Measuring Fundamental Housing Prices in the Baltic States: Empirical Approach

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Abstract

Purpose – The purpose of this paper is to develop a comprehensive framework for assessing housing price misalignments from the fundamental prices in the Baltic States.

Design/methodology/approach – This paper uses several statistical indicators (price-to-rent ratio, price-to-income ratio, price deviations from Hodrick-Prescott filtered trend) together with econometric panel error correction model. The model takes advantage of the reduced form specification of equilibrium prices. Statistical indicators are employed in combination with the model estimates to arrive to clearer conclusions about residential real estate price misalignments.

Findings – The results show that using the framework developed in this paper one could have successfully identified the overheating in the residential real estate markets that was happening in 2005–2008. The estimates also capture the price correction overshooting that happened in the Baltic States after the recession of 2009. Since then, housing prices have been converging to their equilibrium values.

Research limitations/implications – The result implies that no immediate restrictive policy action is required. Looking further, the framework developed here can be used to supplement macroprudential monitoring, risk identification and analysis. It should also help fine-tune various policy instruments that have an impact on the real estate markets.

The limitations of the framework presented in this paper suggest at least two directions in which the research could be improved and extended. First, it would be useful to extend the current modelling set-up to VECM framework for the better understanding of error correction dynamics. Second, better time series would potentially improve the quality of the results as the series used in this paper in some cases had to be extrapolated or interpolated (or were not sufficiently long enough).

Originality/value – This paper contributes to the literature by filling the gap of monitoring housing market developments consistently in the Baltics and developing a framework that can potentially be used to monitor price misalignments in the residential real estate markets of other countries..

Keywords: Housing, real estate, prices, fundamentals, panel, Lithuania, Latvia, Estonia

1. Introduction

Before the economic downturn of 2009–2010, developments in residential real estate markets of the Baltic States[1] were grossly imbalanced. Housing prices were rising at much faster pace than economic fundamentals could justify (see, e.g., Rosenberg, 2008). Even at that time it was clear that such trends cannot be sustained indefinitely;

[1] In this paper The Baltics, The Baltic States and the Baltic countries are used as synonyms to refer to Lithuania, Latvia and Estonia together.

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however, the consensus was that the readjustment would happen naturally and painlessly (the so-called "soft landing" scenario, see, e.g., The Baltic Times, 2007). With the benefit of hindsight it is now known that the risks for financial stability in the Baltic countries were erroneously downplayed.

Since most housing purchases involve borrowing against collateral, unsustainable developments in residential real estate market jeopardize financial systems. If the readjustment occurs in a disorderly manner, shocks to the housing market also affect the real economy mainly through repercussions on households' behaviour (e.g. decrease in consumption). It is true that the Baltics have undertaken some policy action that limits the possibility of risk build-up (see, e.g., Lietuvos bankas, 2011) but on the monitoring and risk-identification side little has been done. Indeed, literature mostly analyses the pre-crisis period (see, e.g. Galinienė et al., 2006; Leika and Valentinaitė, 2007) while the works published after the recession of 2009 mostly focuses on explaining the residential real estate market developments *post hoc* (see, e.g., Cocconcelli and Medda; 2013, Stepanyan et al., 2010; Bukevičiūtė and Kosicki, 2012).

Consequently, such questions as whether residential real estate prices in the Baltics are in line with fundamental determinants cannot be answered consistently. For dealing with problems of this kind researchers, indeed, so far resorted to the *ad hoc* approach. Orderly evaluation of developments in the housing market is especially relevant for policy makers because it can decrease the uncertainty regarding the situation in the housing market. Decisions that can potentially affect the housing market (e.g. loan-to-value limits) can be better tailored to be more efficient if made under fuller information.

This paper aims to fill the void in the literature and develop an extensive framework for measuring residential real estate price misalignments in the Baltic countries. For this purpose it employ a set of measures that helps to identify whether the actual housing prices are above, in-line or below their long-term equilibrium values (i.e. justified by fundamental factors). These measures range from simple statistical ratios to estimates from a complex model.

The two relatively simple ratios that are discussed and calculated in this paper are the commonly used price-to-rent and price-to-income ratios. The ratios are supplemented by another simplistic measure, i.e. the estimates of equilibrium housing prices obtained from the Hodrick-Prescott filter exercise. For a more comprehensive assessment of the equilibrium housing valuations in the Baltics, a panel error correction model is developed.

Using each method employed in this paper alone would definitely encompass significant degree of uncertainty. Therefore, this paper proposes how different measures can be combined into a framework that allows making clearer inferences. As a result, real estate market monitoring tools developed in this paper may potentially be used to improve the conduct of macroprudential policy.

The rest of the paper is structured as follows. Important structural features of housing markets are discussed in the next section. After that, modelling strategies that are most commonly used for residential real estate pricing analysis are reviewed. The forth section presents results from the simple statistical measures of price misalignment

followed by the section that describes the estimation exercise. The section after that discusses the results of the paper. Final section concludes.

2. Important features of housing

It is important to understand that residential real estate differs from financial assets considerably and that these differences are crucial when choosing the analysis approach. Therefore, this part of the paper aims to briefly cover important features of housing markets as well as basic stylized facts related to it. Most importantly, it tries to familiarize the reader with the fact that residential real estate is not an ordinary asset and deserves a non-standard treatment. While the literature on this topic is not scarce (see, e.g. Glaeser and Nathanson, 2014; Davis and Nieuwerburgh, 2014, who provide excellent reviews), it is useful to have a short version of it at hand.

Housing assets are extremely heterogeneous, so, in contrast to, e.g., bonds, each unit of housing is unique. For the most part this is determined by the physical location of the object. Generally, the closer the residential real estate is to the concentrated areas of jobs, the more expensive it is; however, even two flats in the same apartment building can differ in their 'intrinsic' value. Pronounced heterogeneity contributes markedly to the information on the current value of such assets being limited. Whereas one can easily obtain the spot price of a particular publicly traded stock, it is virtually impossible to do so with real estate assets.

In most situations housing assets are indivisible. If a household is liquidity constrained and wants to compensate lost income from conventional financial assets, it can do so by selling a fraction of such assets. This is fundamentally impossible with housing assets as most of the time household housing wealth is comprised from a single residence: reducing housing asset holdings essentially means selling the whole object and not just some fraction of it.

Housing transactions happen infrequently, in a decentralized manner, subject to significant search frictions and transaction costs[2] (in contrast to 'usual' financial assets). This renders short-selling the asset impossible. Despite the aforementioned features, housing is often viewed as a good financial investment. Even if it was not considered as an investment choice it often accounts for the biggest share of household wealth and is virtually the only asset against which households can borrow.

Because of this reason housing plays a major role in consumption smoothing. As shown by Hryshko et al. (2010), home equity is used to smooth consumption in light of negative income shocks when housing prices are increasing. On the other hand, if household's leverage is very high, its usual response to a negative shocks is to reduce consumption. Households may 'evolve naturally' to a highly leveraged position or find themselves in it because of sharp home price decreases.

The dividends that residential real estate provide are also very specific. While holding ordinary (financial) assets is associated with pecuniary benefits in form of, e.g., interest payments, housing provides shelter. Such dividends are often referred to as

[2] Transaction costs associated with selling a house usually range from 5 to 10 per cent, see Gruber and Martin (2003).

housing services and are hard to quantify. While in case of renting the rent paid could be considered a good representation of the value of housing services, for owner occupied housing using imputed rents is only an approximation[3].

Because housing by definition must have a physical form, as other kinds of physical capital, it inevitably depreciates. Therefore, to avoid losing value, it requires constant maintenance and investment. No such maintenance is needed for conventional forms of holding wealth (e.g. bank deposits).

Owning or not owning a shelter affects household's portfolio and consumption choices. It is well known that households accumulate wealth when they are young and decumulate it later in life. However, Davis and Nieuwerburgh (2014) document that households do not reduce their housing wealth even late in life while Nakajima and Telyukova (2012) find that retired homeowners spend their wealth slower than those who rent. The researchers show that this is well reflected in the homeownership rates: as homeowners age, the homeownership rates fall from 95% for 65 year olds to about 50% for 90 year olds (these numbers are based on the US data but the researchers find similar figures for other high-income countries as well) while at the same time financial assets are almost completely depleted.

Of course there exist a lot more differences that set housing assets apart from financial assets. However, those mentioned above should be enough to settle that using traditional asset valuation methods used in finance may be misleading if one's aim is to estimate actual over- or undervaluation. Therefore, the next section will try to take this into account when considering methods for fundamental price estimation.

3. Modelling set-up

In the most basic form there exists two ways of empirically estimating fundamental housing prices. The first one rests on theory and models pricing of housing assets in a similar fashion to pricing of financial assets (see Bolt et al., 2011, for an example). Basically it states that housing prices are justified by fundamentals if they are in line with the present value of the dividends that such assets provide (whereas such dividends are usually understood as housing services proxied by imputed rents). The latter approach is often referred to as user costs of owning a house or imputed rents method.

