	(-1.80)*	(0.91)
$\Delta Log(p_{t-1})$	0.014	0.228	-0.020	0.174	0.015	0.299
	(0.39)	(3.01)***	(-0.69)	(2.08)**	(0.44)	(4.21)***
$\Delta Log(p_{t-2})$	0.001	-0.070	-0.036	-0.081	-0.001	-0.089
	(0.06)	(-1.35)	(-2.40)**	(-1.47)	(-0.05)	(-1.71)*
r					-0.004	-0.287
					(-2.75)***	(-1.39)
π					-1.235	-0.092
					(-2.04)**	(-0.69)
LTV_t	-0.015	-0.037	-0.064	-0.214	-0.029	0.007
	(-0.43)	(-0.81)	(-1.14)	(-2.40)**	(-0.71)	(0.16)
$\sum_{j=0}^{2} \Delta Log(y_{t-j})$ x LTV_t	2.118	2.152	1.379	2.414	2.319	1.420
	(1.97)**	(2.45)***	(1.39)	(1.96)**	(1.79)*	(1.75)*
Country Effects?	No	No	Yes	Yes	No	No
Year Effects?	Yes	Yes	Yes	Yes	Yes	Yes
Adj - R^2	0.268	0.297	0.234	0.316	0.223	0.342
Observations	254	567	254	567	254	531
Wald (joint)	274.8	N/A	962.5	N/A	168.1	N/A
	(0.000)**		(0.000)**		(0.000)**	
AR(1)	0.903	N/A	-0.841	N/A	0.497	N/A
	(0.367)		(0.400)		(0.619)	
AR(2)	-0.628	N/A	-1.420	N/A	-0.901	N/A
	(0.530)		(0.156)		(0.368)	

The dependent variable is $\Delta Log(p)_t$, the change in log of housing price index (2010=100). $\Delta Log(y)_t$ is the change in log of real GDP per capita index (2005=100). r is real interest rate which is the nominal long term interest rate on benchmark government bond yield minus the inflation rate in the same period. π is inflation rate that is log of the harmonized consumer price index. LTV_t is the maximum LTV ratio for period t. Number in the parenthesis for specification tests presents the p-value.The estimation period is 2006q1 – 2014q1. The estimation procedure is OLS with robust standard errors. ***, **, * indicate statistical significance at 1%, 5%, and 10% test levels, respectively.

The magnitude of other coefficients seems to differ quite a lot for the two samples in equation (2). The test for general restrictions rejects the hypothesis that imposed restrictions on all explanatory variables except for year and country dummies are valid (Chi^2(7) = 49706.5 [0.0000]), meaning that the estimates obtained by estimating equation (2) are significantly different for CEE-9 and OECD-26 countries. In contrast to equation (1), this test rejects the hypothesis that imposed restrictions on current income, maximum LTV ratio and interaction term variables are valid (Chi^2(3) = 12.248 [0.0066]).

When macroeconomic variables are included in the conditional equation for housing prices (equation (3)), the coefficient on the interaction term for CEE-9 countries increases somewhat and becomes statistically significant at the 10% significance level. In magnitude, this coefficient is higher for CEE-9 than for OECD-26 countries. According to the specification tests presented in table 4.1, it seems that equation (3) for CEE-9 countries is well specified. Goodness-of-fit graphs (Figure A3) for equation (3) suggest that there is an extreme observation that we should account for.

The magnitude of the coefficients for macroeconomic variables seems to differ significantly in the two samples in equation (3). With these additional macroeconomic variables, the coefficients for household income variable increase for CEE-9 countries and seem to become even more different from the coefficients for OECD-26 countries in equation (3). The test for general restrictions, when they are imposed on all explanatory variables except for year dummies, rejects the hypothesis that the imposed restrictions are valid (Chi^2(9) = 42124.2 [0.0000]) in equation (3). When we impose restrictions on current income, maximum LTV ratio and interaction term explanatory variables, the test does not reject the hypothesis stating that the imposed restrictions are valid (Chi^2(3) = 2.96364 [0.3973]). It means that a one unit change in current household income, maximum LTV ratio and interaction term have the same effect on housing prices in CEE-9 and OECD-26 countries when we describe housing price dynamics by the equation (3).

Equation (3) supports the hypothesis of presence of the financial accelerator mechanism since the parameter on the interaction term is positive and significantly greater than zero at the 10% significance level. This coefficient in equation (3) suggests that if there is an equal change in household income, keeping everything else constant, housing prices increase more in countries where maximum LTV ratio is higher. The effect of a change in the multiple term seems to be the highest when we include macroeconomic variables in the conditional equation

for CEE-9 countries (equation (3)). It contrasts the findings presented by Almeida et al. (2006); they find that the effect of a change in the multiple term seems to be the highest when additional macroeconomic variables are not included, but both country and year effects are included in the conditional equation for OECD-26 countries (equation (2)).

The magnitude of coefficients for lagged housing prices seems to be quite different for CEE-9 and OEDC-26 countries in the three equations. Table 4.1 suggests that changes in housing prices in the previous periods seem to have smaller effects on current changes in housing prices in CEE-9 countries than in OECD-26 countries. However, we have to keep in mind, that in the analysis of CEE-9 countries, the previous period is a quarter and in the analysis of OECD-26 countries, the previous period is a year. The test for general restrictions rejects the null hypothesis that restrictions imposed from Almeida et al. (2006) analysis on lagged changes in housing prices are valid for CEE-9 countries ($Chi^2(2) = 423.633$ [0.0000] – for equation (1), $Chi^2(2) = 156.511$ [0.0000] – for equation (2) and $Chi^2(2) = 743.395$ [0.0000] for equation (3)).

To sum up, although the estimates for the corresponding conditional equations for CEE-9 and OECD-26 countries seem to be significantly different, the effect of a change in the interaction term on housing prices, keeping everything else constant, seems to be similar for CEE-9 and OECD-26 countries in the three equations. The coefficient for the interaction term is significantly different from zero in equations (1) and (3) for CEE-9 countries. This finding provides evidence for the presence of financial accelerator in CEE-9 countries. The results obtained by analyzing CEE-9 countries are in line with the findings presented by Almeida et al. (2006).

4.2 The long-run relationship

In the previous subsection, we have analyzed the short-run relationship between housing prices, household income and its interaction with maximum LTV ratios. In this subsection, we expand our research by analyzing the long-run relationship between these variables. We aim to find out whether the effect of existing limits on maximum LTV ratios is temporary or lasting. Moreover, we introduce a new proxy for household income and use a dummy variable for the extreme observation detected in the previous analysis. In this way, we should improve statistical properties of residuals, which would make our inference more reliable.

We begin our analysis by checking stationarity of the variables used in our analysis and testing for a cointegrating relationship between them. A relationship between I (1) (integrated of order one) variables is often indicated as a long-run relationship, meanwhile a relationship between I (0) (integrated of order zero, or stationary) variables is often indicated as a short-run relationship (Hill et al, 2012). Equilibrium correction form describes dynamic relationship between I (0) (integrated of order one, or stationary) variables and at the same time it embeds a cointegrating relationship between these variables. In this subsection, we will be using an equilibrium correction form in order to find evidence supporting the short-run and long-run effects of existing limits on maximum LTV ratios on housing prices. In addition, since we include the interaction term between household income and limits on LTV ratio, we are able to test the hypothesis of the existing financial accelerator when housing price dynamics are described by the equilibrium correction model.

Dickey – Fuller test

In order to test for the stationarity of $Log(p_t)$ and $Log(y_t)$ variables (proxied by both real GDP, y^{GDP}, and household final consumption, y^C) we perform the Dickey-Fuller test. In the following equations, we include as many lagged first difference terms as it is necessary to ensure that residuals are not autocorrelated. The results of the Dickey – Fuller test are presented in Table 4.2.

