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MEASURING HOUSING PRICE MISALIGNMENTS IN THE BALTIC STATES

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1. Introduction

Motivation. After the accession to the EU the residential real estate markets of the Baltic States[1] experienced a very pronounced boom-bust cycle that greatly exacerbated the consequences of the Global Financial Crisis. Beginning with 2004 easily available credit started pouring into the Baltic economies and fuelled demand for housing. With the benefit of hindsight, it is now clear that the developments – strengthened by imbalanced credit expansion – were unsustainable and led to large overvaluation of the residential real estate in Lithuania, Latvia and Estonia. Imbalances unravelled with grave consequences on the real economy with prices falling by 40–50 percent from the peak to the through.

If the price misalignments in the housing markets had been detected in time, policy makers could have taken preventive measures to reduce any further accrual of imbalances. This, in turn, could have helped lessening huge welfare losses that the Baltic States experienced during and after the Global Financial Crisis. However, there was no consistent framework that could have helped with judgments about the state of housing price misalignments in the Baltic countries. Such a framework is still relevant as the possibility for another boom for the residential real estate markets in Lithuania, Latvia and Estonia will always remain. Therefore, developing a robust analytical framework for measuring housing price misalignments would significantly increase the understanding of developments in the residential real estate markets of those countries.

Originality and value. The literature focusing on residential real estate market valuation in the Baltics is rather scarce: the countries only tend to be included in studies as a part of larger panels with little attention to the features that might be relevant to those countries alone (see, e.g., Ciarlone, 2015). Therefore, evaluating whether residential real estate is under- or over-valued has to rest almost solely on expert judgement and *ad hoc* approaches. While it can be argued that the macroprudential policy measures that came into effect after the crisis of 2008–2009 limits the scope of possible price misalignments, at the same

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

time it means that, in a way, policymakers are conducting it while being blindfolded. In other words, researchers, policymakers and practitioners in the Baltic States are forced to resort to the case by case analysis, which is relatively slow and, because of increased time inconsistency problem, is exposed to the higher probability of errors. Therefore, this thesis proposes a robust analytical approach for making inferences about house price misalignments in the Baltic States. The framework can be used in practice, e.g., for macroprudential oversight as the developments in residential real estate sector are instrumental to financial stability.

Purpose and objectives. This thesis attempts to fill the gap in the literature and aims to develop a framework in which statistical measures together with the estimates from theoretical and econometric models can be used for a consistent evaluation of housing price misalignments in the Baltics. In order to achieve this, the following objectives had to be fulfilled:

1. literature that focuses on the Baltic housing markets had to be analysed in order to determine if the work of other authors could be used for building on in this thesis;
2. possible ways to asses fundamental housing prices had to be reviewed and the assessment had to be made on which of them could be implemented in the case of the Baltics;
3. data needs for the application of possible analytical approaches to measuring fundamental housing prices in the Baltic States had to be determined;
4. models for measuring housing price misalignments in the Baltic States had to be constructed;
5. robustness checks had to be performed in order to ensure that the framework is able to capture over- or undervaluation of residential property in the Baltics.

The problem this thesis attempts to solve could be summed up with a question that asks if it is possible to make objective judgements about housing price misalignments in the Baltic States. Thus, the working hypothesis for this thesis is that it is possible to use a consistent analytical framework for identifying residential real estate misalignments in the Baltic States.

Methods, design and approach. The analytical framework was developed by combining estimates from error-correction and theoretical user cost models with estimates from Hodrick-Prescott filtering exercise and price-to-rent and price-to-income ratios. The intuition behind the ratios is simple: because their averages in the long-run should be constant, departure of one of the ratios from its mean might be a sign of housing price misalignments.

One-sided Hodrick-Prescott filter was used to obtain housing price deviations from their long-run trend. This method of deriving equilibrium housing prices rests on observation that balanced price movements are not overly volatile and are supposed to follow a smooth trend. Departure from it (e.g. exponential growth episodes) can be considered a sign of price misalignments.

Error correction models take advantage of the fact that variables that are fundamental determinants of housing prices should show a lot of co-movement with them. In case they depart from such long-run relationship, it may be a sign of imbalances in the market. Since housing markets are structurally very similar across the Baltic States, error correction models were estimated in a panel setting.

Finally, theory was used to determine the equilibrium housing prices in the user costs framework (also known as imputed rents approach) which allows to calculate the equilibrium price-to-rent ratios. The method borrows heavily from the literature of financial economics on asset pricing, thus, have a lot in common with linear asset pricing models. The basic idea behind the methods states that in the long run households should be indifferent to owning or renting a home as the market forces should equate the annual cost of homeownership to the annual rental expenses. Thus, the equilibrium price-to-rent ratios calculated using this method are compared with the actual price-to-rent ratios. In cases where the actual ratio is higher than the one suggested by the imputed rents, housing prices can be considered stretched and vice versa.

Findings and implications. It is shown in this thesis that the proposed framework is able to identify whether housing prices in the Baltics are below, inline or above the levels justified by the fundamentals. Using the framework, one would be able to tell a plausible and consistent story of the residential real estate developments in all three of the Baltic countries. For example, robustness checks show that the framework would have signalled overheating in the housing markets of the Baltic States as early as in 2005.

The approach developed in this thesis could be used in practice for macroprudential oversight purposes (e.g. evaluating if the systemic risk is building up in residential real estate sector). The estimates show that at the end of the sample housing prices in the Baltic states were still below the fundamentals, therefore, no immediate policy action was needed. However, since the fundamentals are affected by the low interest rate environment, they might readjust once the monetary policy starts to normalise. Therefore, the housing markets in the Baltic States deserves close monitoring.

Structure. The rest of the thesis is structured as follows. The next section reviews the literature on why residential real estate requires special attention and on the approaches used in this thesis. The section after that discusses the methods used in the thesis. The forth section describes the data used for estimations, while the next section provides the calculations and results. Final section concludes.

2. Literature review

2.1. What makes residential real estate a special kind of an asset

It is important to understand that residential real estate differs from financial assets considerably and that these differences require to keep certain things in mind when adopting asset pricing techniques. Therefore, this part of the thesis aims to cover important features of housing assets and housing markets. It is important to draw attention to the fact that residential real estate does not belong to the class of ordinary financial assets even though it is sometimes wrongfully considered as such (e.g. brokers often suggest buying housing assets for investment purposes).

If one wanted to apply asset pricing theory for determining residential real estate prices without any modifications, housing assets would have to possess properties that are inherent to financial assets. However, as detailed by Davis and Nieuwerburgh (2014), the differences appear at least in the following areas: housing trades happen infrequently, they are subject to large frictions and large transaction costs; the dividends that housing provides are mostly of non-pecuniary nature and hard to quantify, i.e. housing services; the government interferes significantly in the housing market; compared to other assets held by households, residential real estate tends to be of the largest value. These features alone are sufficient to plausibly assume that the usual asset pricing techniques for determining housing prices will not work as intended. However, the list of differences does not stop there, thus, is explored below in more detail.

Large search frictions and large transaction costs arise due to the fact that housing assets are extremely heterogeneous, so, in contrast to, for example, bonds where each unit of the asset from the same issue is identical, each unit of housing is unique. Therefore, the household must invest time in order to find a structure that suits its needs. 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 (e.g. city centres), the more expensive it is. However, even two flats in the same apartment building will differ at least slightly in their intrinsic value due to the differences in storeys or different views through the window. Moreover, housing structures are characterized by many qualitative properties such as the type of the heating system that, if different, can lead to enormous differences in value of otherwise rather similar objects. Such 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.

The infrequent transactions of housing assets could at least partly be explained by barriers to use such assets for emergency liquidity because in most situations they 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.

The low frequency of housing transactions could be explained by housing markets being decentralized. Because of this selling residential real estate quickly under normal circumstances is impossible. The fact that there exists no central establishment for exchanging residential real estate contributes further to the difficulties in discovering a spot price of housing assets, large search frictions and large transaction costs.

The above mentioned features of housing assets and housing markets render the short-selling of residential real estate impossible. Short-selling, e.g. ability to borrow an asset to sell it with an expectation that it could be bought back at a lower price in the future, is crucial for prices of any asset to stay balanced. It is hard to imagine a situation where one lends his or her house to an investor for selling it on a promise of getting it back. Inability to short-sell an asset limits the probability that the expectations of price decline will form (even though the fundamentals would warrant that). Therefore, buying a house is often viewed as a good financial investment.

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 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, getting proxies for owner occupied housing is a lot more difficult.

Also because housing by definition must have a physical form, as other kinds of physical capital, it inevitably depreciates. Harding et al. (2007) estimates that without maintenance the value of a house would decrease by 2.5 percent annually. To avoid losing value, housing assets require constant investment that in most cases equals the amount of depreciation. Furthermore, the depreciation could happen not only due to physical reasons but also due functional (e.g. facilities get too outdated for the current day needs, for example, by having no access to the Internet) and economic aspects (e.g. the neighbourhood in which the building is located might lose its prestige due to increasing crime rates in the area). In contrast, no maintenance is needed for conventional forms of holding wealth (e.g. bank deposits or bonds). For most financial assets the only cost of holding them is the administrative fees paid to the service facilitator (e.g. a commercial bank).

In some cases, what sets the housing assets apart from financial assets does not affect the valuation of residential real estate directly but have effects on the housing market through various links to other sectors and feedback loops from the macroeconomy. For example, owning or not owning a home affects household's portfolio and consumption choices. Typically, households accumulate wealth when they are young and decumulate it later in life. In addition, Banks et al. (2015) show that because of housing price volatility households' that plan to move up the housing ladder should own their first home at a younger age. Nevertheless, Davis and Nieuwerburgh (2014) document that households do not reduce their housing wealth even late in life while Nakajima and Telyukova (2013) 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 percent for 65 year olds to about 50 percent for 90 year olds while at the same time financial assets are almost completely depleted (these numbers are based on the US data but the researchers find similar figures for other high-income countries as well). All this suggests that the tendency to own a home affects the structure of the housing market. Since the homeownership rates vary across countries, estimation techniques cannot be extrapolated blindly from one country to another and have to be calibrated carefully for each individual housing market.

This point is further strengthened by how different housing market structures vary in their sensitivity to the interest rate variability. Since a large part of home purchases (especially for first-time buyers) are carried out with at least some external financing, i.e. by borrowing from a financial intermediary, decision to own a home exposes households to interest rate shocks. In fact, Agarwal et al. (2015) argue that one of the main channels how low interest rates set by the monetary policy makers spur the economy is through encouraging mortgage refinancing. However, if the adjustable interest-rate mortgages are dominant, when the monetary policy gets stricter, households might find themselves unable to meet their liabilities. If a significant number of indebted households opts to sell their property because of this, it could produce a fall in housing prices due to the oversupply on the market. Thus, while the mortgage interest rates are viewed as a fundamental factor in determining housing prices, it has to be kept in mind that it plays a different role in different housing markets.

The episodes of large housing price increases can affect the labour market in surprising ways that have repercussions even in the medium term. Charles et al. (2015) show that housing booms provide job opportunities for younger people. Most of those opportunities, however, are in the construction sector and do not require knowledge intensive skills. Thus, by providing employment opportunities housing bubbles simultaneously increase the opportunity cost of attending a college or a university. Consequently, college enrolment rates decrease and lead to a lesser human capital accumulation which reduces the growth rate of the economy in the medium term. While this does not affect the pricing of residential real estate directly, a bust from a pronounced housing boom might be followed by a more difficult recovery. In comparison with a milder one, housing prices would, arguably, find it more difficult to bounce back because a larger share of households would face income problems due to the lack of sellable skills on the labour market.

Housing assets are also the most important component of households' wealth (Granziera and Kozicki, 2015). Because of that, changes in residential real estate value affect household wealth, expenditure decisions, financial sector and, consequently, real economy. For example, a large fall in house prices can lead to households perceiving their wealth as smaller. This, as documented by

Berger et al. (2015), because of the negative wealth effect (see, e.g., Lettau and Ludvigson, 2004, for an explanation of the wealth effect), can result in reduced consumption.

A house or an apartment is basically the only asset that a household could use as collateral to borrow against. Because of this reason housing plays a major role in consumption smoothing. As shown by Hryshko et al. (2010), if the residential real estate prices are increasing, in light of negative income shocks home equity is used to maintain consumption at the usual levels. Moreover, if housing prices are rising, households might opt to extract equity by increasing their mortgages. Therefore, it is reasonable to expect that being good collateral increases the worthiness of housing assets. However, it has to be kept in mind that if households are in a highly leveraged position this property might lose some of its relevance.

On the other hand, the fall in collateral value that can be obtained in case of borrower's bankruptcy increases the risk of mortgage lending. In extreme cases, this can result in large losses throughout the banking system and lead to a financial crisis (such as the one in the Baltic States in 2008–2009). Rutkauskas et al. (2015) using Household Financial Monitoring Information System compiled by the Bank of Lithuania (Lietuvos bankas) stress tested Lithuanian households with a residential real estate price shock (along with three other shocks) and show that a fall in housing prices during a financial crisis would exacerbate possible losses to the banking system significantly as compared to no fall in housing prices. In addition, Fuster and Zafar (2014) show that when the financing conditions worsens (as such is the case during financial crises), a feedback loop forms as the housing demand plummets. Thus, residential real estate can have huge effects on financial stability and, when coinciding with other types of unravelling of imbalances, increase the severity of a crisis: Reinhart and Rogoff (2009) document that financial crises that coincide with a housing market bust are deeper and longer than those with no imbalances in real estate sector, while Persaud (2016) shows that such crises are a rather common phenomenon.

The importance of housing to financial stability makes this asset class special in terms of policy focus. As noted by Cerutti et al. (2015), on the one hand, policies that increase access to housing through supporting mortgage borrowing are desirable because of the social aspects of the matter. On the other hand, larger loan-to-value ratios, longer loan maturities and more generous fiscal incentives (such as tax deductibility) are associated with excessively rapid house price movements during housing booms and worse outcomes in the aftermaths of such booms. Therefore, fiscal policies that try increase the homeownership rate might clash with the macroprudential policies that try to contain financial stability risks.

Of course there exist a lot more interesting features of housing assets and housing markets than were covered in this section. However, for the purpose of this thesis those mentioned above are enough to show the importance of housing markets in the economy and to settle that using traditional asset valuation methods used in financial economics may be misleading. Before turning to specific housing valuation techniques, the next section settles what a fair price is when it comes to residential real estate assets.

2.2. The fundamental price

The term "fundamental price" (also known as "the intrinsic value" or "the equilibrium value") is used to refer to the "true" price of an asset that takes into account all the tangible and intangible factors about the asset. This price is determined through various analytical techniques without any reference to the market value of the asset. The notion is perhaps most commonly used for analysing security markets where investors try to estimate which investments exceed their current market values.

As noted by Hommes (2005) and Staszkiewicz and Staszkiewicz (2015) among others, the fundamental price is completely determined by economic fundamentals and given by the discounted sum of expected future dividends. If everyone had symmetrical and perfect information on all the factors relevant for an asset, no one acting rationally would agree to trade it below or above the fundamental price. However, in reality the information buyers and sellers possess is far from symmetrical and by no means perfect (see, e.g., Baker et al., 2008, or Vissing-Jorgensen, 2003), thus, the market prices can depart considerably from their intrinsic values (see, e.g. Barberis et al., 2016, Summers, 1985, or Rozeff and Zaman, 1998). Nevertheless, such departures are not sustainable as sooner or later investors realise that the spot price does not reflect the fundamentals (see, e.g., Shiller, 2003, Malkiel, 2003, or Bracke, 2013).

Determining the intrinsic value of a financial asset is relatively straightforward. Since the dividends securities provide are pecuniary, the math behind the calculation of their discounted future cash streams can be worked out. For example, usual discounted cash flow techniques are considered to be able to approximate fundamental values rather well.

Defining what a fundamental price is and estimating it play a large role in determining asset price bubbles. While there is still no strict consensus on what should be considered an asset price bubble, episodes of prolonged departures from fundamental prices are often considered as such. Mayer (2011) reviewed literature on asset price bubbles and concluded that most authors attempt to determine whether a bubble exists by comparing actual house prices with what house prices should be based on a model of fundamentals. Therefore, phrases such as “not justified by fundamentals” are rather common in this field.

It has to be noted, that there are some who argue that market prices almost always incorporate all the relevant information, thus, equal fundamental prices (see, e.g., Malkiel and Fama, 1970, Malkiel, 2003, or Ball, 2009). This claim is grounded in the belief that markets are efficient, thus, there is no scope for arbitraging assets. This line of reasoning in principle makes sense in markets that are indeed close to being efficient due to high liquidity, frequent trades and centralised infrastructure for carrying out transactions (such as stock exchanges). However, it falls short in explaining residential real estate markets because of various inherent market features (see Section 2.1).