The second one builds on the empirical analysis and statistical estimation. Essentially this method tries to find reasonable correlations in the data that help explain housing price developments. Consequently, it potentially overcomes problems stemming from treating housing as an ordinary financial asset (see Section 2) and estimates price misalignments with greater precision (e.g. Fuster and Zafar, 2014, show that user costs approach considerably overestimates the importance of mortgage interest rates on housing demand). For this reason, this paper focuses on the statistical estimation.

[3] To be more specific, owning a house or a flat can contribute to household's utility in even harder to quantify ways such as getting satisfaction from being a homeowner or owning a residence in a particular place (see Micheli et al., 2014).

Choosing variables for a regression is usually rather challenging and time consuming process. Therefore, reviewing literature is a good start for narrowing down the number of potential variables. Leung (2014) in a simple DSGE framework shows that income affects the equilibrium housing prices. Hott (2009), e.g., derives a model that justifies income, population, mortgage interest rates and the activity in construction sector as housing price fundamentals. Muellbauer (2012) in his supply and demand approach identify stock of housing, income and after-tax interest rate for borrowing as factors driving equilibrium housing prices. In short, income, some measure of housing supply (e. g. housing stock or construction costs), population, mortgage interest rates, mortgage credit are the variables that are most commonly referred as fundamentals in literature[4].

It is also important to note that fundamental housing values are greatly affected by other features of residential real estate markets that are harder to represent as quantified 'fundamental' indicators. The elasticity of housing supply can contribute greatly to the price dynamics as documented by Micheli et al. (2014): the more able supply is to react to demand changes, the lesser is the probability that in the short-run prices will increase above their fundamental values. The quality of rental markets also affects the housing price dynamics: If the rental market is underdeveloped (or restricted), renting a house is a poor substitute for owning a house. Moen et al. (2015) show that even the order of buying and selling residential real estate affects the equilibrium housing prices.

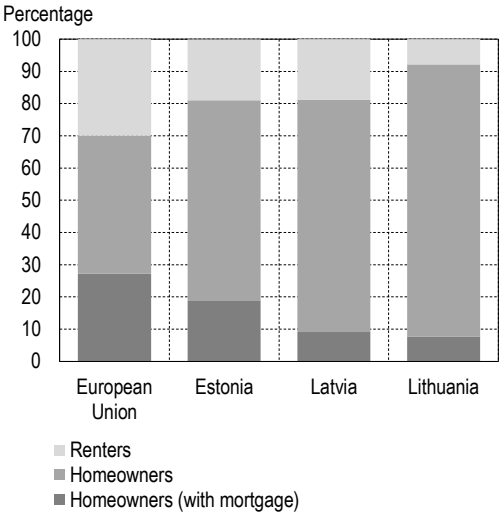
It is reasonable to expect that the aforementioned hard-to-quantify and other structural features of the residential real estate markets in the Baltics are similar. All of these countries started their transitioning to market economies basically at the same time and transformed their institutions in a similar manner (e.g. all three of them joined EU and adopted euro). Huynh-Olsen et al. (2013) show that transition specific factors are as important as fundamentals for transitioning economies in determining equilibrium housing prices.

In addition, housing market structures in terms of the occupier type seem to share common features in the Baltics. As can be seen in Figure 1, all three Baltic States had higher than 80% homeownership rate in 2013. Though Lithuania stood out with the homeownership rate exceeding 90%, it is rather clear that households prefer owning a house to renting in the Baltics more than on average in the EU. The Baltic States also have significantly larger shares of homeowners without mortgage as compared to the average of the EU[5].

[4] See Appendix 2 for a brief summary of how often various factors are referred as fundamentals in literature.

[5] It can be argued that such structure is the evidence of underdeveloped renting market but in case of the Baltics a more plausible explanation is that it is the result of large privatization following the break-up of the Soviet Union that resulted in overall preference shift in favour of owning a house.

Figure 1: *Home occupiers in the Baltics and EU by ownership type in 2013*



Source: author's calculations based on Eurostat data.

All these similar features of the housing markets in the Baltic States suggest that modelling price dynamics is reasonable in a panel setting. The biggest advantage of treating the Baltics as a panel is the increase in data points on which the estimation exercise is run (provided parameter homogeneity restrictions across the countries). However, in case of small ($i = 3$) and fairly homogenous cross-section with relatively large time dimension ($t = 58$) estimating panel regressions in terms of technique is not that different from estimating country-specific models. Consequently, a lot of possible problems that occur in large panels will not be relevant here (e.g., incidental parameter problem, see Neyman and Scott, 1948).

In the most general sense, prices in the housing market are the result of demand and supply interaction. To account consistently for the developments in the market and avoid possible estimation biases both, the supply and the demand side of the market, have to be considered simultaneously. To see how these biases can occur, consider the following example. Let the equilibrium of real estate markets in the Baltics in the long-run be described by such system of equations:

$$\begin{cases} P_{it}^{S} = \alpha_1 CIPI_{it} + \alpha_2 Q_{it}^{S} + fixed_{it}^{S} + \varepsilon_{it}^{S} & (1) \\ Q_{it}^{D} = \beta_1 INC_{it} + \beta_2 P_{it}^{D} + \beta_3 POP_{it} + \beta_4 CRED_{it} + \beta_5 I_{it} + fixed_{it}^{D} + \varepsilon_{it}^{D} & (2) \end{cases}$$

Where equation (1) is the supply equation and equation (2) – the demand equation. Both, the demand and the supply, equations are needed to determine the quantity and the price that prevails in the market. In equations (1) and (2) i indexes country, t is the time index, S and D subscripts distinguish between supply and demand variables, P denotes housing prices, Q – quantity (housing transactions carried out in the market), $CIPI$ – construction input prices, INC – income, POP – population, $CRED$ – mortgage credit portfolio, I – mortgage interest rates, $fixed$ – is the country-specific constant term.

Suppose there is a positive shock to the demand ($\varepsilon_{it}^{D} > 0$). The shock makes the quantity of housing demanded (Q_{it}^{D}) greater. However, in order for the market to clear,

the quantity demanded must be equal to the quantity supplied ($Q_{it}^D = Q_{it}^S$). To balance the effects from the increase in demand, the supply price (P_{it}^S) must increase in the supply equation[6]. If the supply prices (P_{it}^S) increase, prices paid by the buyers (P_{it}^D) must also increase because in an equilibrium the supply and demand prices are equal ($P_{it}^D = P_{it}^S$). Thus, we have a situation where a positive demand shock increases the quantity demanded and at the same time pushes the price up. Since the demand shocks (ε_{it}^D) and the prices (P) are correlated, simple ordinary least squares estimates of the parameters would be inconsistent.

The structural equations (1) and (2) can be reduced to a single equation that can be consistently estimated using ordinary least squares. Since we know that in the equilibrium $Q_{it}^D = Q_{it}^S = Q_{it}$ and $P_{it}^S = P_{it}^D = P_{it}$, we can plug equation (2) in (1) and get:

$$\begin{cases} P_{it} = \alpha_1 CIPI_{it} + \alpha_2 Q_{it} + fixed_{it}^S + \varepsilon_{it}^S \\ Q_{it} = \beta_1 INC_{it} + \beta_2 P_{it} + \beta_3 POP_{it} + \beta_4 CRED_{it} + \beta_5 I_{it} + fixed_{it}^D + \varepsilon_{it}^D \end{cases}$$

$$\begin{aligned} P_{it} = {} & \alpha_1 CIPI_{it} + fixed_{it}^S + \varepsilon_{it}^S + \\ & \alpha_2(\beta_1 INC_{it} + \beta_2 P_{it} + \beta_3 POP_{it} + \beta_4 CRED_{it} + \beta_5 I_{it} + fixed_{it}^D + \varepsilon_{it}^D) \end{aligned}$$

$$\begin{aligned} (1 - \alpha_2\beta_2)P_{it} = {} & \alpha_1 CIPI_{it} + (fixed_{it}^S + \alpha_2 fixed_{it}^D) + \alpha_2\beta_1 INC_{it} + \alpha_2\beta_3 POP_{it} + \\ & \alpha_2\beta_4 CRED_{it} + \alpha_2\beta_5 I_{it} + (\varepsilon_{it}^S + \alpha_2\varepsilon_{it}^D) \end{aligned} \quad (3)$$

$$\begin{aligned} P_{it} = {} & \frac{\alpha_1}{1 - \alpha_2\beta_2} CIPI_{it} + \frac{fixed_i^S + \alpha_2 fixed_i^D}{1 - \alpha_2\beta_2} + \frac{\alpha_2\beta_1}{1 - \alpha_2\beta_2} INC_{it} + \frac{\alpha_2\beta_3}{1 - \alpha_2\beta_2} POP_{it} + \\ & \frac{\alpha_2\beta_4}{1 - \alpha_2\beta_2} CRED_{it} + \frac{\alpha_2\beta_5}{1 - \alpha_2\beta_2} I_{it} + \frac{\varepsilon_{it}^S + \alpha_2\varepsilon_{it}^D}{1 - \alpha_2\beta_2} \end{aligned}$$

Notation used in the last two lines of equation (3) can be simplified, i.e. the parameters of the reduced form prices equation that are expressed as functions of the original equation parameters can be denoted as single symbols:

$$P_{it} = fixed_{it}^P + \gamma_1^P CIPI_{it} + \gamma_2^P INC_{it} + \gamma_3^P POP_{it} + \gamma_4^P CRED_{it} + \gamma_5^P I_{it} + \varepsilon_{it}^P \quad (4)$$

A reduced form equation for quantities (Q_{it}) can be obtained by following similar steps as in equation (3)[7]. Equation (4) is sufficient to estimate the effects of various factors on the equilibrium housing prices. In most cases like the currently analysed where housing price misalignment is of primary concern, such framework is a natural candidate as it keeps the model highly traceable and easy to comprehend. Alternatively, a non-reduced form equation can be estimated using two stages least squares with the exogenous or lagged endogenous variables as instruments.