The reported number in the brackets in Table 4.2 is *tau* (τ) value, which is the t-value, but because we suspect that these variables might be nonstationary, we use a different (nonstandard) distribution from the t distribution and, in order to avoid confusion, we rename the t-value to the τ-value. In this test, we use critical values for the Dickey-Fuller test. The τ value for housing price variable is -6.75, for household income variable, proxied by real GDP, the value is -6.81 and for the household income variable, proxied by household consumption expenditure, τ is -6.90. The 5% critical value for *tau* (τ_c) is -2.88. In all three cases, the reported *tau* value is smaller than the critical value for *tau,* meaning that there is sufficient evidence in the data to reject the null hypothesis that series are nonstationary. However, we should be very careful while interpreting the results reported by this test. We should keep in mind that, although the size of coefficients is reasonable and they have a right sign, this data cannot decide the stationarity issue. The time series in our panel data set are too short for testing (the longest series contain 33 observations). Moreover, there is a possibility that financial crisis dominates the figures.

Table 4.2 Dickey- Fuller test for explanatory variables

Dependent variables	$Log(X_{t-1})$	$\Delta Log(X_{t-1})$	$\Delta Log(X_{t-2})$	$\Delta Log(X_{t-3})$	$\Delta Log(X_{t-4})$
$\Delta Log(p_t)$	-0.099	0.157	0.088	0.080	0.083
	(-6.75)				
$\Delta Log(y^{GDP}_t)$	-0.088	0.378			
	(-6.81)				
$\Delta Log(y^{C}_t)$	-0.122	0.259	0.323		
	(-6.90)				

Explanatory variable X is the real housing price in equation for $\Delta Log(p_t)$, the real GPD per capita index in equation for $\Delta Log(y^{GDP}_t)$ the final consumption expenditure of households index in equation for $\Delta Log(y^{C}_t)$. The estimation procedure is LSDV (least squares fixed effect) with robust standard errors and country dummies.

According to this analysis, real housing prices seem to be stationary. Since real GDP and final consumption expenditure of households also appear to be stationary, there is no need for cointegration when both house prices and household income variables enter equation in levels, because we already have a balanced equation. However, as it was mentioned above, the sample size is short and experience shows that GDP and consumption have stochastic trends.

Equilibrium correction form

We use an equilibrium correction model in order to test whether there is a cointegrating relationship between housing prices, household income and limits on maximum LTV ratio. We have chosen this method of testing for the cointegrating relationship because we are interested in more than one cointegrating relationship. In contrast to Almeida et al. (2006) analysis, we do not use year dummies, since this model includes dynamics, at the same time it allows us to have a higher degree of freedom. However, we include country effects since the test for excluding these variables (the exclusion restrictions test available in OxMectrics) rejects the hypothesis of excluding these variables[4]. We start by writing a conditional model for housing prices given household income, lagged housing prices, maximum LTV ratio and its interaction with the household income. An EC (equilibrium correction) model for housing prices that characterizes an equilibrium relation between explanatory variables and dependent variable is described by equation (4.3).

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[4] The test for exclusion restrictions when we use GDP as a proxy for household income is: Chi^2(9) = 215778 [0.0000]. The test for exclusion restrictions when we use final consumption expenditure of households as a proxy for household income is: Chi^2(9) = 24428.7 [0.0000]

$$\Delta Log(p_t) = \varphi_0 + \alpha\big(Log(p_{t-1}) - \gamma Log(y_{t-1})\big) - \varphi_2\Delta Log(p_{t-1}) + \beta_0\Delta Log(y_t) -$$

$$\beta_2\Delta Log(y_{t-1}) + \beta_3\Delta Log(y_t) * LTV_t + \beta_4 LTV_{t-1} + \epsilon_t \qquad\qquad (4.3)$$

Where $\alpha = \varphi_1 + \varphi_2 - 1$ and

$$\gamma = \frac{(\beta_0 + \beta_1 + \beta_2)}{(1 - \varphi_1 + \varphi_2)}.$$

The disturbances ϵ_t are assumed to be independently and identically distributed with mean zero and constant variance. Equation (4.3) is the equilibrium / error correction model (ECM). The magnitude of α (the adjustment parameter) shows how fast $\Delta Log(p_t)$ converges to zero, which is an equilibrium outcome in the stationary case. From this equation we can see that the immediate impact of a change in $Log(y_t)$ on $Log(p_t)$ is equal to $\beta_0 + \beta_3 * LTV_t$. According to equation (4.3), even in the cases when ϵ_t and changes in variables are equal to zero, $\Delta Log(p_t)$ is not equal to zero (is not in equilibrium) until:

$$Log(p_{t-1}) = \frac{-\varphi_0}{\alpha} + \gamma Log(y_{t-1}) - \frac{\beta_4}{\alpha} LTV_{t-1}.$$

Results of the estimated ECM (equation (4.3)) for CEE-9 countries are presented in Table 4.3. We start our analysis of the ECM with the discussion of the results obtained by estimating housing price dynamics when we use the same proxy for household income as Almeida et al. (2006) use in their analysis (real GDP per capita). We continue our analysis by discussing the results of the ECM for housing price dynamics with final consumption expenditure of households as a proxy for household income.

A test for cointegration in the ECM is a test of significance of the adjustment parameter ($Log(p)_{t-1}$ in our analysis). This test follows non-standard distribution under the null of no cointegration. We use critical values for the Dickey-Fuller test, which are taken from Ericsson and MacKinnon (2002). The 5% critical value for τ^5 is -3.51. Since we keep the assumption that level variables in this equation are nonstationary, we use the critical values for the Dickey-Fuller test in testing the significance of other level variables and long-run multipliers. In testing the significance of the difference, multiple term, LTV ratio and dummy variables

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[5] τ corresponds to $\kappa_{C}(3)$ in Ericsson and MacKinnon (2002). It means that we use critical values of the ECM test of cointegration with a constant term and three variables (p_t, y_t, and LTV_t).

we use the t distribution and corresponding critical values, since experience shows that most differenced macroeconomic variables are found to be stationary.

Table 4.3. Equilibrium correction model with multiple term for CEE-9 countries

Explan. Variables	(a) when y = y^{GDP}	(b) when y = y^C
$\Delta Log(y)_t$	-1.765	-1.421
	(1.499)	(0.473)***
$\Delta Log(y)_{t-1}$	0.619	0.510
	(0.177)***	(0.096)***
$Log(y)_{t-1}$	-0.007	-0.025
	(0.022)	(0.038)
$\Delta Log(p)_{t-1}$	0.047	0.017
	(0.029)	(0.024)
$Log(p)_{t-1}$	-0.019	-0.014
	(0.013)	(0.015)
LTV_{t-1}	0.057	0.044
	(0.021)***	(0.009)***
$\Delta Log(y)_t * LTV_t$	3.202	2.760
	(1.725)*	(0.590)***
Dummy	-1.168	-1.168
	(0.003)***	(0.004)***
L-R multiplier for y_t	-0.368	-1.786
	(0.999)	(1.659)
L-R multiplier for LTV_t	3.000	3.143
	(2.343)	(3.604)
Country Effects?	Yes	Yes
Year Effects?	No	No
Adj - R^2	0.841	0.859
RSS	0.305	0.272
Observations	263	263
Wald (joint)	8661.	14830.
	(0.000)**	(0.000)**
AR(1)	1.082	0.032
	(0.279)	(0.2974)
AR(2)	0.222	-0.632
	(0.824)	(0.527)

The dependent variable is $\Delta Log(p_t)$. $\Delta Log(y_t)$ is the change in log of real GDP per capita index (2005=100) in equation (a) and the change in log of final consumption expenditure of household (2005=100) in equation (b). Dummy is a dummy variable for the extreme observation. Standard deviation for L-R multipliers is calculated by the delta method. The estimation procedure is LSDV (least squares fixed effects) with robust standard errors. For other explanations see footnotes to table 4.1.