Consequently, determining the intrinsic value of a dwelling is more complicated than doing so for a conventional financial asset. Firstly, the dividends housing provides, as discussed in Section 2.1, are shelter. It is rather hard to quantify the benefits associated with housing services as they are not pecuniary. Secondly, as also outlined in Section 2.1, housing assets differ from usual financial assets in a lot of dimensions: they are extremely heterogeneous, indivisible and very rarely traded.

There are numerous reasons why in the short-run residential real estate prices could depart from their equilibrium values (see Cho, 1996). In fact, due to the specificities of housing assets prolonged periods of housing price misalignments are more characteristic to housing assets than to financial assets (Ambrose et al., 2013). Such events are usually associated with various imbalances in an economy (e.g., excess supply of credit, see ESRB, 2015), thus, the price correction that usually follows sends the financial sector to a period of distress and hurts the real economy. Given the importance of residential real estate markets to financial stability, the estimation of fundamental housing prices should be the first step in preventing unnecessary risk build-up in the sector. Therefore, the following three sections review various methods that could be used to determine fundamental housing prices.

2.3. Price-to-rent, price-to-income and other simple measures of housing price misalignments

Price-to-rent similarly as the price-earnings ratio for equity stocks, can potentially signal imbalances in the residential real estate market. The intuition is very simple: if the housing prices become too steep as compared to the rent prices, market participants will favour renting instead of buying, thus, decreasing the demand for house purchases and increasing the demand for rental apartments. This should cause an increase in the rental prices and a decrease in the selling prices that should put the market back in balance (see Krainer and Wei, 2004).

In the simplest form price-to-rent ratio is used as a purely empirical estimate of housing profitability, i.e. a ratio of price and rent time series. Such a ratio alone is not really able to tell anything about fundamental housing prices or price misalignments in the market. However, with sufficiently long time-series some patterns emerge: if there is such a thing as the equilibrium price-to-rent ratio, it is reasonable to expect that in the long run the time series of the ratio would tend to revert to mean which should approximately represent the equilibrium ratio (see Davis et al., 2008, or Chen, 1996). Thus, episodes when the actual ratio is above such average are associated with stretched valuations.

Price-to-income ratios operate through a similar mechanism but they are rough estimates of housing affordability. If the ratio is getting higher, housing is becoming less affordable, i.e., it shows that the income cannot keep up with the increasing property prices. If the prices get too steep, the demand for housing falls and puts pressure on the housing prices to decrease. Thus, this self-correcting mechanism should put the prices back in balance (see McCarthy and Peach, 2004).

Pure price-to-income ratios, similarly to price-to-rent ratios, do not say anything about fundamental housing prices. Based on the same line of reasoning as with the price-to-rent ratios above, when relatively long time series of such ratios are available, one can estimate the equilibrium level of price-to-rent ratio by simply taking an average of the sample. Episodes of price-to-income ratios being above said average are considered to be related to overvaluation in the market.

Price-to-rent and price-to-income ratios do not seem to have ever been calculated for the Baltic States. Therefore, this thesis relied on the research done in other countries. For example, Chen (1996) used price-to-rent ratio to see if residential real estate was overvalued in China and found that the housing assets were transacted above equilibrium values. In a more recent study, Fox and Tulip (2014) looked into Australian housing market with the focus on price-to-rent ratios but found no signs of a bubble as the housing prices were moving in line with the rents. Price-to-income ratio, for example, was used by Chung and Kim (2004) among two other indicators to examine housing price developments in South Korea. The authors found that the prices were above their equilibrium levels; however, not to a dramatic extent that would signal possible negative spillovers to other parts of the economy.

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 smoothing parameter (λ) values[2] (see, e.g., Agnello and Schuknecht, 2011, and European Commission, 2012). The intuition behind the method is fairly simple: healthy developments in the market should not deviate from a smooth trend, thus, departures from it (e.g. exponential growth episodes) might be a sign of imbalances in the market. Since this method does not take into account any additional information apart from house price dynamics, real house prices are used for calculations to eliminate the effects of variation in the general price level.

Just as price-to-income and price-to-rent ratios, Hodrick-Prescott filter has not been applied to measure housing price misalignments in the Baltic States. However, Hodrick-Prescott filter is rather commonly used to determine housing price booms. Goodhart and Hofmann (2008) considered a period as being a housing boom if the housing prices were above the smooth Hodrick-Prescott trend by more than 5 percent for two consecutive quarters. Agnello and Schuknecht (2011) took a similar approach but considered housing prices as booming if they were 10 percent or more above their Hodrick-Prescott trend.

One has to keep in mind, that the results from such ratios and other simple measures must be interpreted with care as they suffer from various limitations. Himmelberg et al. (2005) argue that price-to-rent and price-to-income ratios generally fail to reflect the state of housing costs (e.g. due to ignoring interest rates), thus, their deviations from historical averages might not be a sign of price misalignments. André (2010) suggest that highly regulated rental markets, and the fact that such ratios can be greatly affected by income distribution among house-

[2] Large smoothing parameter values are chosen because of the length of housing market cycle which is usually much longer than a business cycle (see Bracke, 2013).

holds and even the changes in average size of a household distort the interpretation of the ratios.

Similarly, estimates obtained using Hodrick-Prescott filter are almost completely atheoretical. This means that even when the results from this procedure indicate possible misalignments in a housing market, there is no way to know for certain that a departure from a smooth trend was not justified by fundamentals. For example, if housing prices are rising in response to large housing demand shocks (e.g. due to increased credit accessibility), actual real house price time series will likely deviate from a smooth trend pattern.

In addition, the available housing price and rent indices are comprised of different objects each quarter, thus cannot control for changes in quality. For example, if the popularity of higher quality housing increases in some quarter, such an index would show an increase in prices even though the prices for the types of dwellings that were sold in the previous quarter might not have changed. Furthermore, the price and the rent indices used in calculations (see Section 4.1) are calculated based on different samples, therefore an increase in price-to-rent ratio might simply reflect that owners choose higher quality housing as opposed to renters who opt for cheaper apartments and not an actual divergence between the rental and sale prices of homogenous dwellings. Indeed, as shown by Hill and Syed (2016), hedonic quality-adjustment reduces the price-to-rent ratio by on average 18 percent.

However, the results from the ratios and from the Hodrick-Prescott filter exercise still carry useful information. This is especially true, when they are used alongside other measures of price misalignments. Besides, they are easy to calculate, therefore, in order to check if further analysis is warranted estimating them first is often a good idea.

2.4. Using error correction models for determining equilibrium housing prices

In the most basic form there exists two ways of estimating fundamental housing prices. The first one relies more 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 relies more on empirical estimation of fundamental housing prices. Simply put, this method tries to find reasonable relationships in data that help determine the equilibrium level of housing prices. It potentially overcomes problems stemming from treating housing as an ordinary financial asset[3] and estimates price misalignments with greater accuracy: Fuster and Zafar (2014) show that user costs approach overestimates the importance of mortgage interest rates on housing demand while Hott and Monnin (2008) argue that fundamental price models significantly outperform models based only on the observed price dynamics.

Previous work on fundamental housing prices in the Baltics is rather limited: the countries have been analysed in this regard only as a part of larger panels in Stepanyan et al. (2010), Égert and Mihaljek (2007), Huynh-Olesen et al. (2013) and Ciarlone (2015). Stepanyan et al. (2010) estimate an error correction model for the former Soviet Union countries. Because the countries included in their analysis are structurally very different[4], they used pooled mean group estimator with the assumption of parameter homogeneity only in the equilibrium relationship. Their dataset ends with the third quarter of 2009 and, as far as the Baltics are concerned, housing prices in Latvia and Estonia are represented by the averages of housing prices in respective capitals (in addition, Latvian time series start only in the first quarter of 2005). While it can be argued that the capitals represent the housing price movements in those countries well enough, pooling them together with other former Soviet Union countries introduces a lot

[3] See, e.g., Davis and Nieuwerburgh (2014) and Glaeser and Nathanson (2015) as well as Section 2.1 for reviews on the differences between housing and ordinary financial assets.
[4] For example, some are members of the EU and are considered advanced economies by the IMF (2015), others have made little progress transforming their economies after the collapse of the Soviet Union.

of uncertainty. Because the Baltics are the only members of the pool with the European Union institutional set up, the forces driving equilibrium housing prices might differ from those in other countries in the sample.

Égert and Mihaljek (2007) analyse 8 transitional European countries along with 19 OECD countries in a mean group dynamic OLS panel. They show that in the former group housing prices are determined to a large extent by the variables that are most commonly considered as fundamentals for the developed economies. However, the study does not cover all of the Baltic States: Latvia is not included in the sample.

Huynh-Olesen et al. (2013) using stock-flow model by Meen (2010) as a theoretical benchmark for fundamentals in an unbalanced panel cointegration setting estimate equilibrium housing prices in Central, Eastern and South-eastern EU countries covering the period from 1999 to 2011. They show that prior to the financial crisis of 2007 residential real estate prices of the region rose above the levels warranted by macroeconomic fundamentals and undershot their equilibrium values after the correction that followed. Nevertheless, because of the unbalanced panel approach, the Baltic States are not covered for all the period under review.

Ciarlone (2015) investigates the characteristics of house price dynamics in 16 emerging economies from Asia and East Europe. All three of the Baltic States are included in the panel estimation that covers the period from 1995 to 2011 (the panel is not balanced and the Baltics have a few data gaps in the earlier periods). The author shows that housing markets rarely displayed dramatic signs of overvaluation: according to the results only in Latvia overvaluation reached 40 percent. Such finding is rather surprising at least from the perspective of the Baltic countries: one would expect that the situation was similar in Lithuania and Estonia.

Papers by Égert and Mihaljek (2007), Huynh-Olesen et al. (2013) and Ciarlone (2015) all found transition specific factors to be significant drivers of housing prices in emerging European economies. The examples of such factors include institutional development and remittances. While as of 2015 it could be argued that the institutions were fairly well developed in the Baltic countries, the income levels were still lagging behind those of higher-income OECD members, thus, remittances were still an important way to fund housing purchases.

With a different focus than fundamental housing price estimation, developments in the Baltics (as well as in the Central and Eastern European countries) were analysed by Leika and Valentinaitė (2007). They argued that large housing price increases in the region during 2004–2006 were a result of rapid credit expansion. While Leika and Valentinaitė (2007) did not estimate fundamental housing prices, they used simple panel regression to show that in the short-term changes in lending for house purchase, interest rates and income can explain almost half of the variation of housing prices.

To sum up, the literature focusing on the developments in the Baltic residential real estate markets is rather scant. The Baltic countries are only analysed as a part of larger panels, thus, specificities of these markets might get ignored. To properly answer if the imbalances in the Baltic housing markets could be identified early on, the countries should be analysed in detail.

2.5. Determining long-term housing prices with the linear asset pricing models

There are quite a few variants of the user cost of housing approach but they all share similar basic features: residential real estate is priced fairly if housing prices equal the expected value of discounted future benefits from owing a dwelling. In its modern form the method was popularized by Poterba (1984) drawing from the literature on financial asset pricing, thus, as noted by Glaeser and Nathanson (2015), user cost models are often referred to as linear asset pricing models.

The basic intuition behind all user cost models rests on inter-temporal no arbitrage condition: the value of owning a home must equal the benefits derived from owning today plus the present value of the asset in the future. Glaeser and Nathanson (2015) illustrates the relationship with a simple equation: $R_t + \frac{E(P_{t+1})}{1+r} = P_t$, where P_t reflects the price, R_t incorporates the benefits of owning and $\frac{1}{1+r}$ is a discount factor. In such case the fundamental value equals $E\left(\Sigma_{j=0}^{\infty}(1+r)^{-j}R_{t+j}\right)$. The benefits of owning (R_{t+j}) are usually associated with rental prices (see Himmelberg et al., 2005) or with the location of the structure (see Glaeser et al., 2014, and Head et al., 2014). Rents are argued to reflect the benefits of owning as they are set in the market between the renters who seek to buy shelter benefits and the landlords who seek to sell said benefits. Spatial properties of housing structures capture the benefits of owning because they are correlated with the amenities that go with the property in a particular area[5].

More recently, there have been attempts to augment the user cost of housing approach to better gauge the fundamental housing prices. Hott and Monnin (2008) propose two alternative models for deriving equilibrium residential real estate valuations. First, they calculated the fundamental house prices not only based on the current fundamentals, but also on their expected future values. Then the authors provide two interpretations on the imputed rents: the first one being that they are equal to actual rents (comparable to price-to-rent calculations), the second – that they are the result of market equilibrium between housing supply and demand. In the second interpretation Hott and Monnin (2008) use income as a measure for the demand for housing to calculate a fundamental value of imputed rents (comparable to price-to-income calculations). The authors find that house prices deviate for long periods and to a considerable degree from their estimated fundamental values; however, they apply their augmented model only for the US, the UK, Japan, Switzerland, and the Netherlands.

The user cost approach so far has not been applied to any of the Baltic States. Although European Commission (2012) analysed the prices of Estonian residential real estate among other countries, it excluded the country from user cost calculations. A prior and more comprehensive application of user cost approach on European data (however, without The Baltics) was performed by

[5] It has to be kept in mind, that because of such a large role of location, spatial properties of housing are more complex than just a representation of homeownership benefits. For example, Albouy and Zabek (2016) document that the relative value of dwelling locations can be a major factor in causing wealth inequality.

Hilbers et al. (2008). The authors rest on the framework suggested by Poterba (1984) and analyse the differences of house price movements in European countries. They clustered the countries by the pace of price growth into three groups and found that the price increases in the ones with the fastest price growth were largely driven by user costs.

The imputed rents method can also be employed to analyse the effects of taxation on residential real estate valuations. Poterba and Sinai (2008) use the user cost approach to show how taxing homeowners as landlords would affect the user cost of owner-occupied housing. Their estimation is fairly standard except in the treatment of the risk-adjusted cost of funds. While it is more common to use a loan-to-value weighted average of the mortgage interest rate and a return on an alternative asset for this task, the authors add risk premium component to the user cost calculation. This allows Poterba and Sinai (2008) to capture not only the risk-adjustment required for a housing loan, but also a premium for the refinancing and default options that are provided to the borrowers by the lenders.

Using time series from the US Blackley and Follain (1995) analyse the empirical linkage between the level of residential rents and the user cost of housing. Their results show that about 60 percent of an increase in user cost is transferred into higher rent. The authors also show that the adjustment process is slow: only about a third of the long-run effect is realized in a decade after a user cost shock. The reason for this is the higher volatility of user cost series than that of rent series.

The user costs approach was quite extensively employed to better understand the transformations in the US housing market between mid-1990s and 2006. Glaeser et al. (2010) revisited the standard user cost model in order to analyse the 53 percent increase in the real housing prices over the mentioned period. They showed that the predicted impact of interest rates on prices is much lower once the imputed rents approach is augmented with mean-reverting interest rates, mobility, prepayment, elastic housing supply and credit-constrained households. The authors argue that the low interest rates can explain only one fifth of the price increase in the period under review, while the bulk of the change can be explained by the changes in credit approval rates and increases in loan-to-value levels. Díaz and Luengo-Prado (2012) also try to explain the increase in homeownership rate over the same period using the user cost framework. The authors showed that the user costs did not increase during the years of price upsurge and concluded that this facilitated the observed homeownership pattern.

Quite often the estimates of the user cost of homeownership are used as an independent variable in larger models. For example, Capozza et al. (2002) in their study on what drives the real house price dynamics in large US metropolitan areas use the time series of imputed rents to improve the fit of long-run price equilibrium equation. McCarthy and Peach (2004) employ a similar approach to show that the house prices in the US during the period of mid-1990s–2004 were rising in line with fundamental such as household income and mortgage interest rates. Malpezzi and Wachter (2005), when analysing the role of expectations in real estate cycles, use the user cost of housing equation to support their message on the importance of the beliefs about future price changes.

Therefore, whatever the setting, the imputed rents method is most commonly used for deriving fundamental housing prices. Most of the research effort so far focused on the US: while there were attempts to apply the imputed rents method on European data, the Baltics have not received any attention despite large gyrations in their residential real estate markets. Thus, with the aim to fill this gap, in the next section this thesis describes the framework that will be used to derive the equilibrium housing prices in the Baltic countries.

3. Estimating equilibrium housing prices

3.1. Empirical modelling set-up

Reviewing literature is a good start for narrowing down possible variables for a regression. While a fixed list of variables that determine the equilibrium housing prices do not exist, literature analysis could reveal what variables are most commonly referred as housing price fundamentals. Borowiecki (2008) provides a review of such variables, while the following paragraphs discuss several studies that are relevant to this thesis.