4. Simple statistical measures of price misalignments

Before turning to modelling, it is useful to have simple statistical ratios such as price-to-income or price-to-rent as crude benchmarks for what can be expected from formal models. Figure 2 plots price-to-income and price-to-rent ratios for the Baltic countries. These simple measures seem to be able to capture overvaluation of the residential real

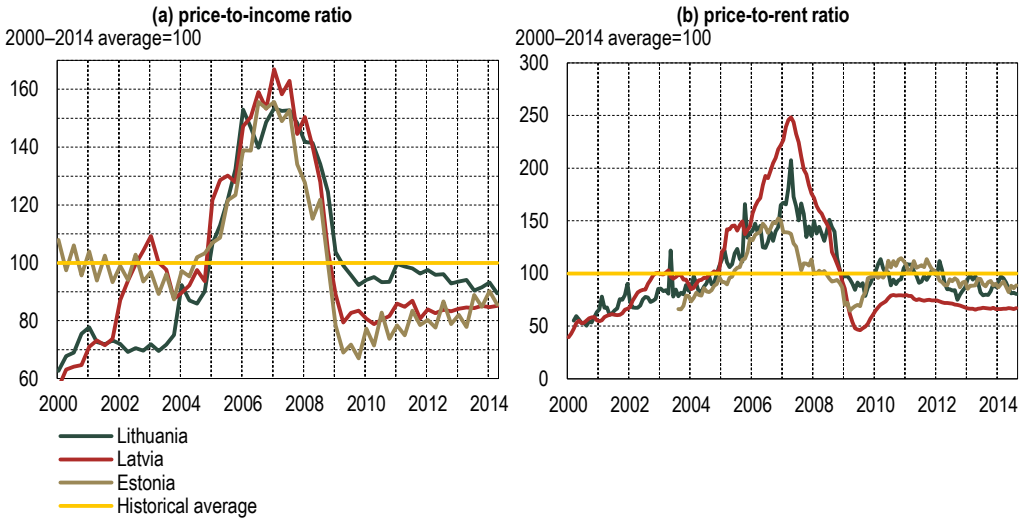
[6] It is assumed that only endogenous variables adjust to supply and demand shocks. It must be noted that the outcomes discussed here are to some extend only possible in this particular partial equilibrium framework. In a general equilibrium framework variables that are exogenous to the system analyzed here would also possibly adjust as they might be set endogenously.

[7] The equation is not derived here as this paper focuses only on the housing prices.

estate during the years prior the financial crisis of 2008, i.e. the ratios are well above their historical averages. Acco rding to these indicators housing prices plummeted below their equilibrium values after the price bubble burst and more or less stayed undervalued to the extent of 10%–20%.

It must be noted that price-to-rent and price-to-income ratios can be good determinants of the residential real estate over- or undervaluation only if these ratios are stationary. The possibility of non-stationarity is a material one as the equilibrium value of housing assets might adjusts because of factors that are not incorporated into these simple ratios leading to permanent shifts of the ratios. With the time series available at the writing of this paper it would be rather optimistic to expect stationarity. First of all, the time series are rather short and that complicates making definite conclusions. Secondly, deviations from the average seem to be long-lasting, thus formal statistical procedure would not consider that as mean reversion.

Figure 2: *Price-to-income and price-to-rent ratio indices in the Baltics*



Sources: author's calculations based on Eurostat, national statistics agencies data, UAB Ober-Haus, Estonian Land Board, Latio Real Estate data.

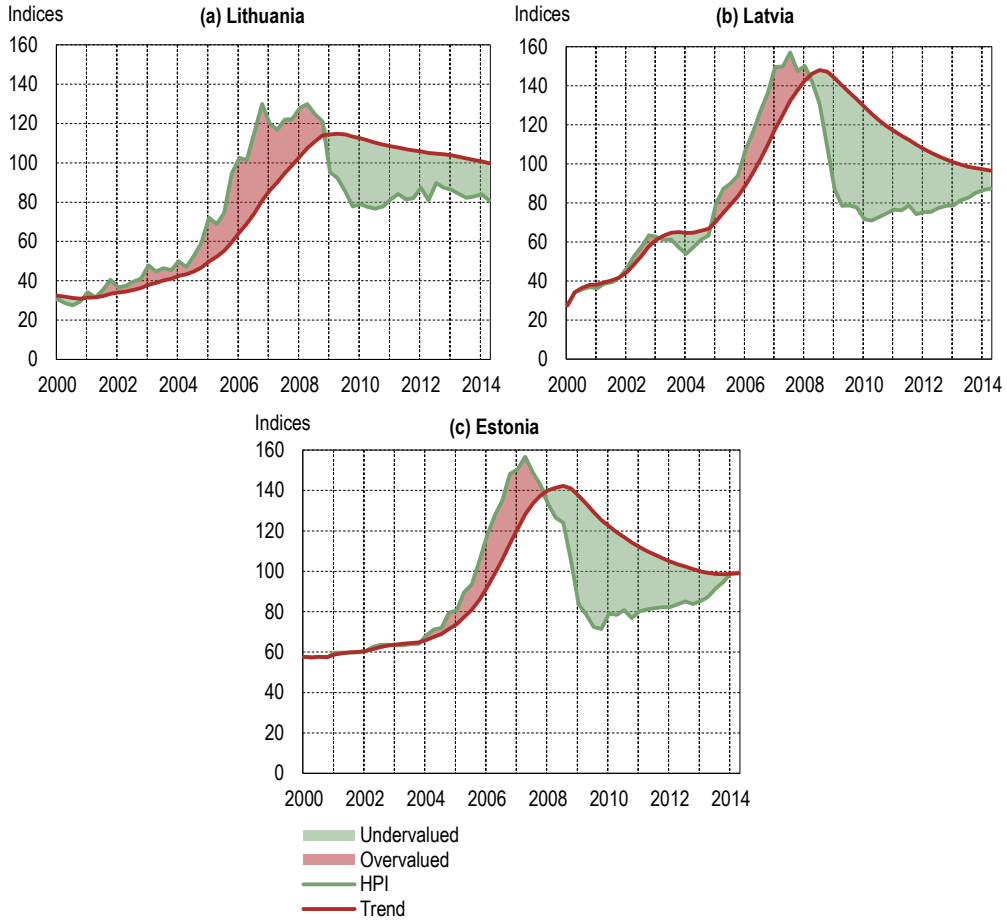
It is also possible to evaluate the housing price developments without taking into account any additional information. A fairly common approach is just to compare price levels with their trends that are usually obtained using Hodrick-Prescott filter with large λ values (see, e.g., European Commission, 2012). Since this method does not take into account any additional information, analysing housing prices in nominal terms might be misleading (e.g. nominal price changes that are in line with the changes in price level may seem as unjustified appreciation). For this reason, housing price indices used here are deflated by the consumer price indices of respective countries.

As can be seen from Figure 3, according to this procedure housing assets are undervalued in Lithuania and Latvia but in line with fundamentals in Estonia. However, results from Hodrick-Prescott filter should be treated only as complementary to other evidence as this procedure is the most atheoretical and the deviations from

smooth trend may not necessary be a sign of imbalances in the market. This method incorporates even less information than the simple ratios discussed above, hence, it is even more prone to misjudge structural shifts.

Simple statistical ratios seem to be able to capture possible housing price imbalances in the Baltic States. However, their signalling performances were worse when it mattered[8]: the variation available for the calculation of such ratios only covered the pre-boom years and was rather short. Hence, while they are good first estimates and benchmarks for further analysis, resting solely on them is not enough in order to convincingly identify over- or undervaluation of the residential real estate.

Figure 3: *Real housing price deviations from Hodrick-Prescott filter (one-sided) trend* ***(λ = 100 000***[9]*)*



Source: Author's calculations based on Eurostat and national statistics agencies data.

[8] One can easily see why by simply restricting calculations not to include data that became available after the end of 2005. While most of the time the indicators would still signal overvaluation, it would arguably be too small to mobilize policy makers for taking restrictive (risk mitigating) measures. See Appendix 3 for the measures calculated on the restricted sample.

[9] The λ value is set following Goodhart and Hofmann (2008) and Agnello and Schuknecht (2011). Lithuanian residential real estate prices data that is filtered here start in 1995.

5. Estimation exercise

This section turns to estimating the equilibrium housing prices using econometric techniques. Several regressions are run with four different error correction terms that are estimated as the residuals from equilibrium equations. The equations are summarized in the Table 1 below.