Equation (a) in table 4.3 presents the estimates of the ECM when we use real GDP per capita index as a proxy for household income. The coefficient on the multiple term (which we use to test for the presence of the financial accelerator mechanism) seems to be significant at the

10% significance level in equation (a). According to the specification tests presented in Table 4.3, and goodness-of-fit graphs presented in Figure A5, it appears that equation (a) is well specified. Based on the results presented in Table 4.3, equation (a), it seems that the immediate effect (or a short run effect) of the change in household income (y^{GDP}) growth on housing prices is affected by the existing limits on the maximum LTV ratio. If households are not collateral constrained (LTV=1), then a one percent increase in real GDP growth, keeping everything else constant, seems to increase real housing prices by a little bit less than 1.5%. In countries with low maximum LTV ratios (for example Bulgaria, where the maximum LTV ratio is equal to 0.5), a one percent increase in real GDP, keeping everything else constant, seems to have no effect on real housing prices. Meanwhile, countries with a high maximum LTV ratio (for example, Lithuania) should experience a one percent increase in real housing prices when real GDP growth increases by 1%, keeping everything else constant. The changes in real GDP in the previous period seem to be important for current changes in housing prices as well. The speed of housing price convergence to zero appears to be slow. This coefficient (0.047) seems to be statistically insignificant and small in magnitude.

According to the results presented in table 4.3, equation (a), the level variable for housing prices ($Log(p_{t-1})$) is not statistically significant, suggesting no cointegrating relationship between housing prices, household income and limits on the maximum LTV ratio. The insignificance of $Log(y_{t-1})$ variable in equation (a) suggests that real GDP growth is not relevant for the housing price growth in the long-run. However, this result might be the consequence of the small sample size. The effect of a change in the maximum LTV ratio appears to be statistically significant in equation (a); however, the magnitude of the effect appears to be small. The long-run multiplier for housing prices and household income is statistically insignificant and has a negative coefficient in equation (a). The negative coefficient for the long-run multiplier suggests that housing prices self-correct, but the income shock drives them in the same direction. The long-run multiplier for housing prices and limits on the maximum LTV ratio seems to be statistically significant at the 5% significance level in equation (a) if we keep the assumption of nonstationary data. The coefficient for this long-run multiplier suggests that housing prices work to "error correct" in the long-run when there is a shock to limits on the maximum LTV ratio.

When we estimate an equilibrium correction model for housing prices with real final consumption expenditure of household as a proxy for household income (equation (b)), the

results, except for the long-run multiplier for household income, seem to be quite similar to the results presented in equation (a). The coefficient on the multiple term (which we use to test for the presence of the financial accelerator mechanism) seems to be significant at the 1% significance level in equation (b). According to the specification tests presented in Table 4.3, and goodness-of-fit graphs presented in Figure A6, it appears that equation (b) is well specified. According to the results presented in Table 4.3, equation (b), the immediate effect (or a short-run effect) of a change in income (y^C) growth rate on housing prices is affected by the existing limits on the maximum LTV ratio. The multiple term in equation (b) is statistically significant at the 1% significance level. If households are not collateral constrained (LTV=1), then a one percent increase in household consumption expenditure, keeping everything else constant, seems to increase real housing prices by somewhat more than one percent. In countries with low maximum LTV ratios (for example Bulgaria, where the maximum LTV ratio is equal to 0.5), a one percent increase in household consumption expenditure, keeping everything else constant, seems to have no effect on real housing prices. Meanwhile countries with high maximum LTV ratio (for example Lithuania where the maximum LTV is 0.85) should experience a one percent increase in real housing prices when household consumption expenditure increases by 1% and everything else is constant. The changes in household consumption expenditure in the previous period seem to be important for current changes in housing prices as well. The speed of housing price convergence to zero seems to be even slower than in a case when we use real GDP as a proxy for household income. This coefficient (0.017) appears to be statistically insignificant and small in magnitude.

Based on the results presented in table 4.3, equation (b), the level variable for housing prices ($\text{Log}(p)_{t-1}$) is not statistically significant, suggesting no cointegrating relationship between housing prices, household income, proxied by household consumption expenditure, and limits on the maximum LTV ratio. The insignificance of $\text{Log}(y_{t-1})$ variable in equation (b) suggests that household consumption expenditure is not relevant for housing price growth in the long-run. However, this result might be driven by the small sample size. The effect of the change in the maximum LTV ratio appears to be statistically significant at the 1% significance level; however, the magnitude of the effect seems to be small. The long-run multiplier for housing prices and household consumption seems to be statistically insignificant. As well as in equation (a), it has a negative coefficient. The long-run multiplier for housing prices and

maximum limits on LTV ratio seems to be statistically significant at the 5% significance level.

The analysis of the ECM for CEE-9 countries provides evidence that the interaction of household income with the maximum LTV ratios still matter when we include both short-run and long-run dynamics. It supports the hypothesis of the existing financial accelerator mechanism in CEE-9 countries when the collateral constraint binds. The immediate effect of a change in household income is affected by the existing limits on the maximum LTV ratio. The magnitude of coefficient for the multiple term seems to be similar in both equations (equation (a) and (b)) in Table 4.3. This insight is supported by the results of the test for general restrictions, when we impose a restriction on the multiple term in equation (a) based on the estimate obtained in equation (b). According to this test, there is insufficient evidence to reject the hypothesis that the imposed restriction is not valid (Chi^2(1) = 0.0634931 [0.8011]). It provides a robustness check for the coefficient suggesting evidence of the existence of financial accelerator. However, our hypothesis of existing cointegrating relationship between housing prices, household income and limits on the maximum LTV ratio has been rejected based on the results presented in Table 4.3. We find evidence that existing limits on the maximum LTV ratio matter for housing prices in the long-run, although the magnitude of the effect appears to be very small. In addition to this, it seems that we were able to find a new proxy for household income, which might be better than the real GDP index. According to Table 4.3, a regression including the income variable proxied by household consumption expenditure has smaller RSS statistics and higher R^2 statistics. Nevertheless, since both real GDP and household consumption expenditure include a housing or construction component, there is potential danger of multicollinearity. In addition to this, if housing prices affect the explanatory variable in the same period, we might face simultaneity bias. Since we do not have a direct measure of household income, our analysis is exposed to the measurement error bias.

To conclude, in this section we were looking for empirical evidence for the existence of the financial accelerator mechanism in CEE-9 countries. When we use conditional equations for the housing prices proposed by Almeida et al. (2006) for CEE-9 countries, we find significant evidence supporting the hypothesis of existing financial accelerator in CEE-9 countries when the collateral constrain binds. Moreover, the effect of a change in the multiple term, keeping everything else constant, on housing prices in CEE-9 countries appeared to be similar to the

effect in OECD-26 countries. We have developed this analysis by including long-run dynamics into the conditional equation for housing prices. The constructed ECM for housing prices supported the hypothesis of the existing financial accelerator mechanism in CEE-9 countries as well. Based on the analysis performed in this section, I prefer the ECM specification for housing prices with final consumption expenditure of household as a proxy for household income for the analysis of the effects of changes in the limits on maximum LTV ratio or household income on housing prices.

5 Dynamic simulations

In this section, we perform dynamic simulations in order to analyze the development of housing prices after the change in household income. In addition to this, we want to compare the housing price development after the income shock under three different limits on maximum LTV ratios: 0.5, 0.75 and 1 (unconstrained case). We are interested in the dynamics of housing prices when household income increases in one period and then remains constant over time (constant increase) and when household income increases in one period and it comes back to its previous level in the next period (temporary increase). We use the ECM presented in subsection 4.2 in order to perform dynamic simulations. However, before using the estimates presented in Table 4.3, we drop the insignificant change variable $\Delta Log(p_{t-1})$, but we leave the income change variable in the equation since it seems to be highly significant in the conditional equation when we use consumption expenditure as a proxy for household income. The estimates used in this dynamic analysis are presented in Table A2 in the appendix.

We assume that in a steady state (up to period t) housing prices and household income (proxied by real GDP and household consumption expenditure) indexes are equal to 100, but we normalize it to 1, meaning that in a steady state $\log(p_t)$ and $\log(y_t)$ are equal to zero. In period t, there is a positive shock to household income, and the index of household income increases to 1.05 (household income increases by 5%). If an increase in income is permanent, the household income index remains equal to 1.05 in all subsequent time periods. If the increase in income is temporary, the index of household income returns to its initial value of 1 in the next period. From the theory presented in section 2, we know that the increase in household income should put an upward pressure on housing prices. Moreover, the effect on housing prices should be increasing in the maximum limits on LTV ratio. The figures presented in this section should allow us to test the theory since they are based on the results of the empirical analysis performed in section 4.