To obtain reasonable results the fundamental variables have to be theoretically linked to the housing prices. Otherwise, it is hard to expect that the findings would not be coincidental. McQuinn and O'Reilly (2007) and Girouard et al. (2006) propose different theoretical DSGE models where housing prices are driven by increases in income. In addition to income, population dynamics, mortgage interest rates, activity in construction sector are also often used as fundamental housing price determinants. For example, Hott (2009), in his imputed rents model employs income, population, mortgage interest rates and construction sector activity variables, while Muellbauer (2012) in his supply and demand approach uses the stock of housing, income and after-tax interest rate for borrowing as factors driving equilibrium housing prices.

Leung (2014) show how a simple DSGE framework used for housing price analysis can produce reduced-form dynamics consistent with error-correction models, thus, the later are natural candidates for equilibrium housing price estimation. Studies in which the Baltic countries are included in larger panels use rather similar variables to those outlined above. Égert and Mihaljek (2007) include GDP per capita (as a proxy for income and wealth) and interest rates on the right-hand side with one of the following as an additional variable: credit, stock market, unemployment, population, labour force and wages. They also include some additional variables for transitional economies that represent institutional housing market improvements. Stepanyan et al. (2010) includes real GDP, remittances (as an additional proxy for income) and foreign direct investment (as a proxy for lending conditions in transitional economies because FDI in those countries mostly reflected bank borrowing abroad) as fundamentals in the long-term equation.

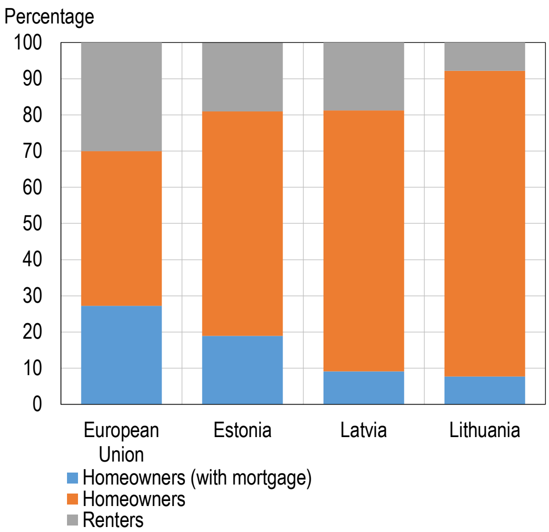
Empirical studies that analyse housing price developments in other countries tend to also choose similar variables to those discussed above. Gattini and Hiebert (2010) built a VECM model for euro area using housing investment, real disposable income per capita and interest rates as fundamentals. A similar approach was employed by European Commission (2012) and ECB (2011). Corradin and Fontana (2013) estimated a Markov-switching error correction model for thirteen European countries to examine house price deviations from their fundamentals. They used disposable income, long-term interest rates and unemployment as price determinants.

In short, income, some measure of housing supply (e.g. housing stock or construction costs), population, mortgage interest rates and mortgage credit are the variables that are most commonly referred as fundamentals in the literature (see Annex 1 for a more detailed list of literature on this matter). However, it is also important to note that fundamental housing values are greatly affected by other features of a residential real estate market 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 abler 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.

It is reasonable to expect that the housing market features outlined above are similar in the Baltics. 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). While Lithuania and Estonia had some form of partial mortgage interest tax deductibility prior the crisis, it has been phased out in Lithuania and reduced by 40 percent in Estonia from 2012 onwards. Real estate taxation in the Baltic countries remains one of the lowest in the EU (Bukevičiūtė and Kosicki, 2012). In addition, ECB (2005) document that the institutional characteristics of the Baltic banking sectors are very homogenous, i.e., the banking systems are concentrated and dominated by the Nordic banking groups.

Housing market structures in terms of the occupier type and rental market seem to also 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. 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 that followed the break-up of the Soviet Union as well as the general preference of owning to renting a residence.

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



Source: compiled by the author using Eurostat data.

Housing market similarities across the Baltic States suggest that modelling price dynamics is reasonable in a panel setting. Homogenous institutional arrangements and market structures warrant the assumption of parameter homogeneity. In addition, 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 time series 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), but usual time series issues have to be accounted for.

Based on the literature review, in this thesis equilibrium housing prices in the Baltics are estimated using household income, population dynamics, mortgage credit, mortgage interest rates and construction prices as fundamentals. 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. However, the structural demand and supply equations can be reduced to a single equation (see Wooldridge, 2002) that can be consistently estimated using even ordinary least squares[6]:

$$\begin{aligned} HPI_{it} = const + fixed_i &+ \underset{(+)}{\gamma_1} CCPI_{it} + \underset{(+)}{\gamma_2} INC_{it} + \underset{(+)}{\gamma_3} POP_{it} + \\ &+ \underset{(+)}{\gamma_4} CRED_{it} + \underset{(-)}{\gamma_5} R_{it} + \underset{(+)}{\gamma_6} REMIT_{it} + \varepsilon_{it} . \end{aligned} \tag{1}$$

The variables in Equation (1) are coded as follows. HPI denotes the indices of housing prices, $CCPI$ – construction input price indices, INC – GDP per capita (income), POP – population, $CRED$ – mortgage loan stock, R – real mortgage interest rates and $REMIT$ – remittances. All the time series except for the interest rates in the modelling exercise are used in logs (they are denoted with lowercase letters in the rest of the text). The thorough description of the data is provided in Section 4.1.

Pluses and minuses under parameters denote expected signs in the long-term relationship. Higher construction prices increase the costs of producing new residences, thus the demand for existing structures increases and pushes the prices up. Increases in income makes owning a house accessible for a bigger share of population, consequently increasing the demand and prices (the effect of remittances manifests through the same channel). Population increases also push the demand for housing up, thus, positively affect the prices. Credit growth increases demand for housing, thus, is positively associated with the changes in prices as well. Higher interest rates mean that credit accessibility deteriorates and dampens the demand for housing putting a negative pressure on residential real estate prices.

[6] It is possible that the error correction could occur not only through the housing prices, i.e. one or some of the right-hand side variables may not be exogenous. In order to avoid parameter biases associated with endogeneity in the explanatory variables, panel dynamic ordinary least squares are used in the section 5.2.

3.2. The user cost framework

Deriving user costs has at least several advantages over alternative methods for measuring housing price misalignments. For example, the comparison of price-to-rent ratios with their long-term averages, which is commonly used for gauging over- or under-valuation in the housing market, ignores the developments in the fundamentals such as interest rates. Consequently, an increase in such a ratio may not be a sign of over-valuation but could simply reflect an improvement in the fundamentals (e.g. easier financing conditions via decrease in interest rates). The user cost framework has a clearly defined linkage with the developments in the fundamental factors that affect the benefits of owning a house. In addition, the imputed rents approach does not require having long-time series that would be required for measuring fundamental housing prices with an error-correction model.

Costs associated with owning a house in addition to the purchasing price are dependent on the tax treatment of owner-occupied housing services, the availability of as well as access to collateralized credit. The insurance the property provides against rental price fluctuations and possible transaction costs also affect imputed rents. To account for all these features, this thesis follows Himmelberg et al. (2005) and defines the annual cost of owning a house as:

$$ACO_t = P_t r_t^{rf} + P_t \omega_t - P_t \tau_t (r_t^m + \omega_t) + P_t \delta_t - P_t g_{t+1} + P_t \gamma_t + \\ + P_t \nu_t, \tag{2}$$

where ACO is short for "annual cost of ownership", P_t – the price of housing, r_t^{rf} – the riskfree- interest rate, ω_t – property tax, τ_t – effective income tax, r_t^m – mortgage rate, δ_t – maintenance cost as a fraction of home value, g_{t+1} – expected house price growth, γ_t – risk premium for higher risk of owning versus renting, ν_t – transaction cost. The first term in equation (2) is the opportunity cost for owning a house, i.e. what a homeowner could have potentially earned if he or she had chosen to invest into safe assets instead of a house. The second term represents the one-year sum of property taxes related to the dwelling. The third term is the amount of income taxes that can be deducted because of mortgage interest-rate payments and property taxes. The fourth term represents the cost of maintaining a house so that it does not lose value. If the owner chooses to not incur such cost, it represents the value the home loses because of depreciation. The fifth term stands for expected capital gain or loss because of house price growth. The sixth term captures the additional risk premium to compensate homeowners for the higher risk of owning versus renting (such as fluctuations in the market value, unexpected maintenance expenses, possible mortgage interest rate increases). The last term is the transaction costs as a share of the value of a house.

Housing prices are at the equilibrium level if the annual cost of owning a house is equal to the annual cost of renting the same property. For example, when annual cost of owning a house decrease, but rent prices do not change, house prices are able to rise without deterring potential buyers from buying to renting. If the annual cost of owning a house increases but the rent prices do not change, house prices have to decrease for potential buyers to still prefer buying to renting. This mechanism assumes that there is no arbitrage possible and allows to equate the rent prices to the annual cost of ownership and get:

$$R_t = P_t r_t^{rf} + P_t \omega_t - P_t \tau_t (r_t^m + \omega_t) + P_t \delta_t - P_t g_{t+1} + P_t \gamma_t + P_t \nu_t, \qquad (3)$$

which can further be simplified by moving the price term in front of everything else on the right-hand side:

$$R_t = P_t \left(r_t^{rf} + \omega_t - \tau_t r_t^m - \tau_t \omega_t + \delta_t - g_{t+1} + \gamma_t + \nu_t \right). \qquad (4)$$

The terms in parenthesis in equation (4) are still the user costs of housing, but they are expressed in relative terms, i.e. per currency unit of house value. As noted by Himmelberg et al. (2005), expressing user costs in this way makes deriving equilibrium price-to-rent ratio easy, because it should simply be the inverse of the user cost. Dividing the both sides of equation (4) by P_t gives this result and allows us to objectively judge whether the fluctuations in the price-to-rent ratio are the reflection of the changes in the user costs or deviations from equilibrium (i.e. a sign of over- or undervaluation).

If the mortgage interest rate payment and the property tax cannot be deducted from the personal income tax, then equation (2) turns into:

$$ACO_t = P_t r_t^{rf} + P_t \omega_t + P_t r_t^m + P_t \delta_t - P_t g_{t+1} + P_t \gamma_t + P_t \nu_t, \tag{5}$$

because in this case the property tax and mortgage interest payment increase the user cost.

The imputed rents approach can be extended to take into account borrowing conditions other than mortgage interest rates. Haughwout et al. (2011) argue that the maximum allowed origination loan-to-value ratio and underwriting standards such as requirements for income documentation should be incorporated in the user cost framework. While quantifying the latter is complicated, adding loan-to-value transforms equation (2) into:

$$\begin{aligned} ACO_t = (1 - M_t) P_t r_t^{rf} + M_t P_t r_t^m + P_t \omega_t - P_t \tau_t (M_t r_t^m + \omega_t) + \\ + P_t \delta_t - P_t g_{t+1} + P_t \gamma_t + P_t \nu_t, \end{aligned} \tag{6}$$

where M_t represents loan-to-value ratio. Since the leveraged and unleveraged parts of a house has to be considered separately now, the first component represents the forgone return from home equity. For the leveraged part of the house ($M_t P_t$) the relevant discount rate is the mortgage rate (see Hott and Monnin, 2008). Tax deductibility component is modified accordingly to take account of house being partly financed by cash.

Of course, this framework can be applied only with several caveats due to its simplicity. First of all, it assumes that potential home buyers are perfectly rational. In real estate markets this is a very strong assumption to make, because we know from Glaeser (2013) that investors repeatedly neglect the supply response to rising prices. This leads to extrapolative expectations of housing price growth (see Barberis et al., 2016, for a detailed discussion). On top of that, Case and Shiller (2003) and Shiller (2007) point to the importance of psychological factors for housing price fluctuations. These authors define housing bubbles as situations in which excessive expectations of the public for future price increases cause prices to be temporarily elevated. Also, as Miller (1997) pointed out, efficient markets require the possibility of short-selling. It is near impossible to borrow a house and sell it with a promise to buy it back in a typical housing market (see Section 2.1). This considerably limits arbitraging housing markets and increase the possibility that prices will deviate from fundamentals (Shleifer and Vishny, 1997).

Search for housing is usually a lengthy process (see Section 2.1). Because houses are traded in decentralized markets, there is no benchmark price for a particular house (as opposed to stock prices in stock exchanges), thus, one has to invest time in determining the market value of a dwelling. Also because idiosyncratic features of the house have to be matched with the idiosyncratic tastes of the buyer, finding the right structure can take time. Thus, the lengthy process of buying a house hinders the self-correcting mechanism of user costs equating with the rent prices.

In addition, houses are extremely heterogeneous (see Section 2.1). There is no such thing as identical dwellings (as opposed, e.g., to two identical bonds), thus, the user costs for each housing unit differs. The differences of owner-occupied and rental structures complicate things even further. Glaeser and Gyourko (2008) documented that in 2005 64 percent of owner-occupied dwellings in the US were single-family detached whereas only 18 percent of such structures were among rental units. This means that opting to rent or to buy a house depends on more properties than the user costs approach implies (e.g. buyers are generally richer than renters and have differing preferences).

Moreover, due to small market size (see Figure 1 on page 29) the rental prices are more volatile than the sale prices. This could lead to situations where small changes in the rental market could be captured by the imputed rents approach as fundamental drivers of the prices while in reality they are not. Therefore, it has to be kept in mind while interpreting the results that decisions of developers to build are much more linked to the financial conditions in the market (e.g. the spread between the annual return of rental property from the government bond yields) than those of the households looking for housing services.

All of the mentioned features of housing markets that the user costs approach overlooks points to the no arbitrage condition being too strong. This means that the self-correcting mechanism that equates the rent prices to the user costs in reality might be much weaker than the theory suggests or might occur with considerable lag. Nevertheless, the framework can still be useful for understanding how an equilibrium level of house price-to-rent ratio develops over time and can supplement the information on house over- or undervaluation obtained from other approaches (e.g. error-correction models).

3.3. Price-to-rent, price-to-income ratios and Hodrick-Prescott filter exercise

Calculating price-to-rent, price-to-income ratios and estimating housing price misalignments using Hodrick-Prescott filter is much easier than completing exercises outlined in Section 3.1 and Section 3.2. While this simplicity brings in a lot of drawbacks (see Section 2.3), these methods are very useful for devising if further analysis is needed. This section presents how the simple statistical ratios and a smooth trend was used in this thesis for evaluating housing price departures from their equilibrium in the Baltic States.

The price-to-rent ratios in this thesis were calculated by dividing the values of house price indices at each point in time by corresponding values of the rent price indices. After this step, the average of these results were determined to represent the long-term average (the equilibrium ratio). The calculated ratios were indexed to the long-term average so that 100 would represent a value that equals the equilibrium value. This makes measuring deviations from the equilibrium rather easy as the difference from 100 of the actual value at each point in time is also the percentage deviation from the fundamental value.

The measure of affordability, i.e. the price-to-income ratio is used for measuring housing price misalignments in a similar fashion as the price-to-rent ratio. In terms of calculation the only difference lies in that the income time series (net average monthly wages) are used instead of the rent indices. Otherwise the same steps are taken as those outlined above: the house price time series are divided by the income time series and then indexed so that the long term average of these ratios would equal 100.

The measure of housing price over- or under-valuation using Hodrick-Prescott filter, on the other hand, is calculated using only the housing price time series. The series enter into calculations in real terms to account for general price level changes, i.e. the nominal housing price series were deflated by the harmonized consumer price indices. Since Hodrick-Prescott filter is notorious for its end-point bias (see, e.g., Ekinci et al., 2013) the one-sided version of the filter was used.

This means that the Hodrick-Prescott filter was applied recursively. In a way, such an approach simulates applying the filter in real time as the trend value for each data point is calculated with the sample that is restricted to end at that particular point in time. Bruchez (2003) showed that such modification to the filtering procedure reduces the end-point bias and has several advantages to the more common approach of adding ARIMA forecasts to the series before applying the filter, e.g., the quality of the results does not have to depend on the quality of the forecasts.

The usual choice for Hodrick-Prescott filter smoothing parameter (λ) when used on quarterly time series is 1 600. However, this value is designed to fit business cycles that are relatively short. Residential real estate cycles are much longer, thus, the value of smoothing parameter has to account for that. Based on Agnello and Schuknecht (2011), the value of 100 000 is used in this thesis for λ.

This choice implies that the trend component of residential real estate price time series is rather smooth and does not have sharp turning points. Deviations from the smooth trend can be considered as episodes of under- or over-valuation in the housing market. Just as with the price-to-rent and price-to-income ratios above, the deviations from the equilibrium is measured in percentages.