In all formulations country-specific intercepts (fixed effects) are present (F-test for fixed effects yields a p-value lower than 0.05). Such results are expected: visual heterogeneity inspection of the data suggested that while the data of different countries shows significant co-movement, it occurs at slightly different levels and that is exactly what fixed effects account for. For specifications where CONTR is present on the right-hand side of equations, two stages least squares are used for estimation with lagged values of CONTR as instruments. The residuals obtained from the housing price equilibrium equations are stationary and cointegrated in all four cases (Levin et al., 2002, panel unit root test with lag selection using method proposed by Hall, 1994, as well as Kao (1999) panel cointegration test).

Table 1: *The composition of equations for the estimation of error correction term*

	ECM1 HPI	**ECM2** HPI	**ECM3** HPI	**ECM4** HPI
CCPI				
CONTR				
INC				
I				
POP				
CRED				
Fixed effects	Yes	Yes	Yes	Yes
Residuals stationary	Yes	Yes	Yes	Yes

Source: author's calculations.

The error correction terms that are obtained from the equations reported in Table 1 can only be relevant if they are statistically significant in the short-term dynamics equation. This is essential for the equilibrium adjustment to happen: if the parameter near the error correction term is not statistically different from zero, the adjustment does not happen. In other words, housing prices would not show a tendency to revert back to the equilibrium.

Visually all of the variables seem to have unit-roots (see Appendix 1). Levin et al. (2002) tests confirm this: the times-series used in this paper are integrated of order 1. Hence, in the regressions of short-term dynamics they are used in first differences. To account for possible lags in the price development dynamics, up to two-period (two quarters) lags are allowed. The regressions are run with all possible combinations of variables at first but are rerun afterwards as many times as required to remove variables with statistically insignificant parameters (based on p-value the variable with the least significant parameter is removed at each iteration). The estimation is performed using two stages least squares to account for endogeneity between the prices and the quantities (using the same instruments as in the equilibrium equations). There

are no fixed effects present in all four regressions. The results of estimation are summarized in Table 2.

We can see from Table 2 that the speed of adjustment parameters are statistically significant in all analysed cases. The signs of the parameters near the error correction terms are negative, thus, if the prices are above their long-term equilibrium values and if the other factors stay constant, the prices will readjust. The strongest adjustment would happen in the model with the error correction term obtained from the equilibrium regression that does not include the contracts and interest rates time series on the right-hand side. All else equal, the prices would revert back to the equilibrium values in less than 4 quarters in this case. Formal goodness of fit criteria, such as adjusted R^2 and AIC, favour the model that uses error correction term obtained from the regression that lacks only the interest rates variable on the right-hand side. In this case, all else equal, the prices adjust back to equilibrium in just over 4 quarters.

Table 2: *The estimated error correction models of housing prices in the Baltic States*

	model.ECM1	**model.ECM2**	**model.ECM3**	**model.ECM4**
	$dHPI_t$	$dHPI_t$	$dHPI_t$	$dHPI_t$
$Intercept$	-0.012	-0.010	0.008	-0.002
	(0.008)	(0.010)	(0.005)	(0.004)
$dHPI_{t-1}$	0.385**	0.272**	0.400**	0.423**
	(0.084)	(0.088)	(0.085)	(0.086)
$dCCPI_t$	0.945**	0.825**	0.967**	1.028**
	(0.236)	(0.235)	(0.238)	(0.2497)
$dCONTR_t$	-0.123**	-0.089*	–	0.095*
	(0.012)	(0.043)	(–)	(0.044)
dI_{t-1}	–	0.436*	0.558**	–
	(–)	(0.170)	(0.184)	(–)
$dPOP_{t-2}$	-5.133*	-5.964*	–	–
	(2.454)	(2.496)	(–)	(–)
$dCRED_{t-2}$	–	-0.152*	-0.241**	–
	(–)	(0.073)	(0.072)	(–)
ECM_{t-1}	-0.171**	-0.233**	-0.292**	-0.111**
	(0.038)	(0.038)	(0.044)	(0.031)
Adjusted R2	0.472	0.519	0.499	0.440
AIC	-490.325	-502.959	-498.630	-492.605

Source: author's calculations.
Note: values are rounded to three digits after decimal point. Standard errors of the parameters are presented in parenthesis. Stars indicate statistical significance as follows: "**" – 99%, "*" – 95%. The letter "d" in front of a variable indicates the variable is in first differences.

Before moving on, several country-specific regressions are estimated. For better comparability to the model.ECM2 from Table 2, the individual regressions in Table 3 are only reported with the equivalent specification and error correction terms. Since the error terms from individual country regressions are not significantly correlated, the country specific models are estimates using OLS not SUR.

As can be seen from Table 3, relative to the panel regression case the individual country regressions are comparably good descriptors of the housing price variation in each of the country (based on adjusted R^2). The country-specific model performs best in Estonia's case and fares worst in Latvia's case. However, in each case the results are highly affected by smaller sample as there is less variation available for estimation with time series restricted to individual countries. Hence, some parameters in Table 3 are reported as insignificant or with signs that differ from the panel regression case.

Table 3: *The estimated error correction models for individual countries*

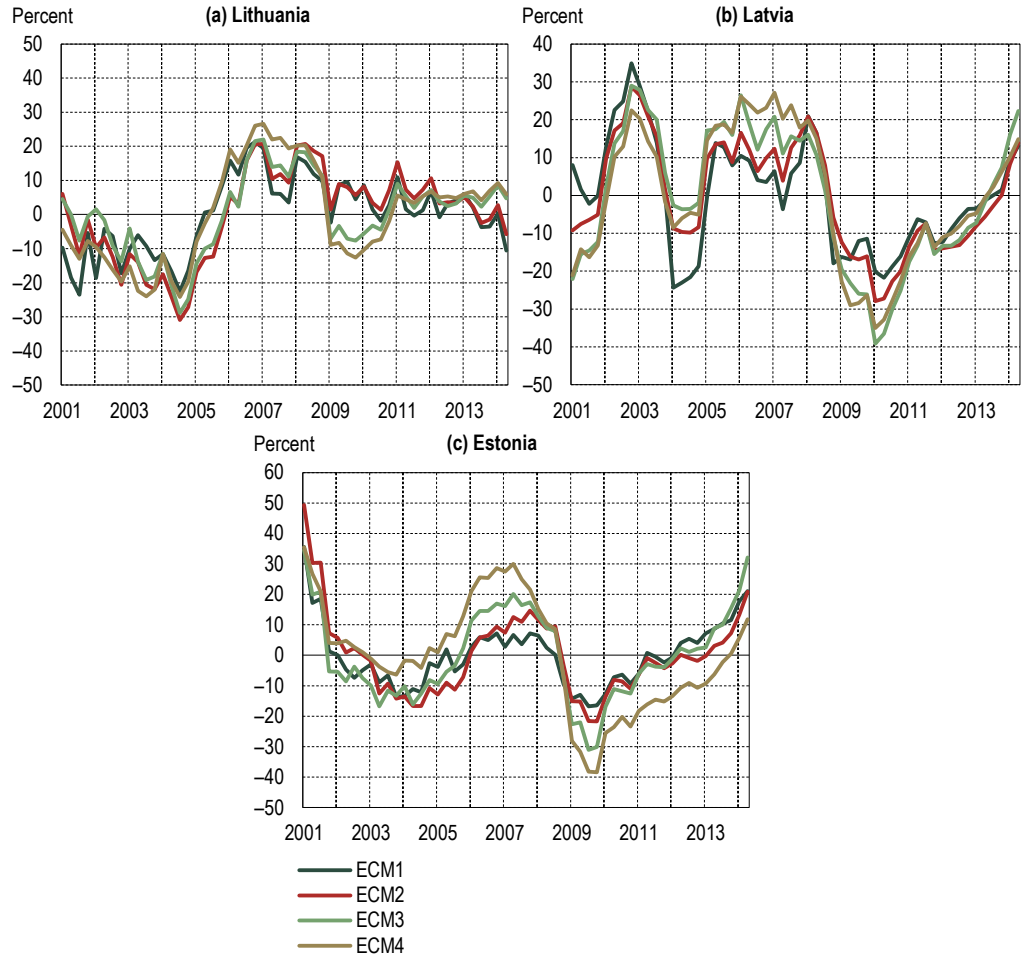
	model.ECM2.Lt	**model.ECM2.Lv**	**model.ECM2.Ee**
	$dHPI_t$	$dHPI_t$	$dHPI_t$
$Intercept$	−0.033	−0.009	−0.037*
	(0.017)	(0.023)	(0.015)
$dHPI_{t-1}$	0.329*	0.495*	0.106
	(0.149)	(0.188)	(0.134)
$dCCPI_t$	0.813	0.678	2.579**
	(0459)	(0.414)	(0.561)
$dCONTR_t$	−0.086	−0.327**	−0.306**
	(0.055)	(0.119)	(0.069)
dI_{t-1}	0.542	0.236	−0.113
	(0.280)	(0.368)	(0.226)
$dPOP_{t-2}$	−7.411	−0.780	−9.056*
	(4.138)	(5.540)	(3.512)
$dCRED_{t-2}$	0.132	−0.083	−0.042
	(0.109)	(0.143)	(0.090)
ECM_{t-1}	−0.328**	−0.201*	−0.277*
	(0.103)	(0.099)	(0.104)
Adjusted R^2	0.481	0.384	0.654
AIC	−166.463	−135.500	−184.281

Source: author's calculations.
Note: values are rounded to three digits after decimal point. Standard errors of the parameters are presented in parenthesis. Stars indicate statistical significance as follows: "***" – 99%, "**" – 95%, "*" – 90%. The letter "d" in front of a variable indicates the variable is in first differences.