Figure 5.1 presents the development of housing prices after a permanent five percent increase in household income, proxied by real GDP, in period t. When the maximum LTV ratio is 0.5, housing prices decrease somewhat immediately after the increase in household income. From period t to period t+1 housing prices rise by 2%. From period t+1, housing prices are slowly converging back to the initial value. When the maximum LTV ratio is 0.75, housing prices

start increasing in the same period as the positive income shock occurs. This increase seems to last for two periods. In period t+1, the rise in housing prices seems to be about 6% which is more than the initial five percent increase in household income. Since period t+1, housing prices start slowly converging back to their initial value. When the maximum LTV ratio is equal to one (households are not constrained), housing prices start growing immediately after the permanent income shock and reach a peak in period t+1. In this period, an increase in housing prices seems to be about 10%, which is more than the initial five percent increase in household income. After period t+1, housing prices start converging back to their initial value. Existing differences in the maximum LTV ratios seem to affect the development of housing prices. According to Figure 5.1, the higher maximum LTV ratio is associated with the higher housing price volatility. In other words, housing prices increase more and decrease more under the higher maximum LTV ratio.

Figure 5.1. Housing price response to the permanent income shock (y=y^{GDP})
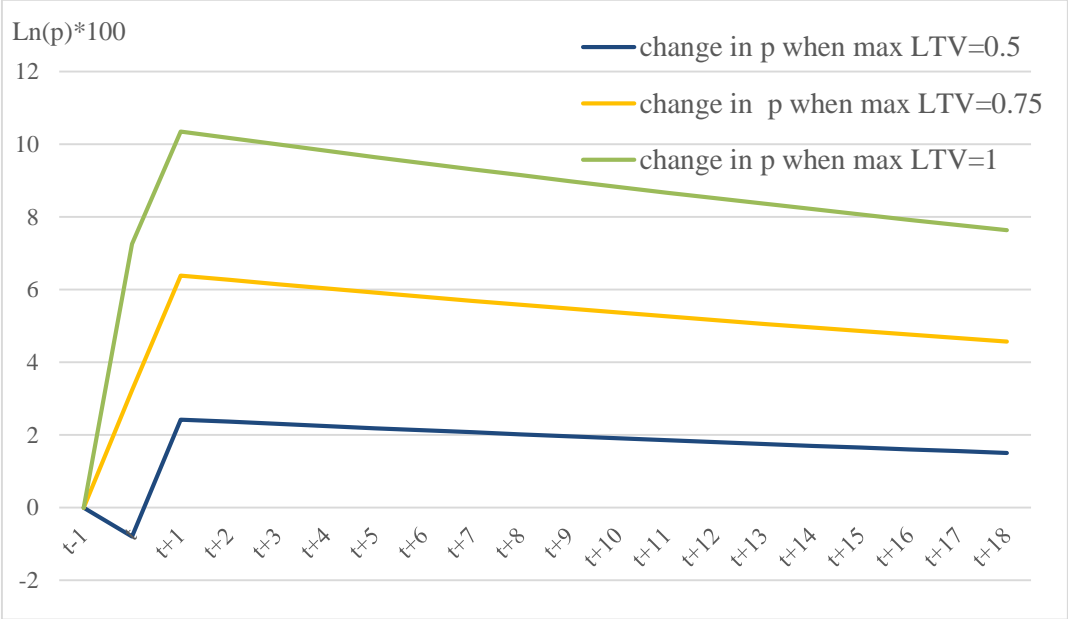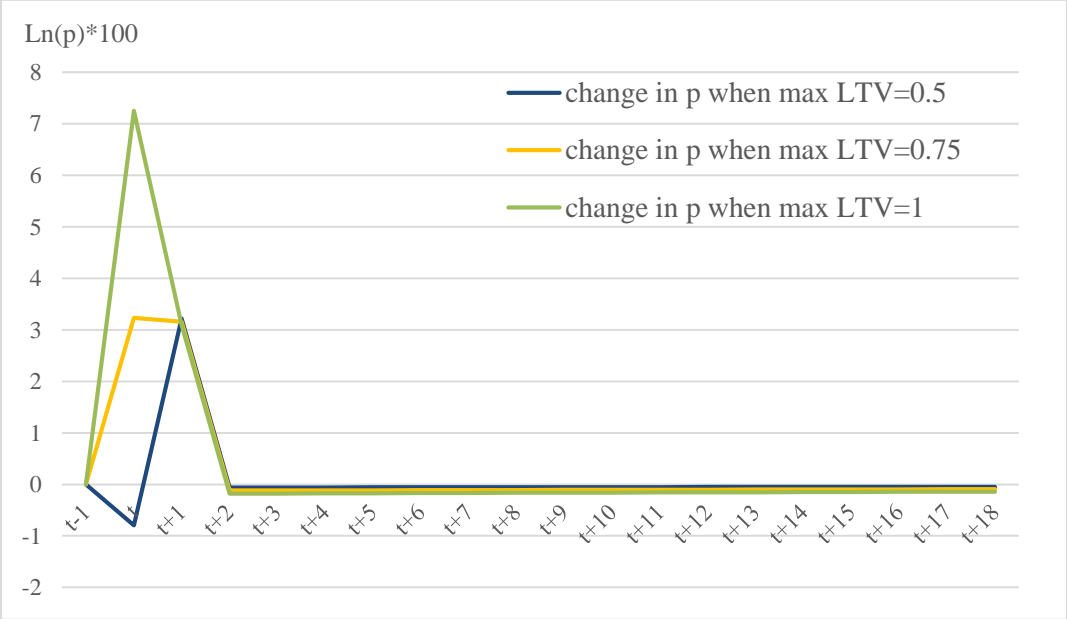

Dynamic simulation is based on the estimates of equilibrium correction model presented in table A4, equation (a).

Figure 5.2 presents the development of housing prices after a temporary increase in household income proxied by real GDP. When the maximum LTV ratio is equal to 0.5, there seems to be a decrease in housing prices, smaller than one percent, in the same period as household income increases. In the next period after the increase in income, housing prices reach a peak. They rise by about 3%. After period t+1, housing prices return to their pre-shock level. According to Figure 5.2, the effect of a shock on housing prices vanishes two periods after the

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shock. When the maximum LTV ratio is equal to 0.75, housing prices increase immediately (in the same period as the income increases) and they reach their peak. The rise in housing prices seems to be about 3%, which is less than a five percent increase in household income. After period t, housing prices start converging back to their initial level. When the maximum LTV ratio is equal to 1, housing prices reach their peak in the same period as household income increases. Housing prices increase by about 7%, which is more than the initial increase in household income. In period t+2, housing prices have already returned to their initial level. Figure 5.2 suggests that, in case of the temporary shock to household income, housing prices are most volatile when collateral constraint is not binding (max LTV = 1). It seems that the volatility of housing prices is similar under 0.5 limit on LTV ratio and 0.75 limit on LTV ratio. However, under the strictest limit on LTV (0.5) ratio, an increase in housing prices is delayed for one period.