4. Data

4.1. Data used for empirical estimates of equilibrium housing prices

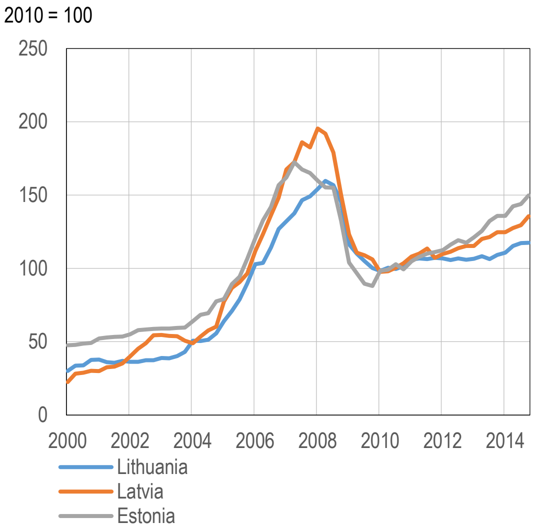
The main purpose of this section is to describe the data used for the empirical estimation of the equilibrium housing prices using error-correction models (Section 5.2). Data sources and various adjustments that had to be applied to the original data are also discussed. At the same time, the time series are represented in a visual form.

Data used for error correction models covers the period from the first quarter of 2000 to the fourth quarter of 2014. Time series of housing prices, 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 in some cases time series had to be interpolated or extrapolated.

House price indices were 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). Lithuanian time series were extrapolated using Real Property Cadastre and Register (Registrų centras) data. These time series are plotted in Figure 2.

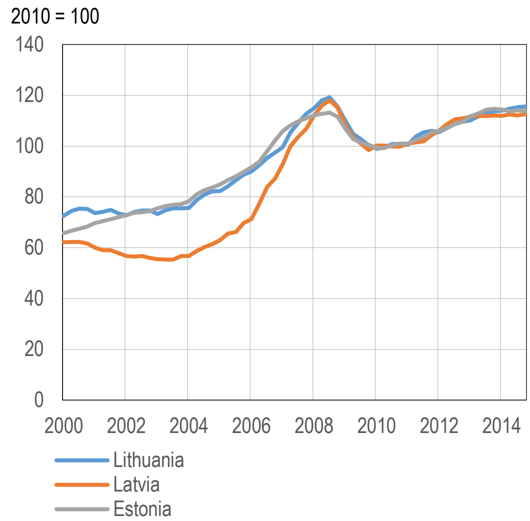
In general, housing prices in the Baltic States show a lot of co-movement. They were rising moderately before 2004, which is the year when these countries joined EU and exposed themselves to large capital inflows. After 2004, the prices started increasing rapidly and came to a halt around 2008 (they approximately tripled during this period). This coincided with the Global Financial Crisis that affected credit supply firmly. Therefore, housing became less accessible and the demand for it plummeted. Consequently, the residential real estate valuations lost their gains in all of the Baltic States adjusting back to the levels of 2006. The housing markets of the Baltic countries started recovering some time in 2010 and continued to do so up until the end of the sample. Estonian housing prices recovered the most from the trough (52.3%), Lithuanian the least (19.6%), while Latvian prices found themselves somewhere in between (38.9%).

Figure 2. Housing price indices



Source: author's calculations.

Figure 3. Construction input cost indices



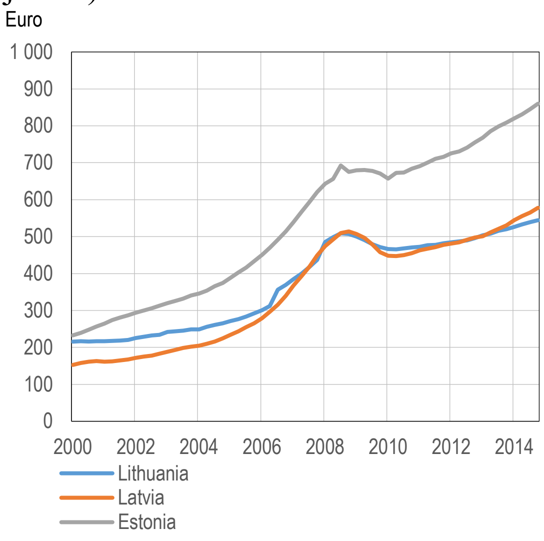
Source: author's calculations.

Time series on costs of construction inputs were available for all three countries at their respective national statistics agencies (see Figure 3). While the development of the construction input prices in the Baltics converged at the end of the sample, during the period of 2000–2004 there were some differences among countries. Estonian and Lithuanian construction input costs were increasing while Latvian prices were falling. Nevertheless, after 2004 Latvian prices started increasing much faster than in the other two countries and at the peak of the boom they have caught up with their peers. While the general pattern of construction input costs development was similar to that of the housing prices, in terms of volatility the costs of construction inputs moved more smoothly through time.

Average net monthly wages were used as the alternative income series (see Figure 4). Lithuanian and Estonian data was available from respective national statistics agencies for the whole timeframe covered in this thesis. 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[7]. As the wages tend to show a lot of seasonal movement, they were seasonally adjusted by the automatic X-13 procedure.

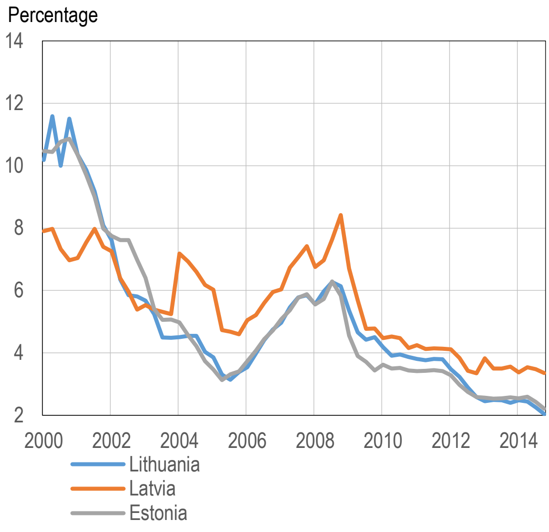
While the average net monthly wages were similar at the start of the sample in Estonia and Lithuania, Lithuanian wages did not manage to keep up and were trailing at the end of the sample. On the other hand, Latvian wages were the lowest at the start of the sample but managed to slightly overtake the wages in Lithuania. Despite these differences in levels and growth rates, the pattern average net monthly wages followed in the Baltic States was similar. They did decrease during the crisis; however, the growth seems to have been rather balanced, especially as compared to the growth pattern of the housing prices in the region. More volatile and increasing faster than the income residential real estate valuation is a sign that there were imbalances in the real estate market.

Figure 4. Net wages (seasonally adjusted)



Source: author's calculations.

Figure 5. Mortgage interest rates



Source: author's calculations.

Lithuanian interest rates on mortgages are taken from the Bank of Lithuania (Lietuvos bankas) database. For the periods before the adoption of common European currency, i.e. before 2015, the interest rates are calculated as the weighted average of interest rates for loans in litas and Euro using the sums of

[7] 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.

newly issued mortgage loans as weights. Since there is no data available on the currency composition of mortgage loans prior to October 2004, the weights for the period of 2000–2004 are assigned according to the currency composition of the last quarter of 2004: 0.21 for loans in litas, 0.79 for loans in euro. Data on Estonian mortgage interest rates are obtained from the Bank of Estonia (Eesti Pank) database. In Estonian case there is no need for arbitrary weights as the data on currency composition of housing loans is available for all the period under review. The time series of mortgage interest rates in Latvia are taken from the Bank of Latvia (Latvijas banka) database. However, since there is no data on the currency composition of newly issued loans, the weights are assigned according to the currency composition of the stock of mortgage loans. Since such data is available only starting from July 2003, the weights are held constant at the average level of the second half of 2003 for the earliest periods of the sample (0.43 for loans in lats, 0.57 for loans in foreign currencies). These series are plotted in Figure 5.

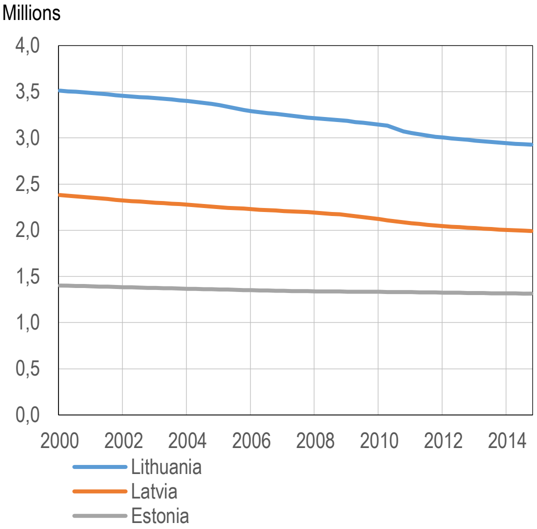
Starting with 1980s the interest rates globally were on a downward path (see Rachel and Smith, 2015). Mortgage interest rates in the Baltic States were no exception. Except for the period of 2005–2009 when the interest rates were increasing due to the monetary policy stance in Europe becoming less accommodative, the mortgage interest rates came down substantially in the Baltic States. They were the higher in Lithuania and Estonia at the start of the sample hovering around 11 percent than in Latvian where loans for house purchase were issued with the average of 8 percent annual interest rates. Throughout the sample the mortgage interest rate series followed similar pattern in all of the three countries; however, at the end of the sample they were the highest in Latvia at around 3.3 percent. Meanwhile, in Lithuania and Estonia loans for house purchase were associated with the average of 2.2 percent annual interest rates.

It is remarkable that for the half of the period when the housing prices were increasing rapidly (2004–2008) getting a housing loan was becoming more expensive. In theory, rising interest rates increases the costs of owning a house (see Section 2.5), thus, should discourage households from buying a house. However, it seems that the expectations of further house price increases were so strong that it fully compensated the increase in the homeownership costs.

Population time series were available fully for all three Baltic States at the respective national statistics agencies (see Figure 6). 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.

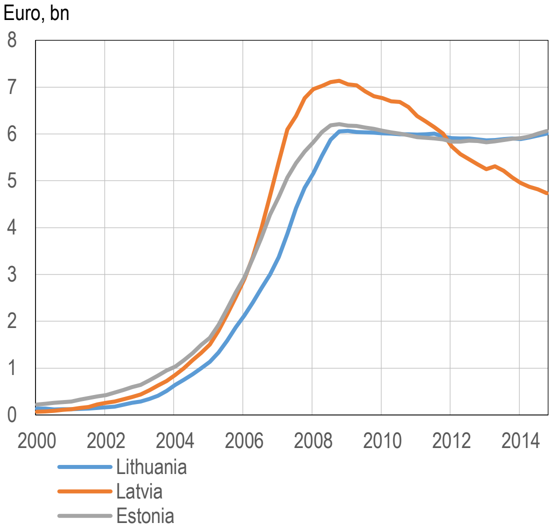
The population dynamics were very similar in all three Baltic States. Populations shrank over the sample, albeit somewhat faster in Lithuania than in Latvia and Estonia. This was both due to emigration to higher-income European countries and insufficient churn rate to keep the populations from shrinking (see Ainsaar, 2009). It has to be kept in mind that falling population numbers reduce the pressure on housing prices because the demand for housing crucially depend on the number of people that could potentially require a dwelling. On the other hand, modern lifestyle which is associated with higher number of individuals living alone (as opposed to living in couples or full families with children), rather low marriage rates and rather high divorce rates (see OECD, 2011) work to balance out the negative demand effects from the falling populations.

Figure 6. Population in the Baltics



Source: author's calculations.

Figure 7. Stocks of mortgage loans



Source: author's calculations.

Stocks of credit issued for house purchase in the Baltics were obtained from respective central banks but it was available from the first quarter of 2000 only for Estonia. Lithuanian data on mortgage portfolio was 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 to the current time series because of changes in what is considered a mortgage). These time series are plotted in Figure 7.

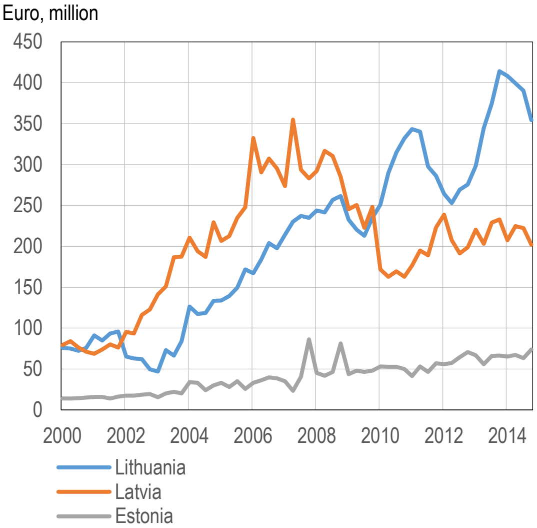
The mortgage credit grew rapidly in the Baltic States up until 2008. The slopes of the series in the mentioned period were similar in all three countries. From 2000 to 2008 the outstanding amount of mortgage debt grew more than 43 times in Lithuania, more than 105 times in Latvia and 27 times in Estonia. Of course, the economies and their income levels also grew over the same period thus the increase in the indebtedness level was not as dramatic. However, with the benefit of hindsight, we now know that this rapid expansion of credit was not sustainable and was one of the primary reasons why the housing markets in the Baltics boomed.

After the crisis hit the Baltic countries at the end of 2008, credit growth came to a halt. The households found themselves with stretched balance sheet, while commercial banks realised they had taken up too much risk. Consequently, the process of private sector deleveraging began. At the end of the sample it still was ongoing in Latvia, but there were some signs of recovery in Lithuania and Estonia. However, since the economies started to grow again in 2010, the actual indebtedness was still decreasing at the end of the sample.

Data on remittances (Figure 8) was obtained from respective central banks' databases. The time series on current transfers (secondary income) to other sectors than general government from Balance of Payments statistics were used. The time series were available in full for all three of the Baltic States, thus, no interpolation or extrapolation was necessary.

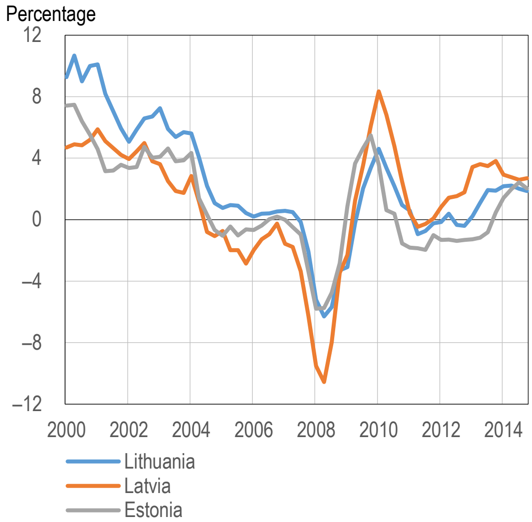
At the beginning of the sample the amount of remittances in Latvia and Lithuania was rather similar and significantly smaller in Estonia (this might be due to the size of economy being smaller). On average the remittances grew throughout the sample, but the dynamics in the Baltic States differed. The amount of money sent in from abroad grew rather steadily in Estonia while the time series in Lithuania and Latvia saw a couple of periods of slight decreases. However, at the end of the period the remittances were aligned in the order of the size of the economies: they were the largest in Lithuania, smallest in Estonia and laid in between in Latvia. Conceptually, remittances should manifest their influence on housing markets through the same channels as other types of income (e.g. average net monthly wages).

Figure 8. Remittances



Source: author's calculations.

Figure 9. Real interest rates



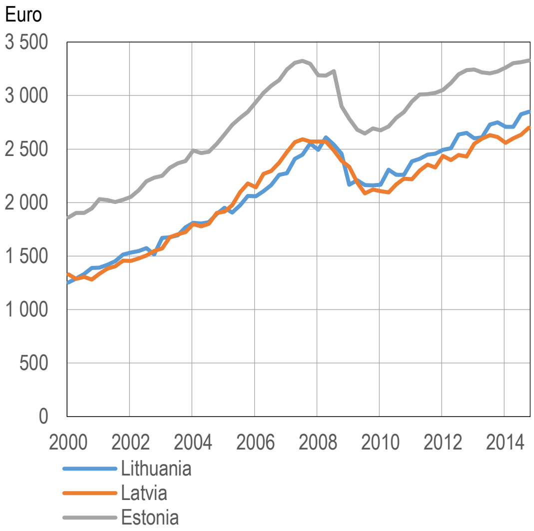
Source: author's calculations.