6. Results

For further analysis the fitted values from panel regression are visually inspected. Housing price misalignments expressed as percentage deviations from the equilibrium values are plotted in Figure 4 (see Appendix 4 for the comparison of fitted and actual housing price logarithms). In each case the long-term equilibrium value is considered to be the fitted value of a respective model's error correction equation (see Table 1).

Figure 4: *The estimated housing price deviations from equilibrium in the Baltics*



Source: author's calculations.

There are several things that are immediately visible from the figure. While the estimates of the long-term equilibrium values of housing prices from different error correction equation disagree on the exact timing of turning points and the extent to which prices are above or below equilibrium, they all follow similar pattern. For all three countries all of the models were able to identify housing overvaluation occurring the subsequent market crashes.

The models signal housing prices wandering above their long-term equilibrium values sometime in 2005. Residential real estate was overvalued in Lithuania, Latvia and Estonia for about 26–30% at the peak of the boom. The largest price corrections

occurred in Latvia and Estonia where housing prices briefly found themselves some 38–39% below fundamentally justified values. The mildest correction occurred in Lithuania with housing prices slipping below their long-term equilibrium values for about 12%.

If we consider the period after 2009, the figures reveal that all models believe the residential real estate prices had already overshoot their equilibrium values in Estonia and Latvia by rebounding too much from the correction that occurred throughout 2009 and 2010. For Lithuania, the models send mixed signals: two of the regressions (ECM1 and ECM2) suggest that housing assets were underpriced at the end of the sample and this message contrasts with the estimates from the other two models (ECM3 and ECM4).

Since the estimates from all models follow similar patterns, it would be difficult to call which of them has the most desirable properties based purely on a visual inspection. Formally, the ECM2 model fits the data better than the alternatives (based on AIC and adjusted R^2, see Section 5), thus, it is considered as a benchmark model for further analysis. The estimates from the latter model showed overvaluation of 14% and 21% in Latvia and Estonia respectively and undervaluation of 6% in Lithuania at the end of the sample (the second quarter of 2014).

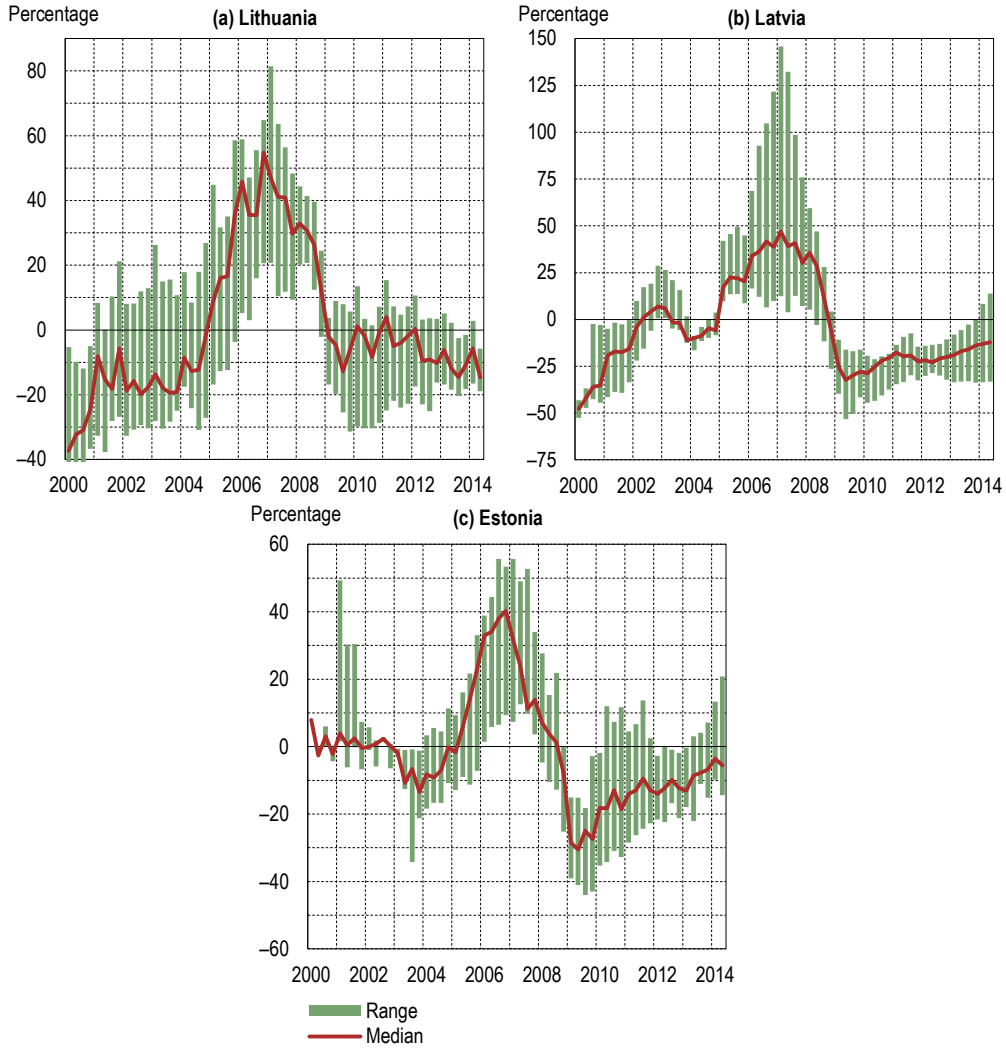
Given the uncertainty surrounding the results from any single method discussed so far, making inferences is rather difficult. To make the task of arriving to clear conclusions easier, it is useful to combine the information obtained from the models with the simple statistical ratios discussed in Section 4. This information is synthesized in a graphical form in Figure 5.

The figure shows the ranges of price misalignments at different points in time in the Baltics. The ranges are calculated from the price-to-rent ratio, the price-to-income ratio, the deviations from Hodrick-Prescott filter trend and the estimates obtained from an econometric model. For the latter the regression with the ECM2 error correction term was chosen (see Table 1).

For all three Baltic States Figure 5 is able to tell a rather plausible story of housing price developments. The overheating that took place in the period of 2005–2008 is clearly visible for all the countries under consideration. Although the ranges are wide, in all cases even the minimum values leave no doubt of housing assets being traded considerable above their long-term equilibrium prices. The same framework with sample restricted to end at the beginning of 2006 is still able to identify unsustainable developments in housing prices early on albeit with slightly reduced precision (see Appendix 3).

Residential real estate prices overreacted in correcting accumulated imbalances after 2009. Actual housing prices slipped under their long-term equilibrium values in all three Baltic States. Although the correction was of different size (and it basically corresponds to the size of overvaluation prior the burst of the bubble), the prices are converging to their equilibrium levels and, judging by several indicators, were already balanced in the second quarter of 2014.

Figure 5: *Residential real estate price deviations from fundamental values in the Baltics*



Source: author's calculations.
Note: ranges are comprised from price-to-rent ratio, price-to-income ratio, deviations from Hodrick-Prescott filter trend and estimates from econometric model.

It must be noted, that the actual prices being above or below their equilibrium values does not necessary translate to price correction. The equilibrium prices can move in response to various developments in fundamental factors[10] (e.g. due to changes in population) and close the under- or overvaluation gap without any apparent movement in the actual prices. It seems that the convergence after the undershooting in Lithuania happened not because of the prices falling back to the equilibrium levels but because of the levels of equilibrium prices increasing closer to the actual housing prices.

Judging by the signalling performance of Figure 5, this framework could be used for making judgements about price misalignments rather successfully. There is no reason

[10] These developments themselves might be unsustainable but gauging the exact effect of fundamentals overshooting their equilibrium (sustainable) values falls out of the scope of this paper.

to believe that in the future if the actual housing prices depart from their equilibrium values it will not be able to detect the decoupling. Although in the second quarter of 2014 the estimates did not signal any immediate dangers stemming from the housing markets, the situation might change in the future as the prices have more or less converged to their equilibrium values from the correction that took place after the recession of 2009. Especially the cases of Estonia and Latvia require careful monitoring as according to some estimates their residential real estate markets can be overheating.

7. Concluding remarks

This paper showed how inferences about the housing price misalignments in the Baltic States can be made using a combination of price-to-rent, price-to-income ratios, deviations from Hodrick-Prescott trend and estimates from econometric models. The results show that using this framework one could have successfully identified the overheating in the residential real estate markets that was happening in 2005–2008. The estimates also capture the price correction overshooting that happened in the Baltic States after the recession of 2009. Since then, housing prices have been converging to their equilibrium values. In the second quarter of 2014 they were more or less in line with the price justified by the fundamental factors in all three Baltic States.