Figure 5.2. Housing price response to the temporary income shock (y=y$^{\text{GDP}}$)
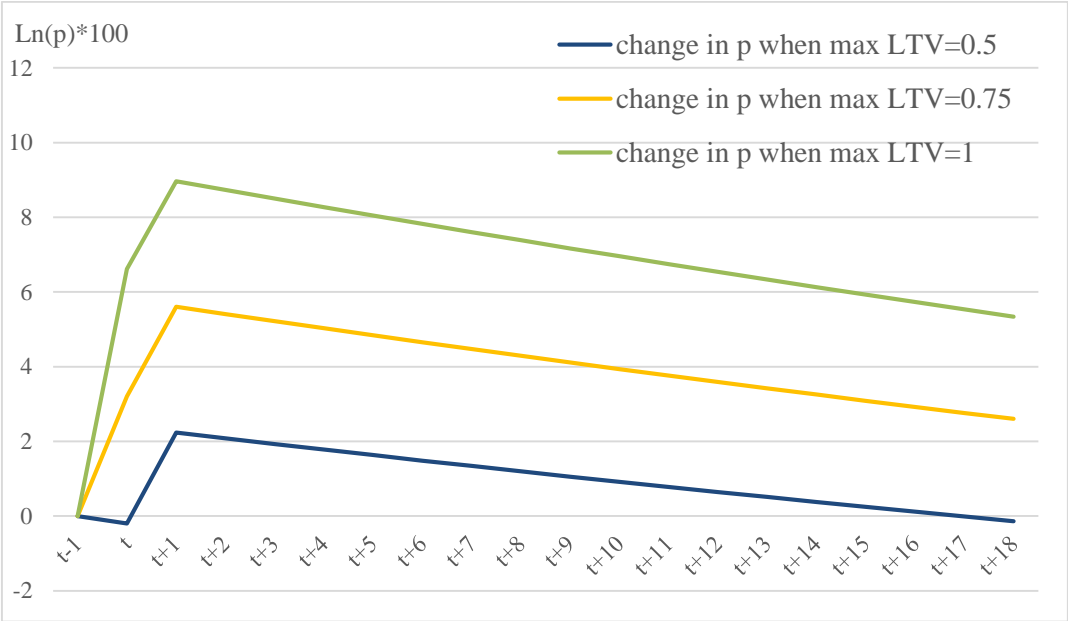

Dynamic simulation is based on the estimates of equilibrium correction model presented in table A4, equation (a).

Figure 5.3 presents the development of housing prices after a permanent increase in household income proxied by the final consumption expenditure of household. When the maximum LTV ratio is 0.5, housing prices start increasing in the next period after the positive shock to household income occurs and they grow for one period by about 2%. From period t+1, housing prices start converging back to their initial value. When the maximum LTV ratio is 0.75, housing prices increase at the same time as the positive income shock occurs and they

grow for two periods. In period t+1, housing price growth peaks at about 5.5%, which seems to be similar to the initial five percent increase in household income. It appears, that housing prices start converging back to their initial value from period t+1. When the maximum LTV ratio is equal to 1, housing prices increase immediately after the permanent income shock. Housing prices reach their peak in the next period after the income shock occurs, in period t+1. In this period, housing prices have increased by about 9%. The increase in housing prices is higher than the initial five percent increase in household income. After period t+1, housing prices start converging back to their initial value. Immediately after the shock to household income, different maximum LTV ratios seem to affect housing price growth in response to the permanent income shock. Figure 5.3 suggests that housing prices are the more volatile the higher maximum LTV ratio is. It seems that the effect of the permanent income shock (increased housing prices) lasts for several years.

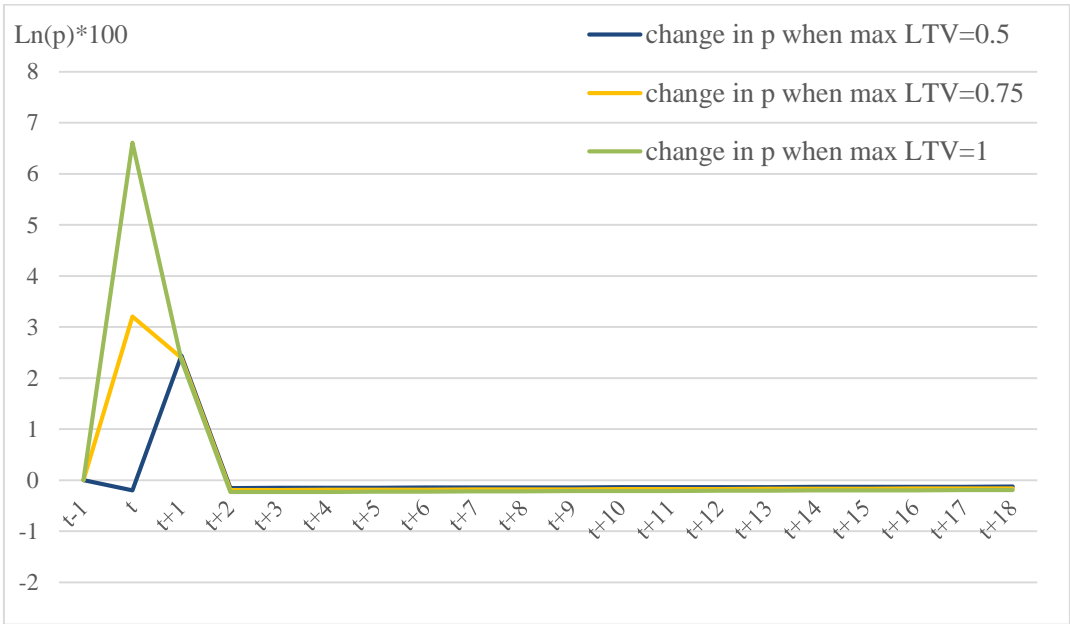**Figure 5.3. Housing price response to the permanent income shock ($y=y^C$)**

Dynamic simulation is based on the estimates of equilibrium correction model presented in table A4, equation (b).

Figure 5.4 presents the development of housing prices after a temporary increase in household income proxied by the final consumption expenditure of household. When the maximum LTV ratio is equal to 0.5, housing prices increase one period after the shock to household income occurs. In period t+1, the increase in housing prices is about 2% and they come back to the initial level immediately in the next period (t+2). When the maximum LTV ratio is equal to 0.75, housing prices rise at the same period as the positive income shock occurs and the growth peaks at about 3%. Since period t+2, housing prices are already back at their initial

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level. When the maximum LTV ratio is equal to 1, housing prices rise immediately after the permanent shock to income occurs and reach a peak in period t. In this period, housing price growth seems to be about 6.5%, which is more than the initial five percent increase in household income. In all three cases, housing prices come back to their initial level in period t+2. According to Figure 5.4, different limits on the maximum LTV ratios matter for housing prices only in the first two periods after the temporary income shock. Housing price volatility seems to be positively correlated with limits on the maximum LTV ratios in the short-run.

Figure 5.4. Housing price response to the temporary income shock (y=y^C)

Dynamic simulation is based on the estimates of equilibrium correction model presented in table 4.4, equation (b).

Based on the findings presented in this section (Figures 5.1-5.4) we can conclude that different limits on the maximum LTV ratio matter for housing price volatility in the short-run. These figures suggest that an increase in housing prices is higher when the limit on the maximum LTV ratio is higher. If the shock to household income is temporary, it seems that housing prices come back to their pre-shock levels two periods after the income shock occurs. These findings support the conclusion made in the previous section that limits on the maximum LTV ratio matter for housing prices in the short-run. If the shock to income is permanent, it seems that the effect of this shock on housing prices lasts for several years after the income shock occurs. According to Figures 5.1-5.4, the effect of an increase in household income on housing prices appears to be higher and the convergence of housing prices to their initial level appears to be slower when we use real GDP as a proxy for household income. It

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does not seem that housing prices stabilize at a higher level when there is a permanent increase in household income. This finding is in line with the results presented in table 4.3, which suggest that there is no long-run relationship between housing prices and household income.

6 Conclusion

In this thesis, we have taken an advantage of high cross-country variability in the limits on maximum LTV ratio in nine Central-Eastern Europe countries in order to provide evidence supporting the financial accelerator theory. In addition to this, we have been able to compare the effect of a change in household income when income is interacted with the maximum limits on LTV ratio in CEE-9 countries and OECD-26 countries. Furthermore, we have extended the existing analysis proposed by Almeida et al. (2006) by including the long-run dynamics in the conditional equation for housing price dynamics.

In the short-run analysis of CEE-9 countries, we find evidence supporting the hypothesis that financial accelerator is present when collateral constraint binds since the income-price sensitivity is increasing in the limits on LTV ratio and this effect is statistically significant from zero. Moreover, this effect appeared to be similar in CEE-9 and OECD-26 countries. When long-run dynamics are included in the analysis, the income-price sensitivity remains statistically significant and a positive effect of a change in household income is increasing in the limits on LTV ratio as well. The use of the final consumption expenditure of households as another proxy for household income provided a robustness check for the results obtained by analyzing equilibrium correction model for housing prices. The results appeared to be robust to this re-specification.