Real mortgage interest rates (Figure 9) are calculated as the difference between nominal mortgage interest rates (Figure 5) and the price inflation as measured by the annual change in harmonized consumer price indices taken from Eurostat. Arguably, this measure of mortgage interest rates is more relevant for estimation exercise. The reason behind this is that if the inflation rate is way higher than the interest rate than in real terms you are actually repaying less than you have borrowed.

Indeed, contrary to what was visible in Figure 5 (nominal mortgage interest rates), Figure 9 shows that real mortgage interest rates in the Baltics were not increasing at any time during the boom phase of the housing cycle (i.e. 2004–2008). In addition, real interest rates in Latvia, Estonia and Lithuania were at much more similar levels throughout the sample. This means that the nominal interest rate differences in the Baltic States might have been present only due to different levels of inflation. Since the inflation came down to very low levels after the Global Financial Crisis, there were basically no difference between the nominal mortgage interest rates and the real mortgage interest rates at the end of the sample.

Real GDP per capita time series were taken from Eurostat (see Figure 10). ESA 2010 national accounts classification was used. The data is available for all three Baltic countries beginning with 1995. Therefore, no extrapolation had to be done.

Figure 10. Real GDP per capita



Source: author's calculations.

The GDP per capita dynamics were very similar in all three of the Baltic countries. The income levels were higher in Estonia than in Latvia or Lithuania approximately by 15 percent. However, the pace of income growth or the extent of downward correction after the imbalances unravelled were basically the same in all three of the Baltic States. As compared to the dynamics of average net monthly wages, the GDP per capita time series are more volatile. This is probably due to the fact that the later measure also captures other types of income in the countries (including from the informal sector).

It is clearly visible from the charts above that there is indeed a lot of homogeneity among the Baltic countries in terms of housing price movements, i.e. 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.

4.2. Unit-root and cointegration tests of variables used in error-correction framework

If the time series described in Section 4.1 are to be used for the error-correction model estimation, they have to possess certain statistical properties. Firstly, they have to be integrated. Secondly, the order of which they are integrated has to be the same. Thirdly, they have to be cointegrated (i.e. share a common stochastic trend). This section runs various statistical tests in order to make sure that the mentioned properties are indeed present in the dataset.

A quick peek at the plots in Section 4.1 suggests that none of the time series under consideration is stationary: at very least they do not seem to have time-invariant means. Since it is close to impossible to determine the order of integration by visual inspection, such insights are better tested formally. Probably the most common approach to do so is by running augmented Dickey-Fuller (see Dickey and Fuller, 1979) or other so-called unit-root tests.

When dealing with the panel data, knowing whether times series of an individual cross sectional unit has a unit-root is not sufficient. When the dataset is treated as a panel, the whole panel has to have a unit root, because, in a way, corresponding time series of different cross sectional units are treated as different realizations of the same data generating process. The most commonly used panel data unit root tests are extensions of the augmented Dickey-Fuller test. The results of such tests for the levels of time series are provided in Table 1.

Table 1 summarizes the results from four panel unit root tests: the Levin–Lin–Chu test (Levin et al., 2002), the Im–Pesaran–Shin test (Im et al., 2003), the ADF–Fisher test (Maddala and Wu, 1999) and the PP–Fisher test (Choi, 2001). In all cases the null hypothesis assumes unit root process, but in case of the Levin–Lin–Chu test, a common unit root process is assumed whereas individual unit root processes are assumed under the other tests. The lag selection for autoregressive elements in the tests was performed according to modified Schwarz (1978) information criterion (resulted in lag order selection of either 1 or 2). Individual intercepts were assumed in all cases because visual data inspection revealed that the time series do vary at different levels in the Baltic States.

Table 1. Panel unit-root tests for the levels of the time series: individual intercepts, automatic lag selection based on modified Schwartz criterion (Zhang and Siegmund, 2007)

	hpi	ccpi	inc	pop	cred	R	remit
Levin et al. (2002)	−1.10 (0.134)	−1.293 (0.098)	−2.458 (0.007)	−1.415 (0.079)	−3.569 (0.000)	−0.432 (0.333)	−0.998 (0.159)
Im et al. (2003)	0.121 (0.548)	0.438 (0.669)	−0.646 (0.259)	1.519 (0.936)	−1.630 (0.051)	−1.328 (0.092)	0.228 (0.590)
Maddala and Wu (1999)	3.635 (0.726)	2.961 (0.814)	6.257 (0.395)	3.606 (0.730)	10.907 (0.091)	9.958 (0.126)	3.777 (0.707)
Choi (2001)	6.470 (0.373)	2.458 (0.873)	5.454 (0.487)	20.578 (0.002)	21.765 (0.001)	10.425 (0.108)	4.471 (0.613)

Source: author's calculations.

Notes: values are rounded to three digits after decimal point. Null hypothesis is unit root in all cases, p values are presented in parenthesis.

The table reveals that the null hypothesis of unit root cannot be rejected according to at least one test at the conventional significance level (0.05). In addition, with the exception of the stock of mortgage credit variable, the tests produce unanimous results. In case of the credit variable, only the Im–Pesaran–Shin and the ADF–Fisher tests do not offer to reject the null hypothesis. However, if we take the visual information from Section 4.1 into account, we can easily judge in favour of these two tests.

We can conclude the variables tested in Table 1 are integrated, but the tests performed only on the levels of the variables are not able to tell the order of integration as the first differences of variables could also be unit root processes. If the variables are stationary in their first differences, that would mean they are integrated of order 1. To find that out, Table 2 repeats the unit root test exercise with the first differences of the time series. This time no intercepts are assumed (since the first differences of the time series are tested), so the Im–Pesaran–Shin test is not run.

Table 2. Panel unit-root tests for the first differences of the time series: automatic lag selection based on modified Schwartz criterion (Zhang and Siegmund, 2007)

	Δhpi	Δccpi	Δinc	Δpop	Δcred	ΔR	Δremit
Levin et al. (2002)	−4.078 (0.000)	−3.563 (0.000)	−2.185 (0.015)	−1.737 (0.041)	−2.787 (0.003)	−7.411 (0.000)	−9.648 (0.000)
Maddala and Wu (1999)	23.356 (0.001)	19.170 (0.004)	13.234 (0.040)	8.068 (0.233)	14.911 (0.021)	60.167 (0.000)	241.484 (0.000)
Choi (2001)	52.331 (0.000)	30.858 (0.000)	22.978 (0.001)	9.4890 (0.148)	10.397 (0.109)	60.993 (0.000)	430.334 (0.000)

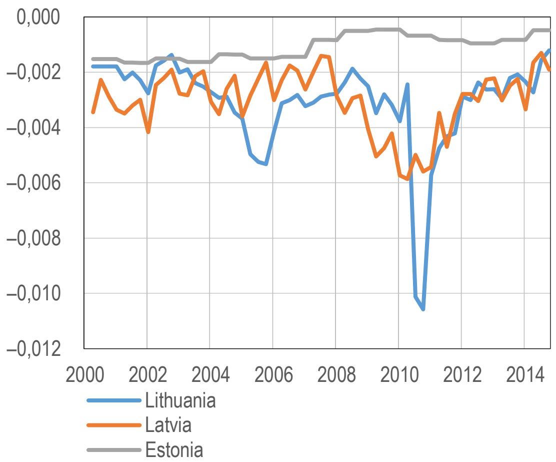
Source: author's calculations.

Notes: values are rounded to three digits after decimal point. Null hypothesis is unit root in all cases, p values are presented in parenthesis.

As can be seen from the table, at least one test rejects the null hypothesis of unit root process for all variables. The rejection is unanimous at 0.05 significance level in all cases but for the first differences of the population time series. For the latter the ADF–Fisher and PP–Fisher tests are not able to convincingly reject the null hypothesis of unit root process, though the Levin–Lin–Chu test does that.

It is well-known that unit root tests have arbitrary low power in finite samples (Cochrane, 1991), thus, such contradictions as with the first difference of the population time series above plague these test quite a lot. In these cases, researchers are forced to make judgments based on their experience and additional information available to them. However, there is no reason to believe that the first differences of the population series were non-stationary (see Figure 11).

Figure 11. First differences of the logarithms of the population time series



Source: author's calculations.

Visual inspection of the series reveals that the result of non-stationarity in some of the tests might stem from a couple of outliers in Lithuanian time series.

The data points in 2010 clearly stand out but they do not indicate actual shrinkage of the population. In 2010 a lot of people who had *de facto* emigrated from Lithuania but *de jure* had not been registered as not residing in the country had to declare the fact of emigration in order to avoid paying for health insurance (Milinis, 2010). These declarations affected the official statistics in the quarters that received the biggest number of declarations, however, the changes should have been distributed backwards to the quarters that correspond to moving out of Lithuania.

Having settled that the variables are integrated of the same order (namely – 1) it is important to check if they are cointegrated[8]. In other words, if the integrated variables are not governed by the same stochastic trend (or, simply put, do not show co-movement), then they cannot be analysed in an error-correction framework as the estimates would turn out spurious. In order to test for cointegration Johansen (1988) tests were performed. The results are summarized in Table 3 and Table 4. For the test the variables are run as a vector error-correction (VECM) system with 4 lags (to correspond to quarterly data and remove the serial correlation). The population time series were included in the system as an exogenous variable since it was not Granger (1969) caused by other variables.

Table 3. Johansen (1988) cointegration test (trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.294553	166.1710	95.75366	0.0000
At most 1 *	0.281484	108.5987	69.81889	0.0000
At most 2 *	0.202125	54.05510	47.85613	0.0117
At most 3	0.060127	16.79765	29.79707	0.6549
At most 4	0.029534	6.565977	15.49471	0.6286
At most 5	0.009767	1.619516	3.841466	0.2032

Source: author's calculations.

Notes: trace test indicates 3 cointegrating equations at the 0.05 level. "*" denotes rejection of the hypothesis at the 0.05 level. "**" MacKinnon et al. (1999) p values. Population time-series are used as exogenous variable since they were not Granger (1969) caused by other variables.

[8] In Section 5.2 the presence of cointegration is additionally tested by making sure that the speed of adjustment parameters are statistically significant and negative (i.e. that the equilibrium adjustment does occur).

Table 4. Johansen (1988) cointegration test (maximum eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigenvalue Statistic	0.05 Critical Value	Prob.**
None *	0.294553	57.57231	40.07757	0.0002
At most 1 *	0.281484	54.54360	33.87687	0.0001
At most 2 *	0.202125	37.25745	27.58434	0.0021
At most 3	0.060127	10.23168	21.13162	0.7226
At most 4	0.029534	4.946461	14.26460	0.7486
At most 5	0.009767	1.619516	3.841466	0.2032

Source: author's calculations.

Notes: max-eigenvalue test indicates 3 cointegrating equations at the 0.05 level. "*" denotes rejection of the hypothesis at the 0.05 level. "**" MacKinnon et al. (1999) p values. Population time-series are used as exogenous variable since they were not Granger (1969) caused by other variables.

At 0.05 significance level the trace test indicates that there should be 3 cointegrating relationships among the variables. That is, the test rejects the null hypotheses of zero, one and two equilibrium relationships but cannot do so for the case of three. This suggests that there could be up to three linear combinations of the variables that could define their equilibrium relationship.

The maximum eigenvalue test also indicates 3 cointegrating relationships at 0.05 significance level. As with the trace test, the null hypotheses of zero, one and two cointegrating relationships are rejected but the null of three is not. While this is not always the case, the trace and max eigenvalue tests agree on the number of cointegrating equations among the variables.

However, conventional Johansen (1988) test could be misleading because it was not designed for use with panel data. This issue did receive attention in literature and the test was tailored to better deal with the specificities associated to panel data. Therefore, as the next step two different tests are performed: the Kao (Engle–Granger based) test and the Fisher (Johansen based) test. They are summarized in Table 5 and Table 6.

First the Fisher (Johansen based) test is run which was proposed by Maddala and Wu (1999). The test is run without the population time series for the same reasons as in the tests outlined above (i.e. the populations in the Baltic States are not Granger caused by the other variables) and with the assumption of linear deterministic trend in the system (intercept in cointegrating equation and in VAR). Based on Schwarz (1978) criterion three lags were included for the test.

Table 5. Maddala and Wu (1999) Johansen based cointegration test

Hypothesized No. of CE(s)	Fisher Stat.** (from trace test)	Prob.	Fisher Stat.** (from max-eigenvalue test)	Prob.
None *	113.8	0.0000	47.43	0.0000
At most 1 *	75.08	0.0000	32.72	0.0000
At most 2 *	47.91	0.0000	31.34	0.0000
At most 3 *	22.28	0.0011	16.67	0.0106
At most 4	11.36	0.0780	11.34	0.0783
At most 5	6.474	0.3723	6.474	0.3723

Source: author's calculations.

Notes: max-eigenvalue and trace tests indicate 4 cointegrating equations at the 0.05 level. "*" denotes rejection of the hypothesis at the 0.05 level. "**" probabilities are computed using asymptotic Chi-square distribution. p values are based on MacKinnon et al. (1999).

As can be seen from the Table 5, the null hypotheses of no, at most one, at most two and at most three cointegrating relationships are rejected at the 0.05 significance level. Both types of tests, i.e. the trace test and the max-eigenvalue test, agree on such conclusion. However, the null of at most 4 cointegrating equations cannot be rejected neither by the trace nor the max-eigenvalue tests. While the conventional Johansen tests in Table 3 and Table 4 above offer different amount of equilibrium equations, the most important conclusion here is that the variables are cointegrated.

Since the alternative error correction equations that are run in Section 5.2 have different combinations of variables in them (based on parameter significance), it makes sense to run cointegration tests tailored to match the variable structure of a particular error correction model. Indeed, if variables taken together are cointegrated, the cointegration might seize to exist if the test is run with a different combination of variables.

For this purpose, a set of Kao Engle–Granger based tests are run and summarized in Table 6. Every test is run with the assumption of individual intercepts for each country. The lags for the ADF test equations were selected automatically based on Schwarz (1978) criterion.

Table 6. Kao (1999) Engle–Granger based cointegration test (cross-section specific intercepts, no deterministic trend)

	EC1	EC2	EC3	EC4	Alt. income	Alt. population	Alt. pop. and inc.
ADF t statistic	−3.949	−3.974	−4.094	−4.280	−3.138	−2.989	−3.145
p value	0.000	0.000	0.000	0.000	0.001	0.001	0.001

Source: author's calculations.

Notes: values are rounded to three digits after decimal point. Null hypothesis is no cointegration. ADF test equation lag is selected based on modified Schwartz criterion.

The first row of the table contains the names of the models that were estimated in Section 5.2. As can be seen from the table, the null hypothesis of no cointegration is rejected for all alternatives at the 0.05 significance level. This just affirms the results from previous tests.

To sum up, the variables that were selected for the error correction exercise are integrated of order 1. In addition, various tests suggest that they are cointegrated. All this makes the error correction approach a valid strategy for estimating the equilibrium housing prices in the Baltics.

4.3. Data used for the user cost estimation

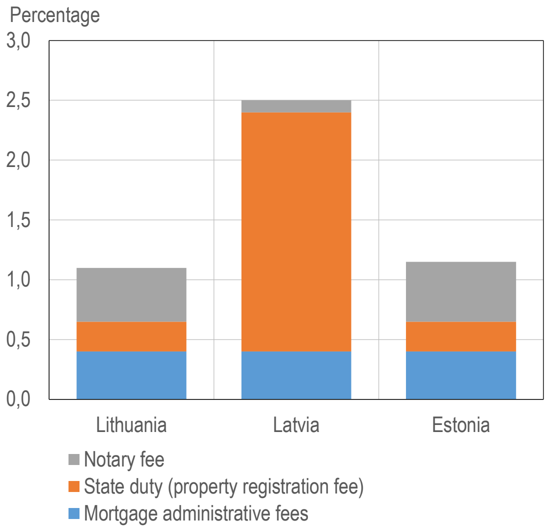
One of the reasons why user cost of housing approach has not been applied to the Baltic States so far is that the data is not easily available. For the purpose of estimating housing user cost in the Baltics it had to be collected from various sources such as real estate firms, official statistics agencies and central banks. The sample starts with the first quarter of 2000 and ends with the second quarter of 2015. This section describes the data collected, the manipulations applied to it and discusses the properties emerging from the time series.

The data on the mortgage interest rates in the Baltic countries were obtained from the respective central bank. This data is plotted and described in the Section 4.1. The series used for the user cost estimates are the same as the series used in the error correction exercise.