The result implies that no immediate restrictive policy action is required. Looking further, the framework developed here can be used to supplement macroprudential monitoring, risk identification and analysis. It should also help fine-tune various policy instruments that have an impact on the real estate markets.

Modelling the equilibrium housing prices reveals that price misalignments in the Baltic States may not necessary lead to corrections in the actual housing prices. Indeed, this means that even if the residential real estate is over- or undervalued in one of the Baltic countries, prices might not actually fall or rise. In turn, the actual adjustment may happen through movements in the equilibrium housing price which can fluctuate quite considerably given variation in fundamental determinants.

The limitations of the framework presented in this paper suggest at least two directions in which the research could be improved and extended. First, in order to learn more about the price correction mechanism in the Baltics, it would be useful to extend the current modelling set-up to VECM framework. In addition to better understanding if the movements in the housing prices are driven by long-term (e.g. because of deviation from equilibrium) or short-term variation (e.g. changes in prices because of non-fundamental factors such as shifts in households' expectations) this would allow forecasting of future housing price changes. By modelling the short-term and the long-term dynamics endogenously, VECM systems would allow assessing the responses of the system to shocks and decomposing the variance. It is also reasonable to expect that further research may benefit from comparing estimates between empirical and theoretical (e.g. imputed-rents approach) models.

Second, the time-series used in this paper were originally incomplete as the actual observations were missing. Extrapolating or interpolating them most probably does not distort the results to any considerable degree because of the careful execution of the task. However, the quality of the results would still improve if the data limitation faced

by this study were eliminated. Moreover, some time series that would have benefited this study could not have been extrapolated with the satisfactory degree of precision, thus can only be potentially used in the future (e.g. construction starts). Consequently, it is reasonable to update this study with a richer set of variables or the dataset that relies less on the synthetically extended (i.e. extrapolated) time series in the future. However, since only one data point per quarter becomes available (given quarterly time series used in this paper), this research direction is not something that can be taken up immediately.

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Appendix 1. Data

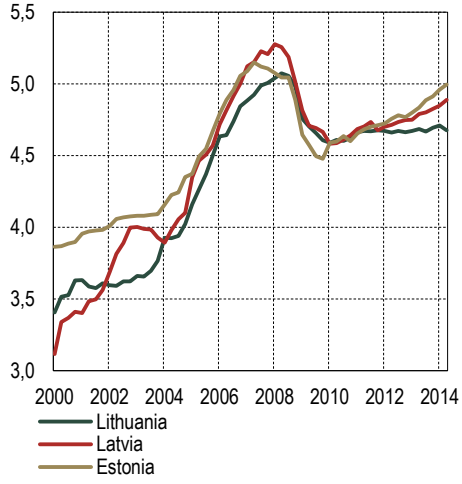
The main purpose of this appendix is to describe the data used in this paper. Data sources and various adjustments that had to be applied to the original data are also discussed. At the same time, the time series are represented in a visual form.

Data used in writing this paper covers the period from the first quarter of 2000 to the second quarter of 2014. Time series of housing prices, residential real estate market transactions, construction input costs, loans for house purchase, income, interest rates on credit for house purchase and population were collected for this exercise. However, data availability in different countries varied and had to be in some cases interpolated or extrapolated.

For notational convenience the names of time series employed in this paper are coded as follows. 'HPI' denotes the indices of housing prices, 'CCPI' – construction input price indices, 'CONTR' – housing transactions, 'INC' – net wages, 'I' – interest rates, 'POP' – population and 'CRED' – mortgage loan stock. All the data except for interest rates in the modelling exercise is used in logs.

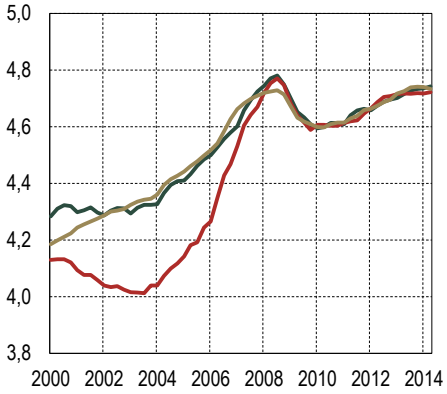
House price indices are taken from Eurostat database. Since it is available for Estonia starting only from 2005 and for Lithuania and Latvia – from 2006, time series had to be extended using supplementary time-series. For Estonia the data was extrapolated backwards to 2003 by mimicking housing price movements obtained from Estonian Land Board transactions database. The data for the period of 2000–2003 was constructed using housing group time series from harmonized index of consumer prices. For Latvia the data was extrapolated backwards to 2000 using average housing prices registered by Latio (a private real estate company). These time series are plotted in Figure A.

Figure A: *Logs of housing price indices*



Source: author's calculations.

Figure B: *Logs of construction input cost indices*



Time series on costs of construction inputs were available for all three countries at their respective national statistics agencies (see Figure B). Volumes of housing transactions were available for the whole period for all three countries as well, although the sources were not homogenous (see Figure C). Estonian national statistics agency provides such data in their database so it was used. Latvian and Lithuanian data on transactions were obtained from respective land registries.

For income data average net monthly wages were used (see Figure D). Lithuanian and Estonian data was available from respective national statistics agencies for the whole timeframe covered in this paper. Data on Latvian net average monthly wages was missing for the year 2000 so it had to be interpolated backwards by mimicking nominal GDP dynamics[11].

Figure C: *Logs of housing transactions*

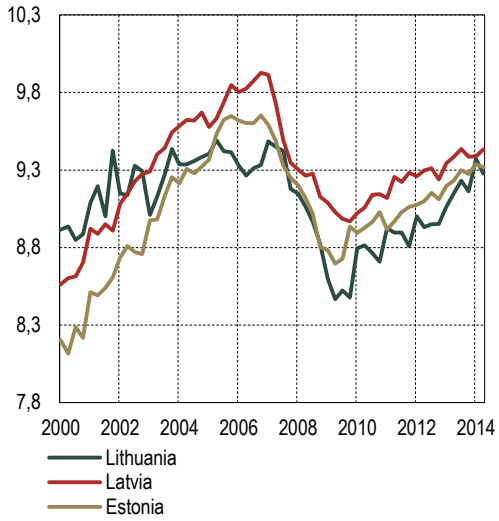
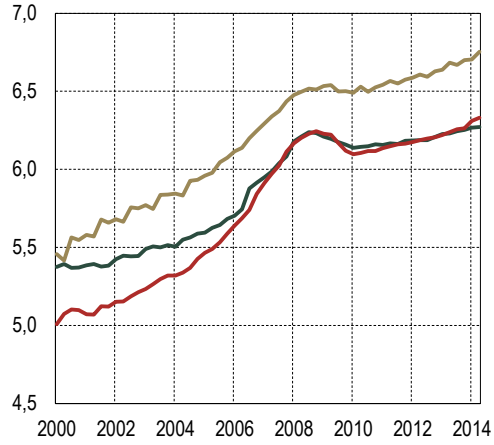


Figure D: *Logs of net wages*



Source: author's calculations.

Data on mortgage interest rates were obtained from central banks (see Figure E). For the periods when the Baltic countries were not part of the euro area, the interest rate is a weighted average of loans issued in the national currency (at the time) and in euro. The data was not fully available only for Latvia; therefore it had to be extrapolated backwards from 2004 to 2000 proportionally to average weighted interest rates on all loans[12].

Population time series were available fully for all three Baltic States at respective national statistics agencies (see Figure F). However, for Estonia the data is provided only at annual frequency and had to be interpolated. Under assumption that changes in population can be described as a smooth process blanks were filled by connecting adjacent data points linearly.

[11] The correlation of nominal GDP and net average wages in Latvia for the period from the first quarter of 2001 to the second quarter of 2014 equals 0.95, therefore it is reasonable to use GDP series to extend time series on net wages.

[12] The correlation of mortgage interest rates and average weighted interest rates on total credit is equal to 0.61 for the period from the first quarter of 2004 to the second quarter of 2013.