A parallel purpose of this thesis was to analyze the long-run relationship between housing prices, household income and limits on LTV ratio. We have found no cointegrating relationship between these variables. However, have found evidence that limits on LTV ratio matter for housing prices in the long-run, although the magnitude of the effect seems to be small.

Based on dynamic simulations, we find positive correlation between housing price volatility and limits on LTV ratio. This finding supports suggestions to use limits on LTV ratio as a tool for mitigating housing price volatility.

The main drawback of this analysis is a short sample size. We need longer time series in order to receive inference that is more reliable. The sample used in this analysis includes only one major expansion and contraction in housing prices, real GDP per capita and real final consumption expenditure of households. In addition to this, it was not possible to test whether

the ECM specification is better for OECD-26 countries than the one proposed by Almeida et al. (2006), since we were not able to get the data they have used.

Going forward I would propose to continue to search for a better proxy for household income, since both real GDP and real final consumption expenditure of households include a housing or construction component. Therefore, there is a potential danger of multicollinearity. Longer time-series should be used in this kind of analysis. I suggest including the supply of housing in empirical analysis, since, according to the theory, changes in housing supply affect housing prices in the long-run.

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Appendix

The housing price dynamics without multiplication effect

Following Almeida et al. (2006), we estimate conditional equations for housing price $(\Delta Log(p_t))$ dynamics given household income$(\Delta Log(y_t))$. We estimate three equations that differ in the number of included explanatory macroeconomic variables (inflation and real interest rate) and dummy variables (year and country effects). They are all constructed in such a manner that we will be able to compare our results with the results presented by Almeida et al. (2006). The estimates for the housing price dynamics without the multiplier effect are presented in Table A1.

Table A1. Housing price dynamics

Explan. Variables	CEE-9	OECD-26	CEE-9	OECD-26	CEE-9	OECD-26
	Equation (1)		Equation (2)		Equation (3)	
$\Delta Log(y)_t$	0.888	0.853	1.091	0.984	0.747	1.023
	(3.73)***	(5.38)***	(5.12)***	(5.46)***	(3.48)***	(6.12)***
$\Delta Log(y)_{t-1}$	0.533	0.377	0.757	0.159	0.508	0.533
	(1.81)*	(2.13)**	(3.11)***	(1.01)	(1.62)	(3.10)***
$\Delta Log(y)_{t-2}$	0.128	0.028	0.318	0.058	0.062	0.287
	(0.476)	(0.19)	(1.24)	(0.39)	(0.236)	(1.82)*
$\Delta Log(p)_{t-1}$	0.035	0.242	-0.012	0.327	0.033	0.185
	(0.996)	(2.90)***	(-0.468)**	(4.44)***	(1.11)	(2.01)**
$\Delta Log(p)_{t-2}$	0.017	-0.065	-0.032	-0.095	0.012	-0.080
	(0.801)	(-1.16)	(-2.25)**	(-1.83)*	(0.692)	(-1.34)
r					-0.004	-0.366
					(-2.84)***	(-1.80)*
π					-1.108	-0.116
					(-2.28)**	(-0.83)
Country Effects?	No	No	Yes	Yes	No	No
Year effects?	Yes	Yes	Yes	Yes	Yes	Yes
Adj - R^2	0.193	0.274	0.228	0.328	0.208	0.299
Observations	254	567	254	531	254	567
Wald (joint)/ Exclusion Test *p*-value	[0.000]**	0.00	[0.000]**	0.00	[0.000]**	0.00

See footnotes to the table 4.1. Wald (joint) test has been used to test for the significance of the regressions for CEE-9 countries. This test should be a counterpart for the Exclusion Test p-value provided for the regressions for OECD-26 countries.

The results presented in Table A1 suggest that a change in current income proxied by real GDP per capita has an effect on housing prices that is significantly different from zero. The effect of a one-unit increase in the change of household income on the change of housing prices is statistically significant at the 1% significance level in all three equations and the

magnitude of the effect ranges from 0.7 to 1.1, depending on specification of a conditional equation. The effect of a one-unit increase in the change of lagged housing prices on current change of housing prices appears to be small in magnitude and statistically insignificant in two out of three equations.

Based on the test for general restrictions, we can conclude that equations describing housing price dynamics without the multiplier effect in CEE-9 and OECD-26 countries differ significantly. However, the effect of a change in current household income seems to be similar in both CEE-9 and OECD-26 countries.

Goodness-of-fit graphs

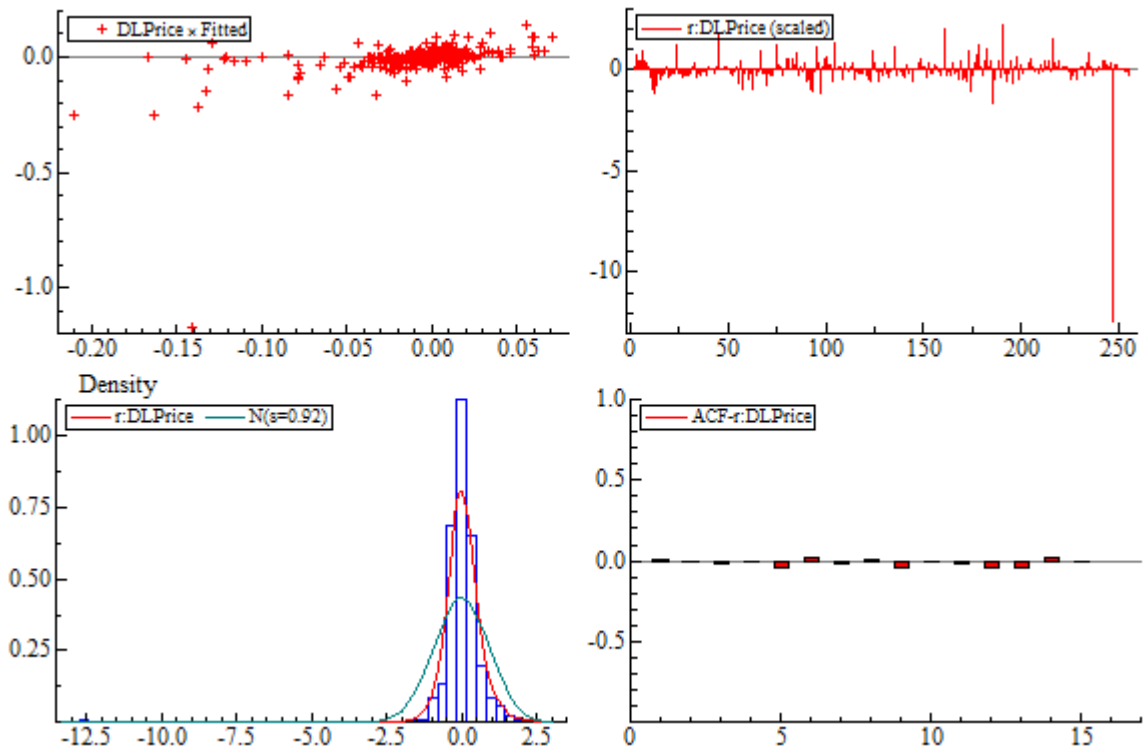**Figure A1. Goodness-of-fit graphs for baseline regression: CEE-9 Equation (1)**
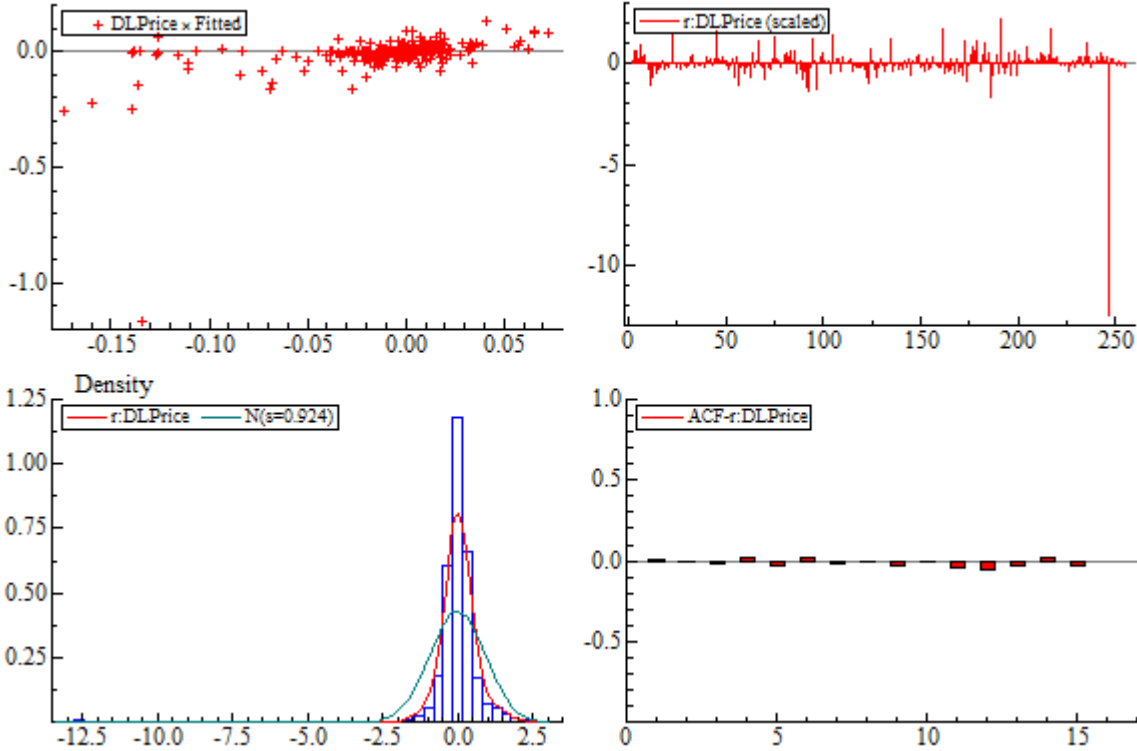
This figure presents the output from OxMetrics after the graphic analysis has been performed. The upper left graph displays the cross plot of actual and fitted values. The upper right graph shows scaled residuals. The lower left graph presents residual density and histogram (kernel estimate). The lower left graph shows residual autocorrelations.