Based on the information available on major commercial banks' websites operating in the Baltic States, the costs associated with registering a mortgage and bank fees for mortgage administration are considered to be 0.4 percent of the transaction value. In addition to this transaction costs in Latvia are increased by 2.1 percentage points, i.e. 2 percent state duty for the purchase transaction plus 0.1 percent notary fee (European Law Firm, 2011). The notary fee in Lithuania amounts to 0.45 percent of transaction value, while the fee for the registration of purchase agreement varies depending on the transaction value in the range of 0.03–0.50 percent, thus, a rough average of 0.25 percent is considered for calculations (Global Property Guide, 2015). Estonian notary fees amount to

0.5 percent of transaction value, land registry fees add 0.25 percentage points (Valters Gencs, 2013). The fees outlined in the paragraph did not change significantly over the period under review in all of the Baltic countries and are plotted in Figure 12.

Figure 12. Costs associated with residential real estate transactions in the Baltic States



Source: author's calculations.

The maximum possible loan-to-value ratio was considered to be 1 if there had been no legal limit in place at the time. Therefore, the loan-to-value ratios are equal to 1 for the majority of the period under review in the Baltics[9]. The cap on the ratio in Lithuania was introduced in November 2011 at 0.85 (Lietuvos bankas, 2011). The limit in Estonia was introduced in the end of 2014 at the same level and came into effect in March 2015 (Eesti Pank, 2014). The 0.9 loan-to-value cap has been in place in Latvia since June 2007 (European Central Bank, 2014).

Latvian property tax is set at 0.4 percent starting from January 2014 (Ministry of Finance of the Republic of Latvia, 2015), prior to that residential real

[9] While it was indeed common practice to borrow up to 100 percent LTV in the years before the crisis (see, e.g. Annex 1 in Financial Stability Review 2014 by Lietuvos bankas), it does not mean that every borrower did so. It only reflects the possibility for almost everyone to outright buy real estate property without having to save for a down payment. However, a lower LTV ratio would not greatly affect the calculations as long as households have sufficient savings.

estate was not taxed. There is no real estate tax in Estonia. In Lithuania residential real estate is taxed only if its value exceeds approximately 289 thousand euro, thus, the vast majority of dwellings are tax-free and for the purpose of calculations in this thesis tax is considered to be 0.

Data on personal income tax is taken from Eurostat (2014). Income tax in Lithuania amounted to 15 percent starting from 2009. Prior to 2006 it was equal to 33 percent, to 27 percent from 2006 to 2007 and to 24 in 2008. Estonian income tax was set at 26 percent up until 2005. In 2005 it was reduced to 24 percent and continued to be reduced by 1 percentage point until it equalled 21 percent in 2008. The tax was reduced once more by 1 more percentage point in 2015. Personal income tax was stable in Latvia up until 2009 at 25 percent. In 2009 it was reduced to 23 percent only to be increased to 26 percent in 2010 and then reduced to 25 percent again in 2011. After that it was reduced two more times: to 24 percent in 2013 and 23 percent in 2015.

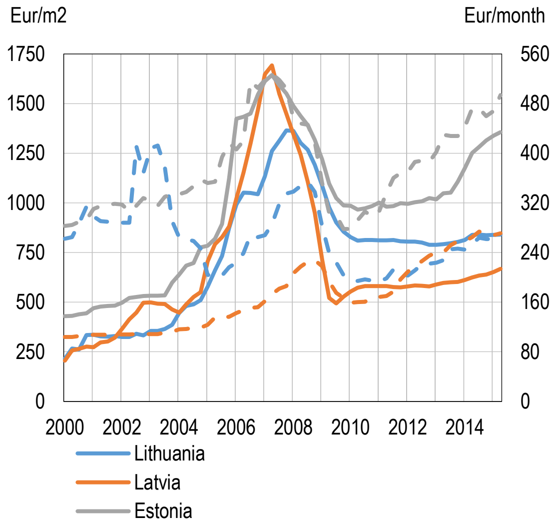
Following Harding et al. (2007) annual house depreciation rate is set at 2.5 percent for all the countries. Marjorie and Yamashita (2002) suggest that the risk premium for owning a house is around 2 percent. However, as noted by Sinai and Souleles (2005), renting is also risky and owning a house provides a hedge against it. Therefore, this thesis uses 1.8 percent as the risk premium for all three Baltic countries[10]. Expectations of annual capital gains from house price appreciation are set to 4 percent which roughly corresponds to 2 percent real annual appreciation above the 2 percent annual inflation (the ECB inflation target). This numbers are somewhat higher than the ones used in calculations for higher-income countries (e.g. Himmelberg et al., 2005, uses 3.8 percent for the US) because of the catching up process in the Baltics. It has to be noted, that household expectations regarding housing price growth may vary through time, but gauging that variation is a complex task that falls outside the scope of this thesis. A commonly used simple strategy to impose extrapolative expectations is not

[10] It is reasonable to expect that the risk component of owning a house varies through time (e.g. due to geopolitical tensions that increase the likelihood of expropriation). However, since the risk of owning a house is not the focus of this thesis and the events affecting this component are rather rare, it is assumed constant across the entire sample.

possible for the Baltic States since the sample is contaminated by a large price bubble which causes the calculations to yield unreasonable results (e.g. annual house price growth of 10 percent).

Rental and house prices for apartments in Lithuania are calculated using Ober-haus time series. Respective time series for Latvian dwellings are taken from Latio. However, in this case rental time series had to be extrapolated backwards in accordance to the actual rentals for housing from harmonized consumer price index due to the lack of data for periods earlier than March 2011. Estonian housing and rental price data is taken from kv.ee portal. However, the time series begin with January 2015, thus, rental prices were extrapolated backwards just as in Latvian case. Sale prices were extended back to August 2003 using the data available in the Estonian Land Board database and back to the beginning of the sample using the housing component from harmonized consumer price index. An apartment of 60 square meters is taken as a benchmark. For calculations in this thesis, however, the characteristics of the benchmark dwelling do not matter: in order to obtain a consistent price-to-rent multiple it is sufficient to use rental and selling prices of the same object. The residential real estate price and rent series are depicted in Figure 13.

Figure 13. Average house and rent prices in the Baltic countries



Source: author's calculations.
Note: dashed lines represent respective country's rent prices for a 60 m^2 apartment per month (right-hand axis).

As can be seen from the figure, the properties at the beginning of the sample cost roughly the same in all three of the Baltic States. During the boom their prices increased the most in Latvia and Estonia (from around 500 euro per square meter in 2004 to around 1 600 euro per square meter in 2007) while in Lithuania, albeit still sharp, the increase was somewhat smaller (from around 500 euro per square meter in 2004 to around 1 300 euro per square meter in 2008). The price adjustment after the crash was the largest in Latvia where prices went down to around 500 euro per square meter. Estonian prices readjusted to around 1 000 euro per square meter, while in Lithuania they stopped falling at around 800 euro per square meter. After that Lithuanian housing prices were more or less stable, in Latvia they increased to some 700 euro per square meter. Estonian housing prices recovered the most and were on average equal to around 1 300 euro per square meter at the end of the sample.

Rent prices in the Baltics followed somewhat "individual" paths. In Latvia and Estonia the patterns resembled those of the house prices; however, the volatility the rental prices experienced was considerably lower. For example, the rental price increase during the run up to the crisis was relatively small (as compared to the change in house prices) in Latvia, amounting to about 90 percent from 2004 to 2008. Consequently, the adjustment after the crisis was also smaller. Albeit at the higher levels, Estonian rental prices developed similarly.

In Lithuania, on the other hand, the fluctuations in the rental prices were somewhat different. For example, at the end of the sample rental prices in Lithuania were lower than at the beginning. In addition, the prices fluctuated a bit around 2003 when they increased to about 400 euro per month and readjusted back to 240 euro per month. Nevertheless, the dynamics of the rental price series during the boom and the subsequent crash periods were similar to those of the other two Baltic countries.

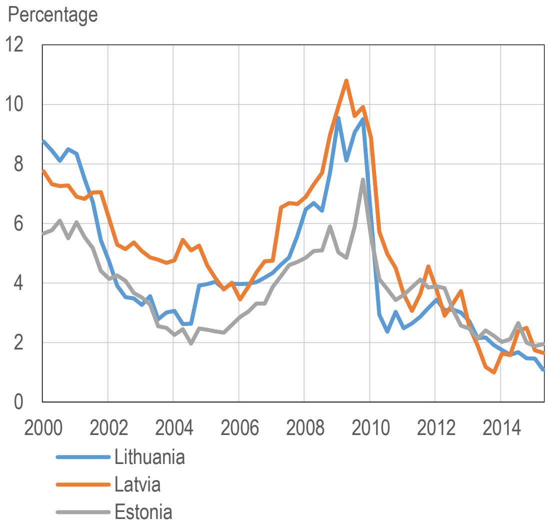
Since the financial markets in the Baltics are shallow and household investment behaviour is very conservative[11], it makes no sense to choose long-

[11] According to the data available at ECB, almost 6 percent of Euro area household financial wealth was

term government bond yields as a risk-free interest rate for household who are the principal buyers of residential real estate. In addition, average household wealth is relatively small so if deposited to a commercial bank it is covered under deposit guarantee scheme. Consequently, the return offered for the longest maturity deposits (in domestic currencies for the periods before euro adoption) is taken as a risk-free rate in the calculations in Section 5.3. The data is available at respective central bank databases and is plotted in Figure 14.

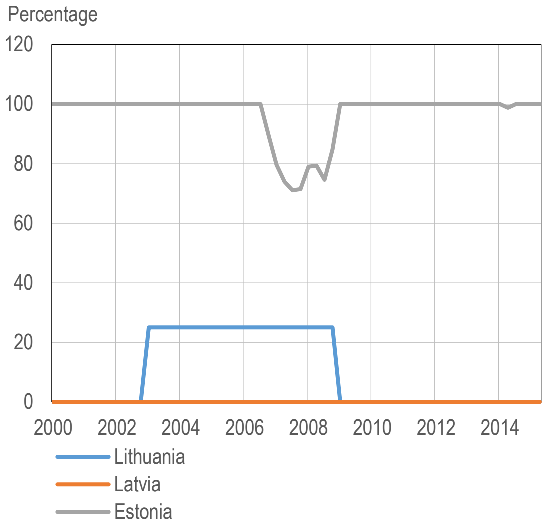
As can be seen in Figure 14, the interest rates paid out for depositors in the Baltic States were very similar. They also followed similar patterns. Deposit interest rates were decreasing at the beginning of the sample and started increasing around 2006. They peaked roughly at 10 percent during the crisis and came down soon after that to the lowest levels on record. At the end of the sample deposit interest rates were equal to some 1–2 percent.

Figure 14. Interest rates on deposits with term of over two years



Sources: Baltic central banks and author's calculations.

Figure 15. Mortgage interest rate deductibility



Source: author's calculations.

The time series of percentages of how much mortgage interest rates could have been deducted are plotted in Figure 15. Mortgage interest payments were deductible in Lithuania from 2003 (OECD, 2005) until 2009 but only 25 percent of the sum could have been deducted. In Estonia they still remain deductible:

accrued in debt securities at the end of the first quarter of 2014. The same figure for Latvia was just below 1 percent, completely negligible for Estonia (approximately 0) and 2.8 percent for Lithuania.

maximum of 1920 euro can be deducted since 2013 (Lindén and Gayer, 2012). The previous limit was equal to 3196 euro; however, in most cases even the lowered limit is sufficient for fully deducting interest rate expenses. For the periods when annual mortgage interest payment exceeds these limits, deductible amount was adjusted to equal the relevant limit. In Latvia mortgage interest rate payments were never deductible (European Commission, 2013; Cerutti et al., 2015).

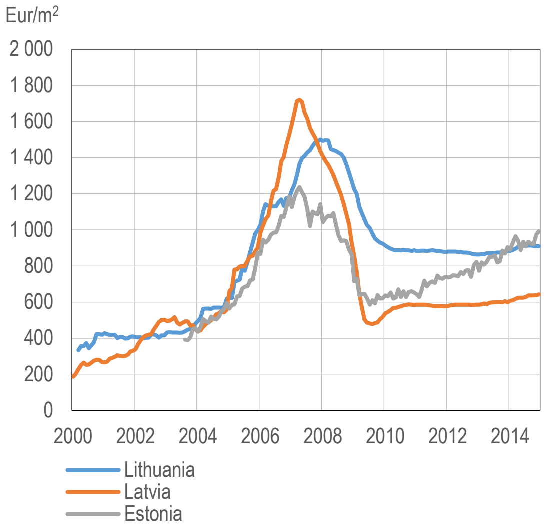
4.4. Data used for price-to-rent, price-to-income ratios and Hodrick-Prescott filter exercise

Monthly frequency time series that cover the period from January 2000 to December 2014 are used for the price-to-rent ratio calculations. This is motivated by the availability of such time series in the data sources that offer the data on rent prices. However, for calculations in the Section 5.4 the monthly estimates are averaged out at each quarter to translate them into quarterly time series.

Latvian house prices are taken from Latio (available at http://latio.lv/) – a Latvian real estate services company. Corresponding Lithuanian time series are taken from Ober-haus (available at http://www.ober-haus.lt/) – a real estate services company that focuses on the Baltic real estate markets. In Lithuania's case, data for the first two months of the sample is missing. Estonian Land Board data was used for housing prices (available at http://www.maaamet.ee). These time series are not extrapolated in any way, thus, the sample is shortened for Estonia to start in August 2003. For all three countries actual rentals from the harmonized consumer price index were used for rent prices. These time series are plotted in Figure 16 and Figure 17.

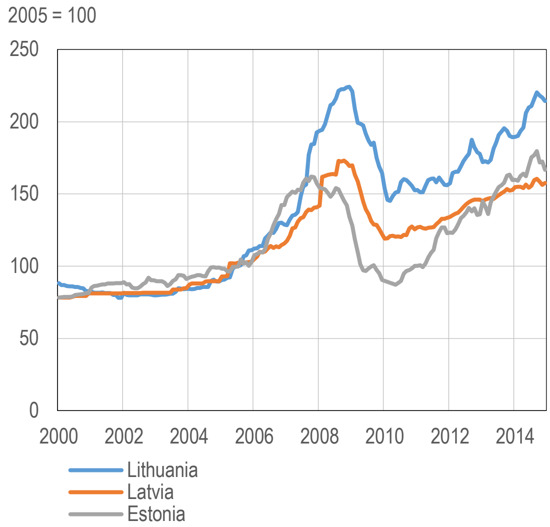
As can be seen in the figures, monthly housing price time series follow the same patterns that were described in Sections 4.1 and 4.3. They started to increase rapidly just after the accession to the European Union in 2004 and continued to do so up until 2007 in Latvia and Estonia and 2008 in Lithuania. Thereafter, the prices plummeted before beginning to recover some time in 2010. While the prices were at similar levels at the beginning of the sample, at the end of it they were at similar levels only in Lithuania and Estonia as Latvian housing prices were somewhat smaller.

Figure 16. Monthly house price indices in the Baltics



Sources: Latio, Ober-haus, Estonian Land Board and author's calculations.

Figure 17. Monthly residential real estate rent price indices in the Baltics



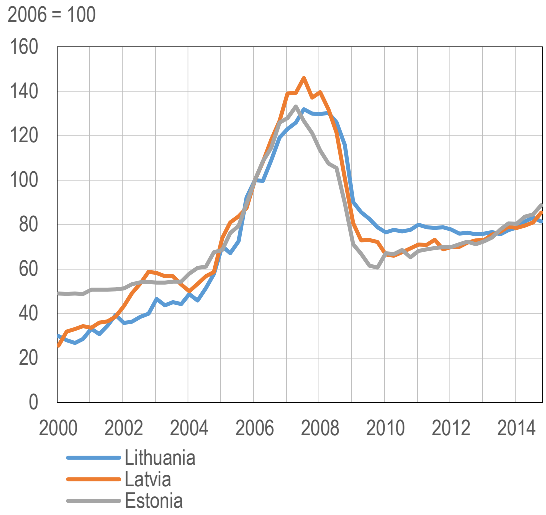
Sources: Eurostat and author's calculations.

As measured relatively to the prices of 2005 (because indices are used) monthly rent prices also started at similar levels. They were stable for a longer period than the housing prices, i.e. they started to pick up only in 2006. However, the behaviour of time series diverged after the date: the rental prices in Lithuania increased the most, in Estonia the least, while Latvian rental prices ended up in-between. After the correction, rental prices, just as the housing prices, started to recover in 2010. At the end of the sample Lithuanian rental prices were higher than the corresponding prices in other two Baltic countries (relative to 2005 prices).

Real residential real estate housing prices were used for Hodrick-Prescott exercise in this thesis. This means, that the housing time series described in Section 4.1 were deflated by the harmonized consumer price indices which are published by Eurostat. The time series are plotted in Figure 18.