Figure E: *Mortgage interest rates*

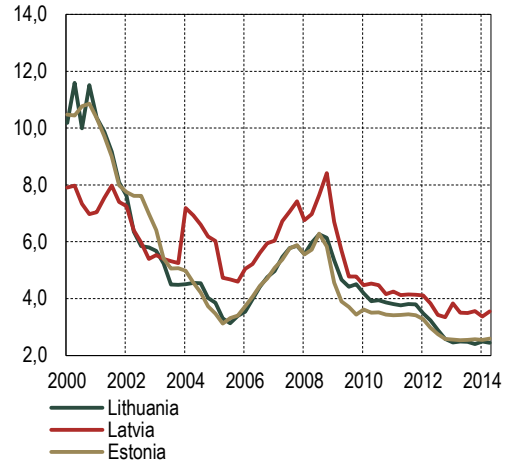
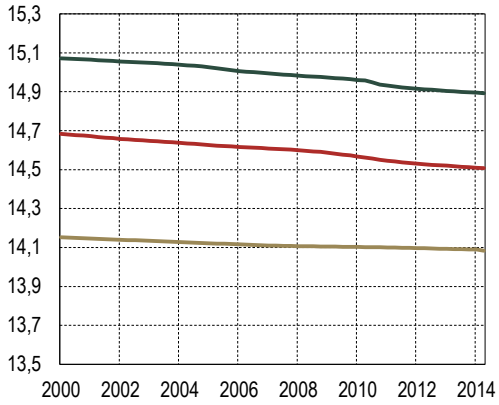


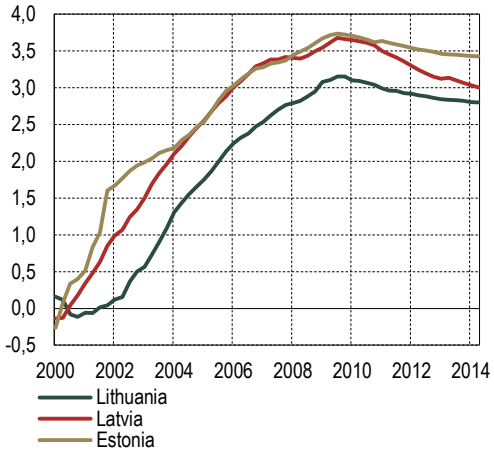
Figure F: *Logs of populations*



Source: author's calculations.

Stocks of credit issued for house purchase were also obtained from central banks but it was available from the first quarter of 2000 only for Estonia. Lithuanian data on mortgage portfolio is available starting from 2004, Latvian – from 2003. For Lithuania it was extrapolated backwards proportionally to the outstanding amounts of total credit issued to households. For Latvia the same procedure was applied but instead of all credit issued to households archived mortgage loan data was used (which is not directly comparable because of changes in methodology). In estimation exercise credit time series are used as credit-to-GDP ratios (quarterly seasonally and working days adjusted nominal GDP figures are obtained from Eurostat and multiplied by 4 for each quarter). These time series are plotted in Figure G.

Figure G: *Logs of loan stock for house purchase-to-GDP ratios*



Source: author's calculations.

For price-to-rent calculations monthly data from consumer price indices is used. Actual rentals for housing index that is a part of harmonized consumer price index compiled by Eurostat is used as a proxy for rental prices. These time series are not extrapolated in any way, thus the sample is shortened for Estonia to start in August 2003.

It is clearly visible from the charts above that there are indeed a lot of homoge-neity among the Baltic countries in terms of housing price movements. In general, time series of all three countries show a lot of co-movement. These synchronized movements suggest that the real estate markets have developed in similar fashion in all three Baltic States and, therefore, respond to shocks of the same kind in a similar way. This makes the case for treating the Baltics as a panel in estimation exercise.

Appendix 2. Housing price fundamentals

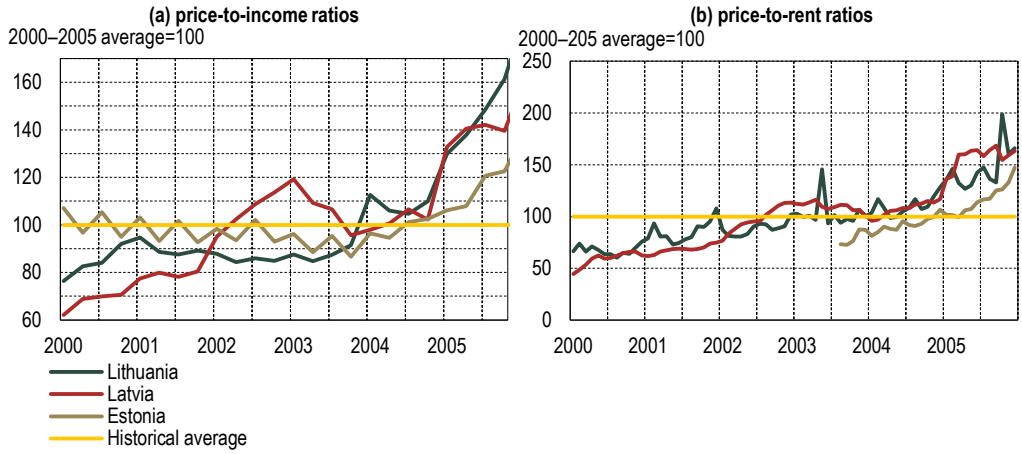
Table A: *Factors that are considered as fundamentals in determining housing prices*

Factor	Considered as a fundamental factor in
Unemployment rate	Kajuth et al. (2013), Andrews et al. (2011), Case and Shiller (2003), Leika and Valentinaitė (2007)
Population	Kajuth, et al. (2013), Huynh-Olsen et al. (2013), ECB (2011), Andrews et al. (2011), Case and Shiller (2003), European Commission (2012), Leika and Valentinaitė (2007)
Income	Knutter and Shim (2013), Corradin and Fontana (2013), Huynh-Olsen et al. (2013), Callesen (2013), Himmelberg et al. (2005), ECB (2011), Andrews et al. (2011), Zhu (2014), Levin and Wright (1997), Case and Shiller (2003), Chen et al. (2013), Fletcher et al. (2014), European Commission (2012), Favara and Imbs (2010), Galinienė et al. (2006), Jonsson et al. (2011), Leika and Valentinaitė (2007), Stepanyan et al. (2010), Bukevičiūtė and Kosicki (2012)
Interest rate	Knutter and Shim (2013), Huynh-Olsen et al. (2013), Callesen (2013), Himmelberg et al. (2005), ECB (2011), Andrews et al. (2011), Towbin and Weber (2014), Levin and Wright (1997), Case and Shiller (2003), Chen et al. (2013), Fletcher et al. (2014), Thwaites (2014), European Commission (2012), Jonsson et al. (2011), Leika and Valentinaitė (2007)
Rental prices[1]	Himmelberg et al. (2005), ECB (2011), Glaeser and Nathanson (2014), Zhu (2014), Towbin and Weber (2014), Fletcher et al. (2014), Micheli et al. (2014), European Commission (2012), Favara and Imbs (2010), Leika and Valentinaitė (2007), Bukevičiūtė and Kosicki (2012)
Credit	Huynh-Olsen et al. (2013), Andrews et al. (2011), Zhu (2014), European Commission (2012), Favara and Imbs (2010), Leika and Valentinaitė (2007)
Construction costs	Huynh-Olsen et al. (2013), Case and Shiller (2003), Chen et al. (2013), Leika and Valentinaitė (2007)
Residential investment	Towbin and Weber (2014), European Commission (2012)
Housing starts	Case and Shiller (2003)
Remittances	Huynh-Olsen et al. (2013), Stepanyan et al. (2010)
Taxes and regulation	Callesen (2013), Andrews et al. (2011), Micheli et al. (2014)
Households' wealth	Jonsson et al. (2011)
Inflation	Callesen (2013), Himmelberg et al. (2005), Levin and Wright (1997), Chen et al. (2013)

[1] Includes cases where rental prices are used as a proxy for housing services received by a homeowner.

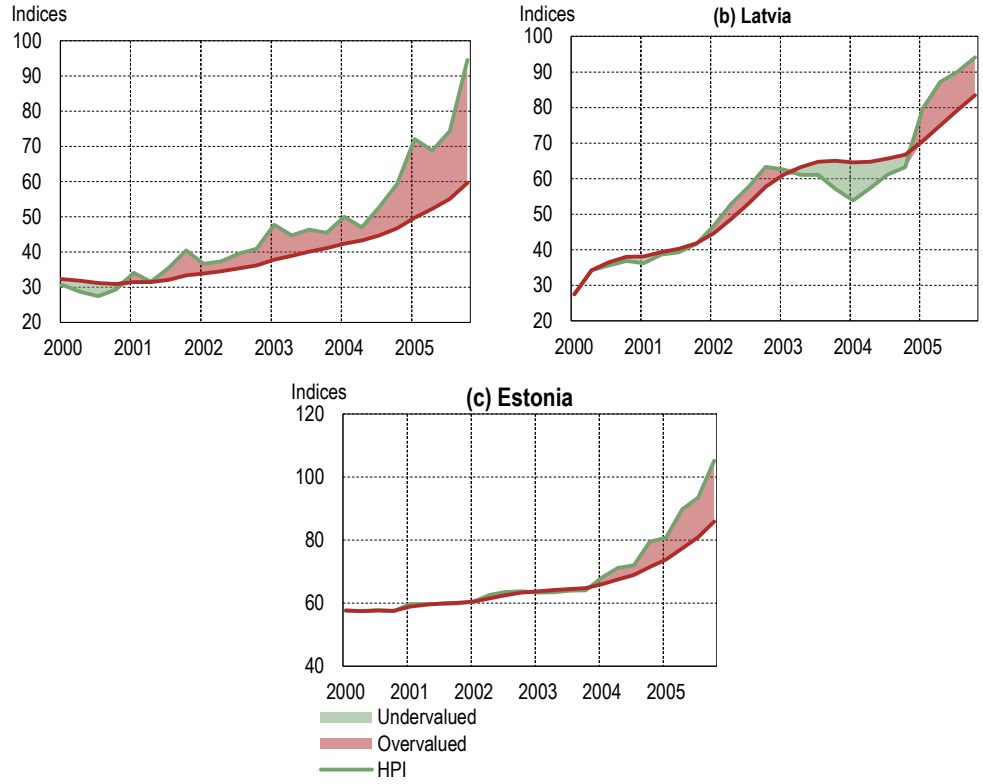
Appendix 3. Fundamental price measurements with restricted data sample

Figure A: *Price-to-income and price-to-rent ratios in the Baltics restricted to data available until the end of 2005*



Source: author's calculations based on Eurostat, national statistics agencies, UAB Ober-Haus, Estonian Land Board, Latio Real Estate data.