Figure A2. Goodness-of-fit graphs for baseline regression: CEE-9 Equation (2)
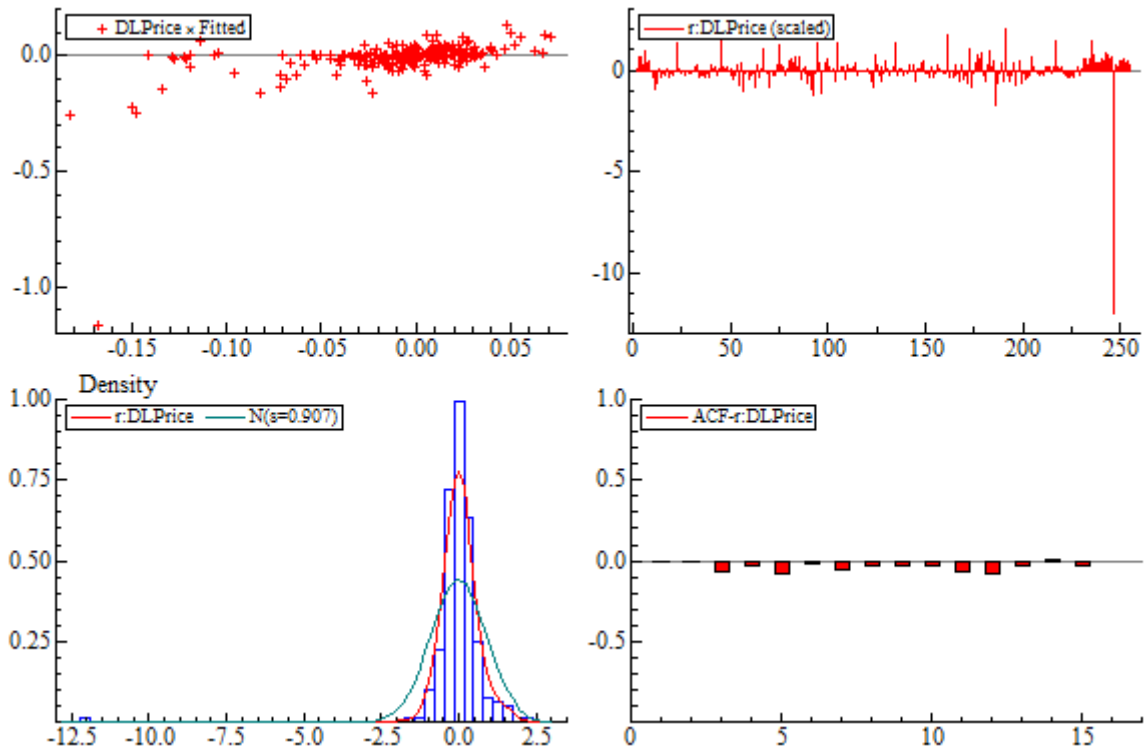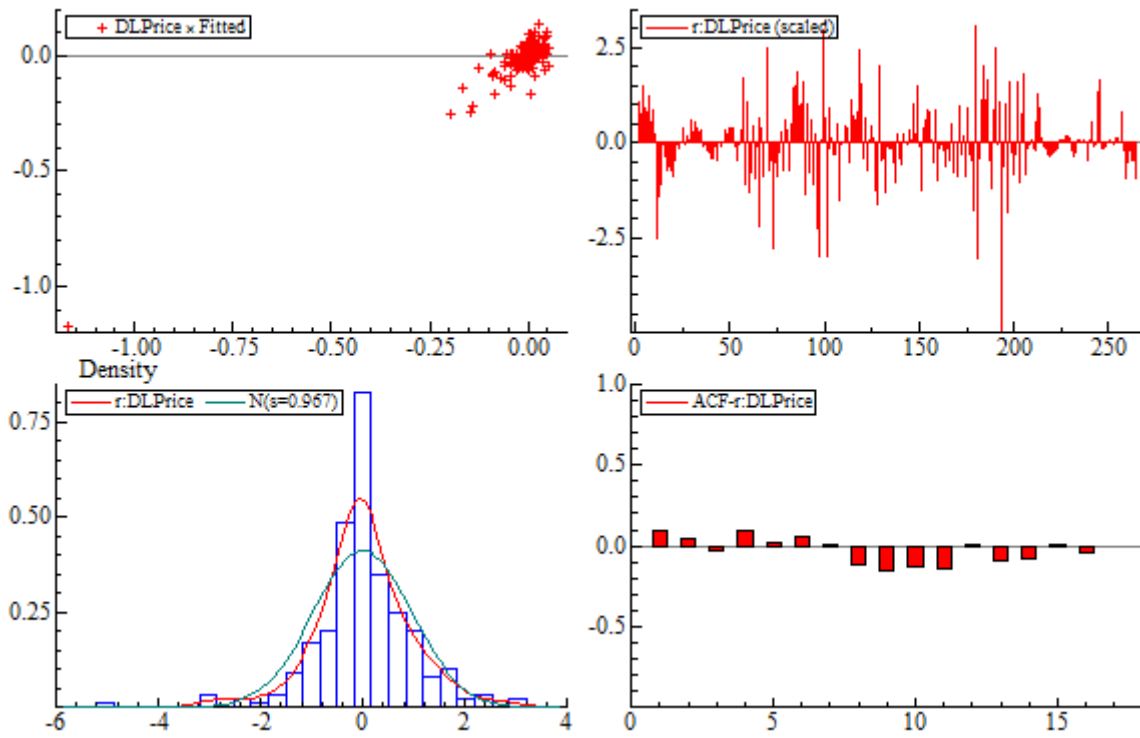

See footnotes to the figure A1.