As can be seen from the figure, real house price developments are much more homogenous than the ones in nominal terms. This just further strengthens the point that residential real estate markets in the Baltic States are similar. However, it also points out that different levels of inflation might mask the trends and make them spuriously seem overly heterogeneous.

Figure 18. Real house price indices in the Baltics



Sources: Eurostat and author's calculations.

In real terms the housing prices also saw the steepest increase start sometime in 2004. They were almost triple the value in 2007. The adjustment began soon after in Estonia, Lithuanian and Latvian real estate markets followed suit in 2008. The real house prices stopped falling in 2010 and started to recover. At the end of the sample they were increasing slightly. Since the inflation at the time came down to very low levels, the nominal price changes were almost equal to the real price changes.

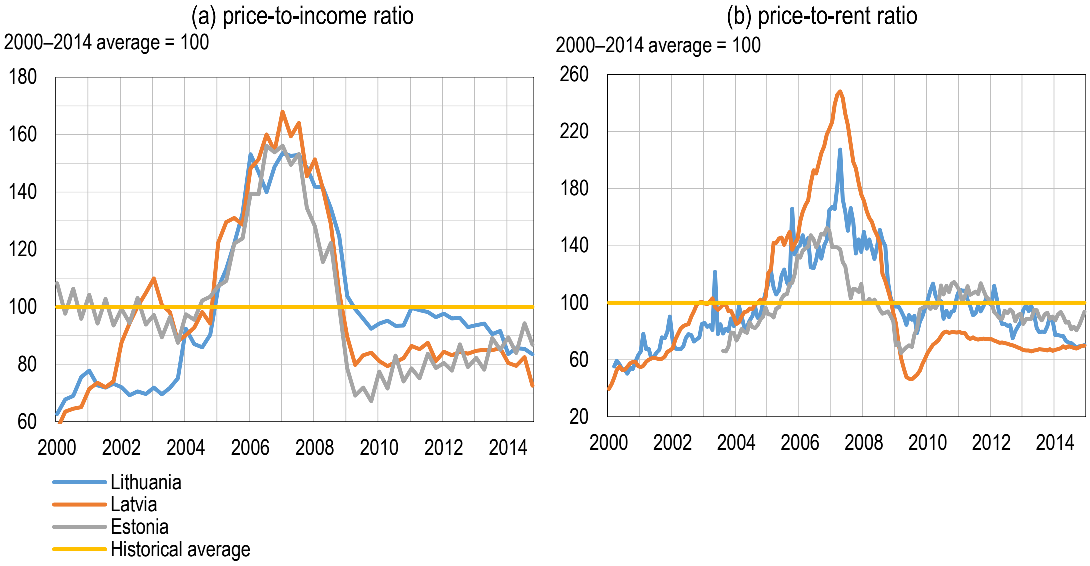
5. Calculations and results

5.1. Evidence from price-to-rent ratio, price-to-income ratio and Hodrick-Prescott filter

Before turning to modelling, statistical ratios such as price-to-income or price-to-rent can be computed to learn if there was indeed something out of ordinary going on in the housing markets in the Baltic States. While these ratios are fairly simple and suffer from various limitations (see Section 2.3), they could serve as valuable first indications of unsustainable housing price movements. If they are able to signal price misalignments, then a deeper analysis of the matter, such as error-correction model estimation, becomes reasonable.

Figure 19 plots price-to-income and price-to-rent ratios for the Baltic countries. These simple measures seem to signal overvaluation of the residential real estate during the years prior the financial crisis of 2008, i.e. the ratios were well above their historical averages[12]. According 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%.

Figure 19. Price-to-income and price-to-rent ratio indices in the Baltics



Sources: author's calculations based on Eurostat, Statistics Lithuania, UAB Ober-Haus, Estonian Land Board and Latio Real Estate data.

The deviations from the long-term average that the price-to-rent and price-to-income ratios register in the Baltic countries are very pronounced. The price-to-rent ratios were about 60%, while price-to-income ratios some 40–150%, higher than their long-term averages in the years prior the crisis of 2008–2009. The deviations of price-to-rent and price-to-income ratios from their long-term averages in other countries that also experienced boom and bust patterns in their property markets were lower (with few exceptions such as Spain and Ireland). For example, data gathered by The Economist (2015) show that such countries as the US, Japan (in the 90s), Belgium and Netherlands at the peak of the boom saw their price-to-rent ratios 40–45% above the long-term average.

So the developments in the Baltic countries' price-to-rent and price-to-income ratios raises a natural question whether those misalignments were justified.

[12] It has to be kept in mind that taking a smaller sample for the long-term average could potentially produce different conclusions. For countries that were undergoing large transitions such as the Baltic States it might be a problem, but Figure 19 does not indicate that this is the case (i.e. the ratios indeed do not depart too far from the average).

It must be noted that the ratios can be good determinants of the residential real estate over- or undervaluation only if these ratios are stationary. However, Caporale and Gil-Alana (2010) show that traditional unit root tests for such ratios suggest non-stationarity. This can occur because of the factors that affect equilibrium housing prices but are not included in the calculation of the ratios (e.g. changes in borrowing conditions), as well as various structural breaks (e.g. changes in rental market regulation). Visually time series in Figure 19 seem to be non-stationary, formal ADF tests support this insight (see Table 7). The reason for this is twofold: the time series are rather short and the deviations from the average seem to be relatively long-lasting; however, asymptotically the time series might still be mean-reverting.

Table 7. ADF test results for price-to-income and price-to-rent time series

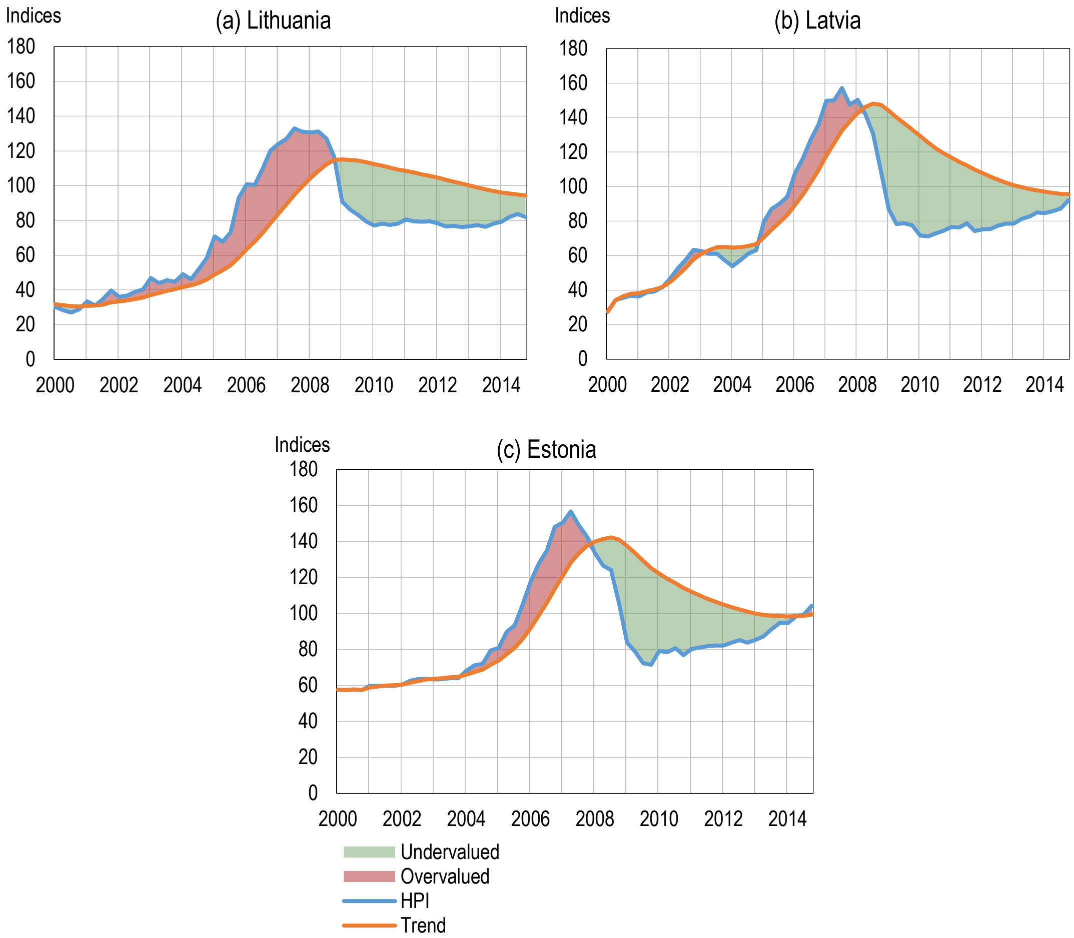
	Price-to-income	Price-to-rent
Lithuania	0.5573	0.3312
Latvia	0.1536	0.3854
Estonia	0.0320	0.3162

Source: authors calculations.
Note: table reports p values for ADF test with a constant and automatically selected lags (BIC criterion).

As discussed in Section 2.3, comparing price level data with the trend obtained using Hodrick-Prescott filter can also be used to evaluate housing price misalignments. To address the end-point problem of the Hodrick-Prescott filter a one-sided Hodrick-Prescott filter was used. Since analysing housing prices in nominal terms might be misleading (e.g. nominal price changes that are in line with the changes in the general price level might seem as unjustified appreciation, see Section 2.3), housing price indices used here were deflated by the consumer price indices of respective countries (i.e. real house prices were used).

As can be seen from Figure 20, this procedure suggests that at the end of the sample housing assets were undervalued in Lithuania but in line with fundamentals in Latvia and Estonia. These results should be interpreted carefully as the procedure is the most atheoretical and the deviations from smooth trend may not necessary be a sign of imbalances in the market. Hodrick-Prescott exercise incorporates even less information than the ratios discussed above, hence, it is even more prone to misjudge structural shifts.

Figure 20. Real housing price deviations from Hodrick-Prescott filter (one-sided) trend (λ = 100 000)[14]



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

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[13]: 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, they are unable to convincingly tell if the housing price developments were sustainable. Thus, there is need for a deeper analysis of the matter.

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[13] 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 look alarming. See Section 5.5 for the measures calculated on the restricted sample.

[14] 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.

5.2. Empirical estimates of equilibrium housing prices

This section turns to estimating the equilibrium housing prices using a panel error-correction approach. Visually all of the variables seem to have unit-roots (see Section 4.1). Formal unit-root tests show that the times-series used in this thesis are integrated of order 1 (see Section 4.2). Hence, in the equilibrium regressions they are used in log levels (except for interest rates which are used just in levels) and tested for cointegration: the results show that the series are indeed cointegrated (see Section 4.2). The full sample is used for the calculation, i.e. the period of 2000–2014.

The tests show that the cointegration rank is at least of order 3, thus, the interplay between variables at the equilibrium is somewhat complicated. However, since this thesis is interested only in the equilibrium of housing prices and their adjustment process, it focuses only on the error-correction equations that have housing prices on the left-hand side. Several regressions are estimated using panel dynamic least squares estimator that accounts for possible endogeneity between variables (e.g. some of the explanatory variables, such as credit, may be endogenous, see Hofmann, 2004, or Anundsen and Jansen, 2013) and serial correlation in the residuals that could pop up in the ordinary least squares setup. The equations are summarized in the Table 8 below.

Table 8. Long-term relationships between housing prices and their fundamentals in the Baltic States

	EC1 hpi	EC2 hpi	EC3 hpi	EC4 hpi
$ccpi$	0.425289 * (0.179951)	0.451050 ** (0.173850)	0.418507 ** (0.175688)	0.575814 ** (0.185899)
inc	1.486337 ** (0.312695)	1.450032 ** (0.305929)	1.679478 ** (0.266879)	2.340452 ** (0.205139)
R	−0.011269 (0.007494)	−0.010824 (0.007461)	− (−)	− (−)
pop	2.870274 ** (0.782591)	2.871443 ** (0.783770)	3.514667 ** (0.658660)	3.373430 ** (0.719890)
$cred$	0.139225 ** (0.043505)	0.128342 ** (0.038674)	0.135824 ** (0.039060)	− (−)
$remit$	−0.038258 (0.070439)	− (−)	− (−)	− (−)
SoA	−0.090549 * (0.043371)	−0.086816 * (0.043294)	−0.103705 * (0.042188)	−0.108312 * (0.037971)

Source: author's calculations.

Notes: standard errors of the parameters are presented in parenthesis. Stars indicate statistical significance as follows: "**" – 99%, "*" – 95%. "SoA" is the speed of adjustment parameter (the parameter near the error correction term).

All the parameters get expected signs but the ones near real interest rates and remittances turn out to be statistically insignificant. The parameter near interest rates is most probably statistically insignificant because interest rate effects are captured by the changes in the stock of mortgage credit. Parameter near remittances turns out to be insignificant most likely because it represents only transitional effects that are in principal temporary, i.e. remittances contribute to the short-term developments in the real estate market but do not affect the long-term equilibrium[15].

The error correction terms that are obtained from the equations reported in Table 8 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 (or is positive), the adjustment does not happen. In other words, housing prices would not show a tendency to revert back to the equilibrium.

The row "SoA" reports speed of adjustment parameter values and their standard error values in the error-correction equations. The parameters are statistically significant at 95 percent confidence level in all the analysed cases. Because they all have a negative sign, the correction does happen, thus a long-term cointegrating relationship between the house prices and the selected explanatory variables exist (this is in addition to the evidence from tests in Section 4.2). 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 includes the least variables on the right-hand side ("EC4"). All else equal, the prices would revert back to the equilibrium values in approximately 9 quarters in this case. However, "EC3" has more statistically significant parameters, thus, should be preferred. In the latter case, all else equal, the prices adjust back to equilibrium in over 9

[15] It has to be noted that in the earlier versions of Kulikauskas (2015) (and subsequently Kulikauskas, 2016) on which this part of thesis is based more variations of time series (such as mortgage credit-to-GDP ratios and remittances per capita) were tried, but that did not change the results.

and a half quarters.

For additional robustness checks some of the specifications of long-term equilibrium are re-estimated using alternative time series. In particular, average monthly net wages are used instead of GDP per capita as the income variable and population aged between 25 and 44 years old is used instead of total population as the demographic variable (individuals in this age group are the most common home buyers, see, e.g., National Association of Realtors, 2015). The alternative specifications are reported only with the statistically significant parameters. The results are reported in the Table 9 below.

Table 9. Long-term specifications between house prices and their fundamentals in the Baltic States using alternative time series

	Alternative income hpi	Alternative population hpi	Alternative population and income hpi
$ccpi$	1.467700 ** (0.305864)	2.071763 ** (0.302269)	– (–)
inc	−0.761005 ** (0.223690)	−1.195139 ** (0.207553)	1.764212 ** (0.281319)
R	−0.024620 ** (0.006822)	– (–)	– (–)
pop	– (–)	0.979229 * (0.395040)	1.760796 ** (0.438313)
$cred$	0.304499 ** (0.043337)	0.341449 ** (0.043054)	0.161660 ** (0.041881)
$remit$	– (–)	0.240683 ** (0.073141)	– (–)
SoA	−0.021054 (0.6068)	−0.051090 (0.041294)	−0.133189 ** (0.037982)

Source: author's calculations.

Notes: standard errors of the parameters are presented in parenthesis. Stars indicate statistical significance as follows: "**" – 99%, "*" – 95%. "SoA" is the speed of adjustment parameter (the parameter near the error correction term).

The equation with the alternative income series gets an unexpected sign near the income parameter. Thus, the real GDP per capita series might be better able to capture income effects than the net wages (e.g. due to income from informal sector). In addition, the error correction does not occur in "Alternative income" and "Alternative population" models. On the other hand, in the model with both of the alternative time series, the error correction does happen. Importantly, the values of the parameters in this model changes little as compared to the models from Table 8, thus the results can be considered robust to model specification changes. As can be seen above, the messages that the models convey do not change when using alternative time series.

Misalignments from the equilibrium housing prices from panel regressions can be visually inspected using the estimation results from above. The series expressed as percentage deviations from the equilibrium values are plotted in Figure 21. In each case the long-term equilibrium value is considered to be the fitted value of a respective model's long-term equation (see Table 8). "ECM alternative" refers to the model with alternative income and population time series (see Table 9).

Figure 21. The estimated housing price deviations from equilibrium in the Baltics

Source: author's calculation.

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 equation disagree on the extent to which prices are above or below equilibrium, they all follow similar pattern. For all three countries the models were able to identify housing overvaluation before the subsequent market crashes in 2008–2009.

The models signal housing prices wandering above their long-term equilibrium values sometime in 2005 or 2006. Residential real estate was overvalued in Lithuania, Latvia and Estonia to the extent of about 10–20% at the peak of the boom. The largest price correction seems to have occurred in Estonia where housing prices briefly found themselves over 20% below fundamentally justified values. A somewhat milder correction occurred in Lithuania and Latvia with housing prices slipping about 10–15% below their long-term equilibrium values.