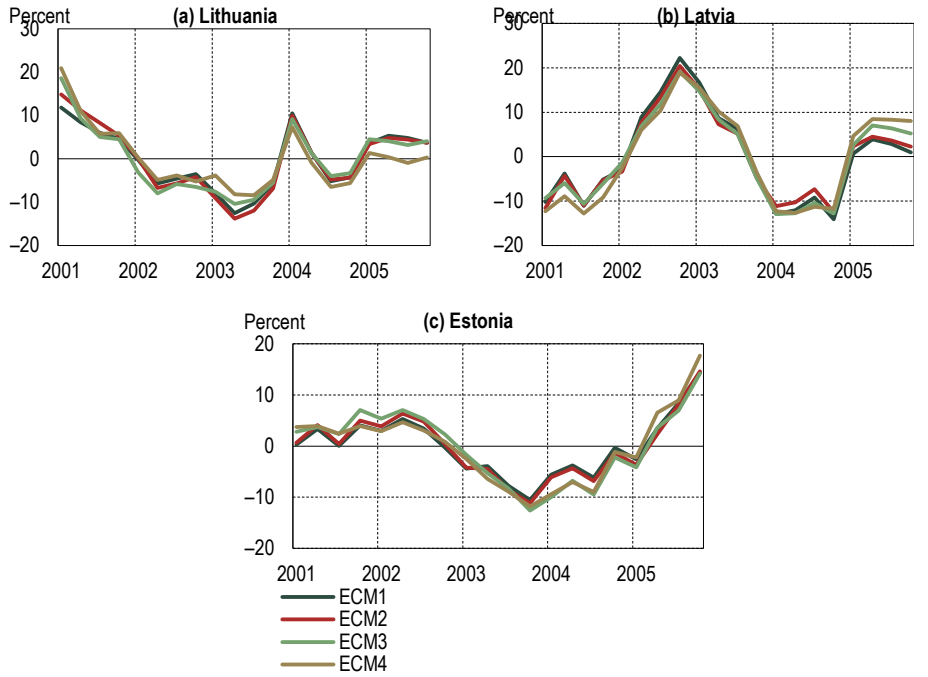
Figure B: *Housing price deviations from Hodrick-Prescott filter (one-sided) trend (λ = 100 000[13])[14]*



Source: author's calculations. based on Eurostat and national statistics agencies data.

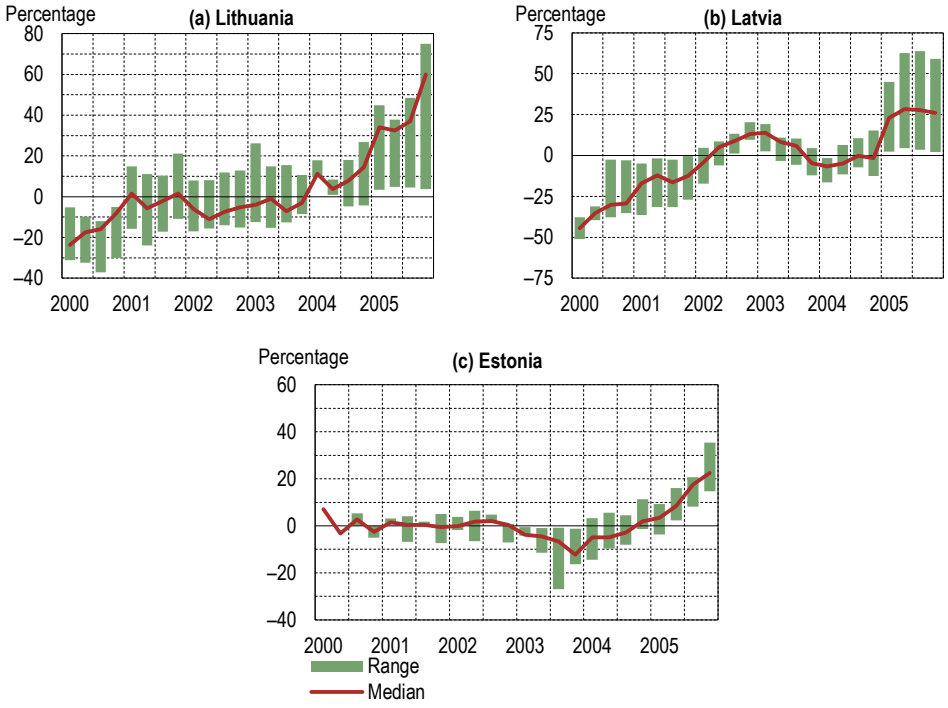
[13] The λ value is set following Goodhart and Hofmann (2008) and Agnello and Schuknecht (2011).
[14] Lithuanian residential real estate prices data that is filtered here start in 1995.

Figure C: *The estimated housing price deviations from equilibrium in the Baltics (restricted sample)*



Source: author's calculations

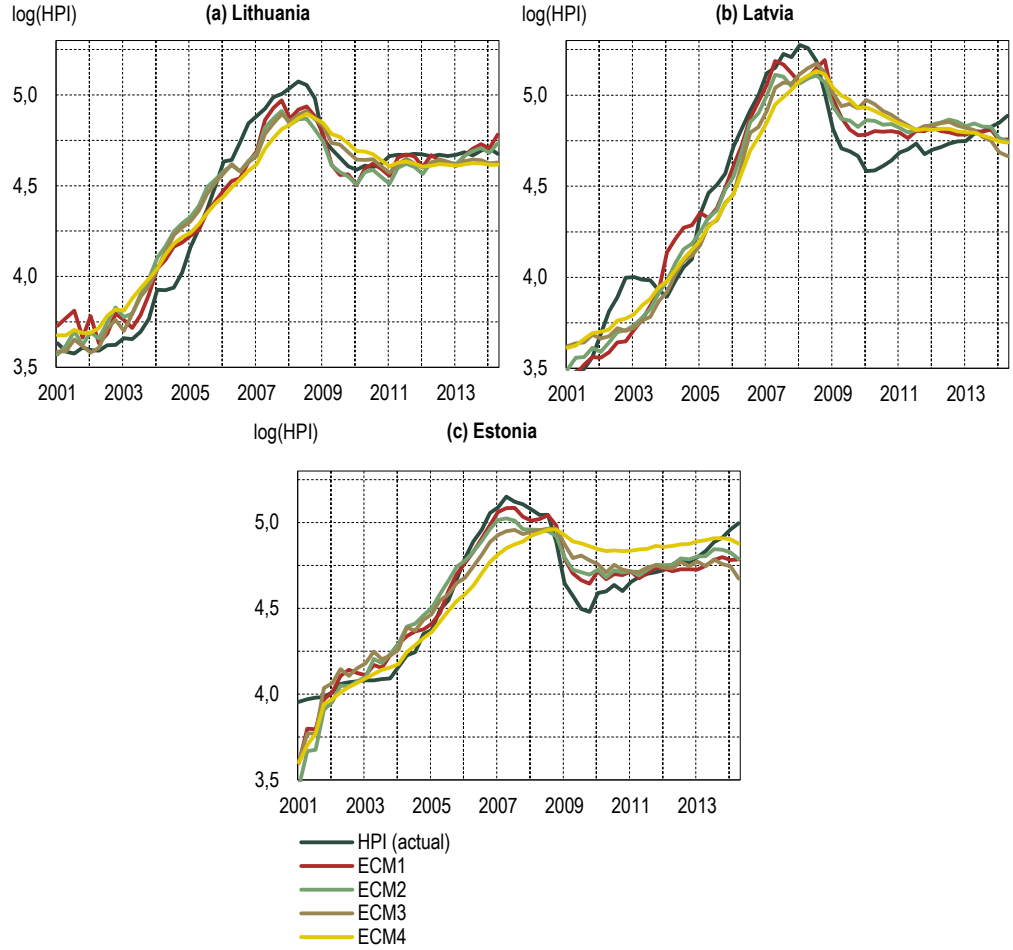
Figure D: *Residential real estate price deviations from fundamental values in the Baltics (restricted sample)*



Source: author's calculations.
Note: ranges are comprised from price-to-rent ratio, price-to-income ratio, deviations from Hodrick-Prescott filter trend and estimates from econometric model.

Appendix 4. Actual vs. fundamental housing prices in the Baltics

Figure A: *Housing price indices in the Baltics and estimated fundamental values*



Source: author's calculations.