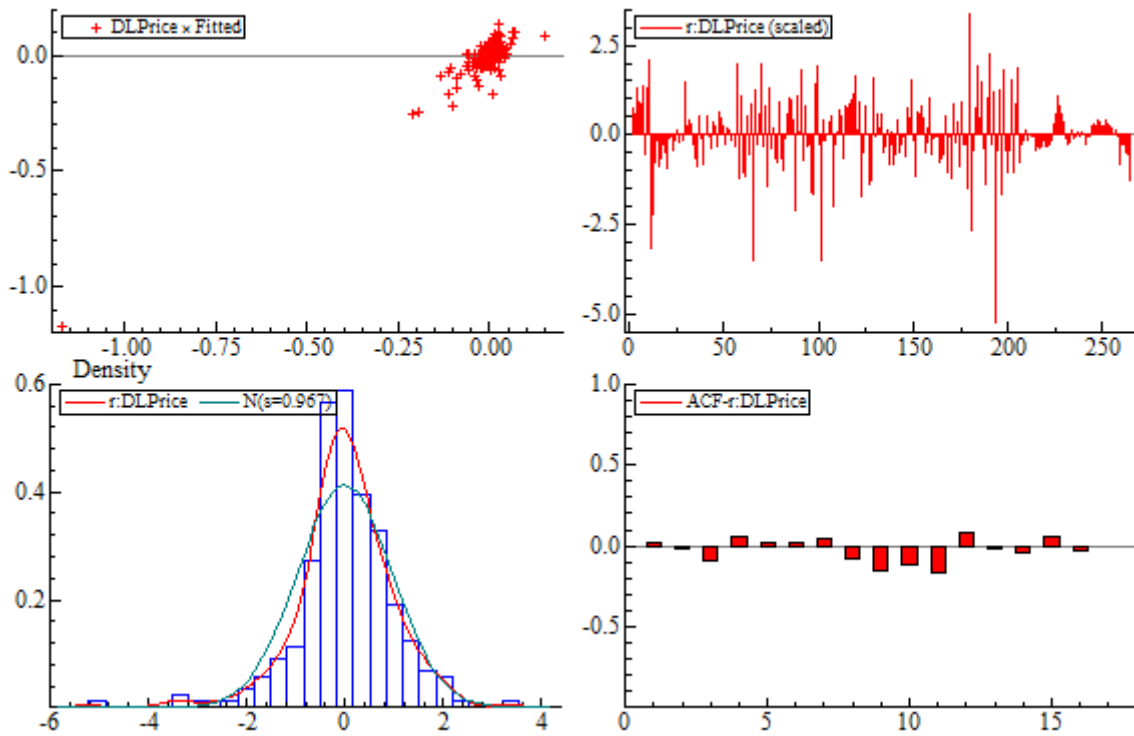**Figure A3. Goodness-of-fit graphs for baseline regression: CEE-9 Equation (3)**

See footnotes to the figure A1.

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Figure A5. Goodness-of-fit graphs for ECM model, equation (a)
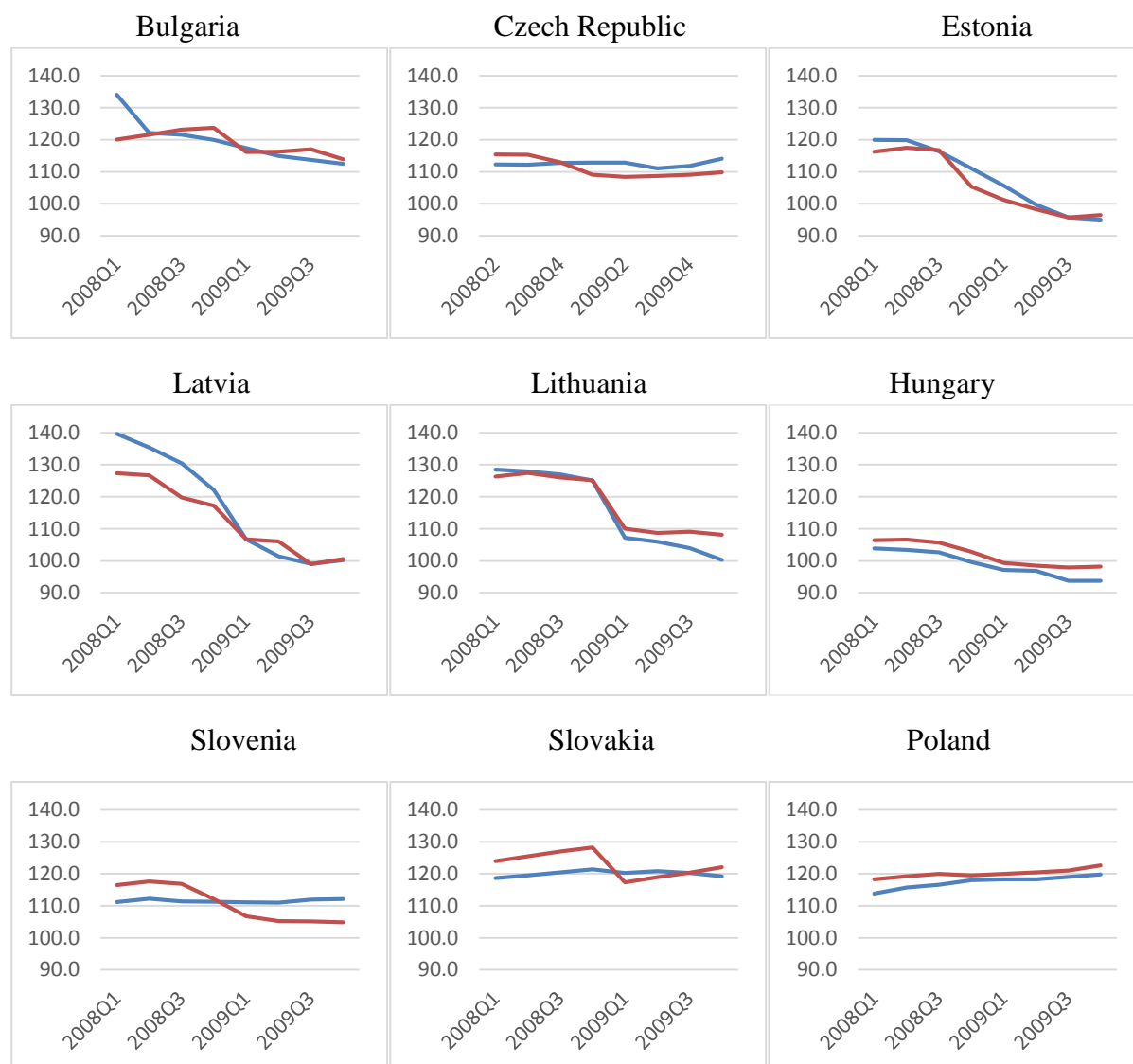

See footnotes to the figure A1.

Figure A6. Goodness-of-fit graphs for ECM model, equation (b)

See footnotes to the figure A1.

Dynamics of household income

Figure A4. Real GDP and final consumption expenditure dynamics over 2008q1 – 2009q1 period

Data source: Eurostat and Macrobond.

ECM for housing prices with reduced number of explanatory variables

Table A2. ECM estimates for the dynamic analysis

Explan. Variables	(a) when y = y^{GDP}	(b) when y = y^C
ΔLog(y)$_t$	-1.812	-1.438
	(1.488)	(0.458)***
ΔLog(y)$_{t-1}$	0.662	0.525
	(0.195)***	(0.097)***
Log(y)$_{t-1}$	-0.005	-0.026
	(0.022)	(0.037)
Log(p)$_{t-1}$	-0.015	-0.012
	(0.011)	(0.014)
LTV$_{t-1}$	0.056	0.045
	(0.020)***	(0.009)***
ΔLog(y)$_t$*LTV$_t$	3.299	2.793
	(1.724)*	(0.553)***
Dummy	-1.170	-1.168
	(0.003)***	(0.004)***
Country Effects?	Yes	Yes
Year Effects?	No	No
Adj - R^2	0.838	0.858
RSS	0.301	0.273
Observations	263	263

The dependent variable is ΔLog(p$_t$). For other explanations, see footnotes to the table 4.3.