After 2009 the residential real estate prices recovered from being undervalued and there is some evidence that they overshoot the equilibrium in Latvia[16]. At the end of the sample the prices in Estonia were at their equilibrium values according to long-term equations from Table 8. In Latvia prices were slightly above the equilibrium, while in Lithuania the residential real estate was slightly undervalued.

5.3. Estimated user costs of housing

This section derives three alternative estimates of the costs associated with homeownership. The first one, which is considered a benchmark case, is based on equation (2) (page 31). This is the simplest approach and does not differentiate between the leveraged and unleveraged parts of home purchase. It proxies all opportunity costs through the risk-free interest rates.

The second estimate is based on equation (6) (page 33), i.e. it takes into account that the risk-free interest rate is the relevant discount rate only for the unleveraged part of the purchase, thus, for the leveraged part the mortgage interest rates are used[17]. This approach also increases the user costs in cases where

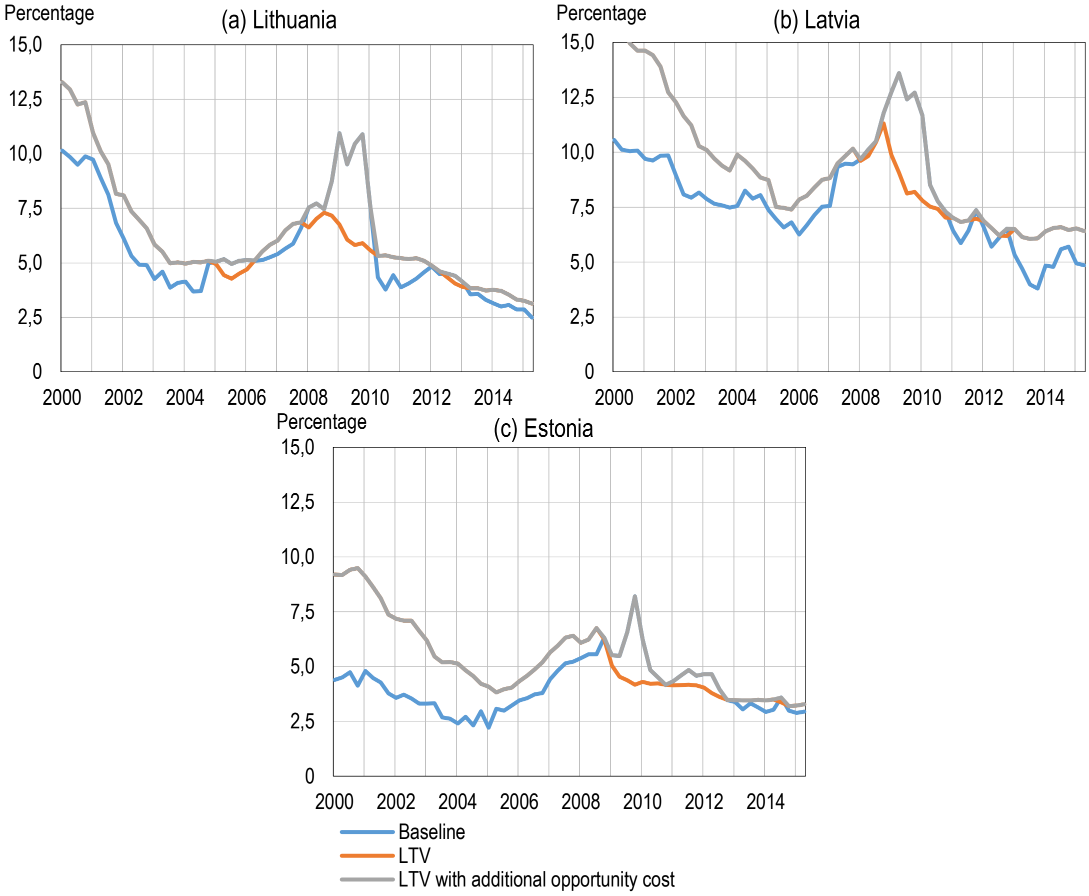
[16] The estimates from "EC3" model showed overvaluation of 7% in Latvia, undervaluation of 5% in Lithuania and prices being equal to their equilibrium values in Estonia at the end of the sample (the fourth quarter of 2014).

[17] For simplicity, e.g. as in Hott and Monnin (2008), the mortgage rate can be considered a relevant

interest rates are deductible because the interest payment amount decreases due to smaller leverage. Due to the use of loan-to-value caps for calculation this alternative is referred to as "LTV" in the tables and figures below.

Since there are periods in the Baltic States history when the deposit interest rates were higher than the mortgage interest rates, borrowing from a bank and buying immovable property could have been associated with additional opportunity costs. To account for this, the third estimate (which is in all other respects identical to the second) increases the user costs by the risk-free and mortgage interest rates spread when the spread is positive. Estimates augmented in such a way are referred as "LTV with additional opportunity cost". The results of all three alternatives are summed up in Figure 22 (the estimated user cost values are provided in Annex 2).

Figure 22. Estimated user costs in the Baltic States



Source: author's calculations.

Note: the "LTV" and "LTV with additional opportunity cost" lines overlap when the risk-free interest rates are below the mortgage interest rates. This renders "LTV" line visible only when the contrary holds.

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discount factor for the total price of the house since the mortgage interest rates and the long-term risk-free rates are highly correlated.

As can be seen from Figure 22, the patterns of the imputed rents developments are similar across the Baltics. In general, the user cost of owning a home decreased over the sample under review. Nevertheless, there are some differences in levels at which the imputed rents fluctuate in each of the Baltic countries. The user costs are the lowest in Estonia because of the deductible mortgage interest rates. While interest payment expenses were also deductible in Lithuania for some time (see Section 4), only a quarter of the costs could have been deducted. Latvian user costs are generally higher than in the other two countries because of larger transaction costs and – at the end of the sample – because of the real estate tax that did not exist for the dwellings in Estonia and did not generally apply for the residential real estate in Lithuania. Apart from these differences, the other fundamentals developed in a similar pattern in all of the Baltic States. Nevertheless, these differences were sufficient to determine fluctuations in equilibrium price-to-rent dynamics of different magnitudes across the countries.

So Figure 22 shows that homeownership was rather expensive in the early 2000s owing mostly to the high opportunity costs (i.e. high risk-free interest rates) and expensive mortgages. Because of these factors for every unit of the euro value of a house the owner had to incur 10–12 cents in costs across the Baltic States. However, the situation changed dramatically as the accession to the European Union neared and the effects of the Russian Crisis wore off: at the end of 2002 the mortgage interest rates had experienced almost a twofold decrease. The imputed rents bottomed-out in 2004 at around 5 percent level and started increasing moderately because the cyclical monetary policy tightening was passing through to the interest rates.

At the end of 2008 the moderate developments turned into sharp shifts in the interest rates as the accumulated economic imbalances (including those in the real estate sector) dwindled. These gyrations caused the user costs of homeownership to increase significantly across the Baltic countries. The largest increase occurred in Latvia (peaking at 13.6%) and Lithuania (peaking at 11.0%), while in Estonia the effects remained largely muted (peaking at 8.2%) due to the interest rate deduction, i.e. in Estonia bigger interest payment expenses did not translate into higher user costs because the households were able to compensate them by deducting taxes.

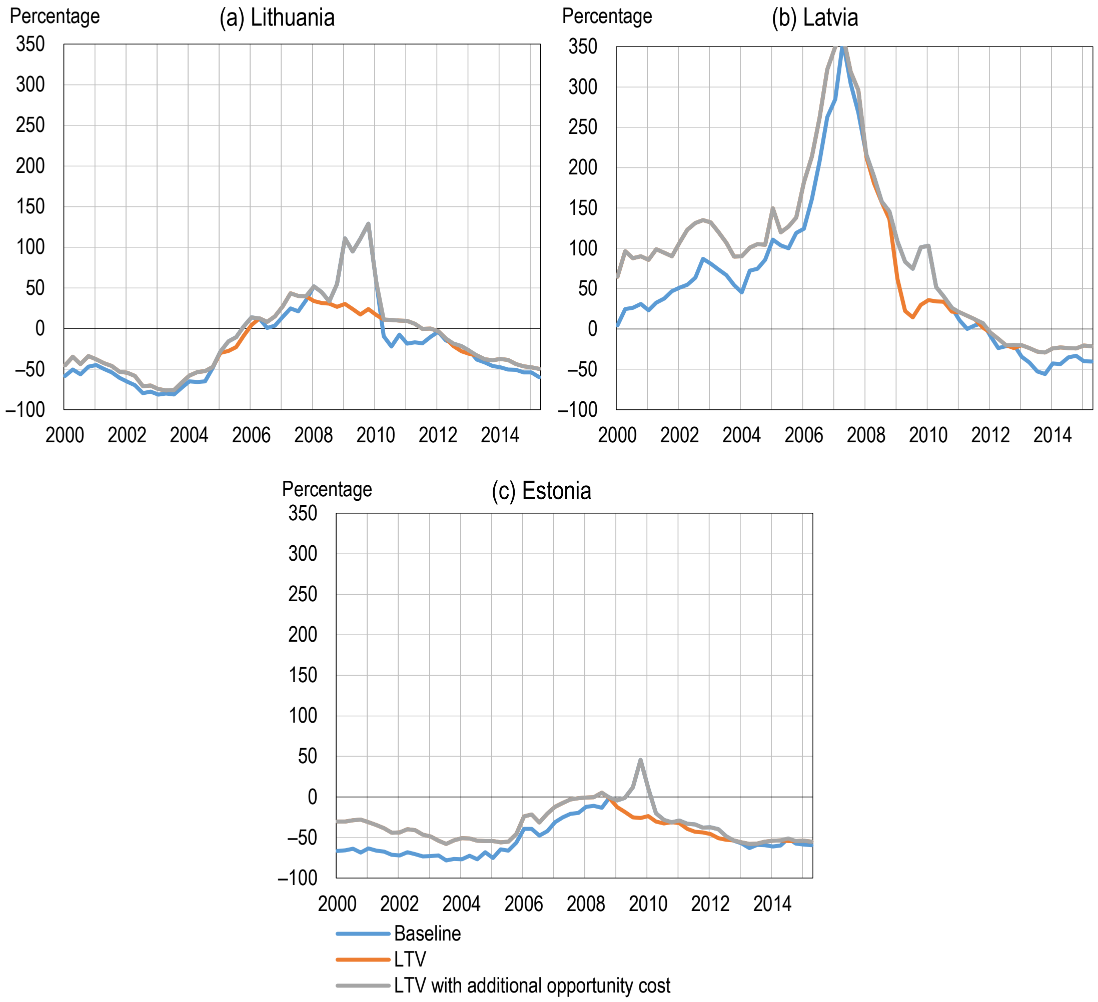
After some time, the effects of the financial crises started to ease and the low monetary policy interest rates began to translate into cheaper borrowing and lower bank deposit interest rates. When the short-term interest rates effectively hit zero, the largest central banks across the world engaged in unconventional monetary policies such as quantitative and credit easing that led to the compression of term and risk premium, thus, the interest rates fell even further. This, at the end of the sample under review, pushed the imputed rents below their pre-crisis lows in Lithuania and Latvia, while in Estonia the effect was balanced out by the interest rates deductibility.

It is evident that the possibility of deducting mortgage interest rate expenses from taxes lowers the user costs in "normal" times, i.e. when the risk-free and mortgage interest rates are approximately at their respective averages. It also acts as a cushion when the interest rates spike sharply. Thus, if the housing price increase occurs because of this, it should be sustainable. However, such developments run a risk of creating unfounded expectations of future price growth because of cognitive biases inherent in the household perception of real estate market (Case and Shiller, 2003; Shiller, 2007). On the other hand, when interest rates become close to zero, the deductibility has little effects.

Given the outlined developments it is natural to ask whether the house price in the Baltics evolved in line with the user costs of homeownership. In order to answer this question, one can compare the actual price-to-rent ratios with the equilibrium ratios suggested by the user cost framework (it should be the inverse of the user costs, see Section 3.2). The deviation of the actual price-to-rent ratios from the estimated ones are pictured in Figure 23.

At the beginning of the sample the actual price-to-rent ratios in Lithuania and Estonia are smaller than the ones suggested by the imputed rents. Therefore, price appreciation or a decrease in rental prices would have been justified at the time. In Latvia the actual price-to-rent ratio starts already above the equilibrium value, thus, in order to have kept the residential real estate market balanced, the prices should have gone down or the rental payments should have increased. However, as can be remembered from Figure 13 (page 54), the house prices and rent prices were increasing modestly simultaneously across all of the Baltic States, thus, the deviation from the equilibrium remained more or less the same up until 2004.

Figure 23. The percentage deviation of the actual price-to-rent ratio from the equilibrium price-to-rent ratio



Source: author's calculations.
Note: the "LTV" and "LTV with additional opportunity cost" lines overlap when the risk-free interest rates are below the mortgage interest rates. This renders "LTV" line visible only when the contrary holds.

The situation started to change when all of the Baltic countries joined the European Union. The house prices more than doubled (even tripled in cases of Latvia and Estonia) in just two years while the developments in rental prices were lagging behind. Such developments would have been sustainable if the user costs had been decreasing at a sufficient pace to offset the divergence between house prices and rents. However, as shown in Figure 22, user costs did not change much over the period of 2004–2006 and were in fact on an upward trend due to increasing interest rates.

In addition to the rising imputed rents, the growth of house prices outpaced that of the rents. This led to the deviation of actual price-to-rent ratio from the equilibrium in Lithuania turning positive, which is a sign of overvaluation in the market. Estonian estimates showed the first signs of overvaluation only at the beginning of 2008 because mortgage interest rate deductibility there limits the effects that the interest rates have on the user costs. In Latvia, since the deviation in 2004 was already positive, the gap widened further. In other words, the estimates from the user cost framework are able to identify the overheating that took place in the market prior the crisis of 2008–2009.

When the imbalances started to unwind the deviation temporary spiked even more as the bank deposit rates hiked. However, after the tensions in the markets cooled, the gap turned to a downward path. Eventually, it became negative across the Baltic States and remained so until the end of the sample.

Looking at such gaps alone might be misleading because the user cost estimates can be biased. Such situation might occur when there are factors that affect the imputed rents but are not included in the calculations. For example, credit availability, i.e. non-interest rate credit standards, and households' preferences affect the user costs but are not part of the imputed rents framework. If the assumption that these factors are roughly constant throughout the sample hold, then in order to remove such biases the imputed-to-actual rent and price-to-rent ratios can be compared to their full sample averages, just as it is done in Figure 24.

As can be seen from the Figure 24, the actual price-to-rent ratios moved roughly in tandem with equilibrium price-to-rent ratios in Latvia and Estonia up until 2005. After that the imputed-to-actual rent ratios started decreasing while the price-to-rent ratios remained either constant (as in the case of Estonia) or continued to increase (as in the case of Latvia)[18]. In Lithuania the price-to-rent ratio did not increase until 2004 even though an increase would have been warranted by the declining user costs. However, after 2004 the ratio started growing rapidly and stabilized in late 2005 just above the levels compatible with the imputed rents.

Figure 24. Imputed-to-actual rent ratios and price-to-rent ratios normalized to their 15-year averages

Source: author's calculations.

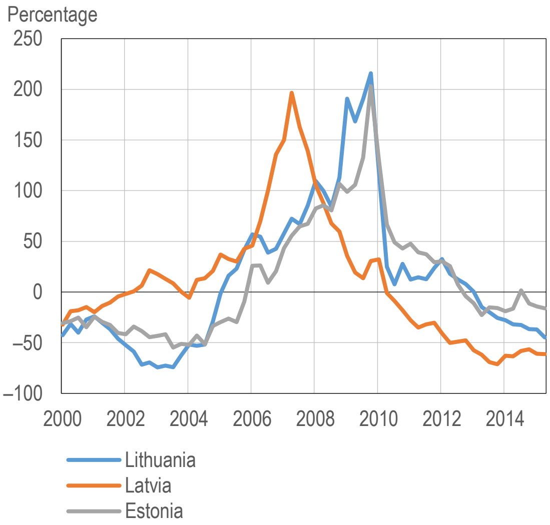
Generally, after 2005 the price-to-rent ratios failed to show co-movement in all of the Baltic countries. The user costs were increasing because of higher interest rates but neither the rents were increasing faster than the prices nor the

[18] With the benefit of hindsight, we know that out of the Baltic countries Latvia experienced the most pronounced housing boom-bust cycle (i.e. in Latvia housing prices rose the most before the crisis but fell also the most after the crisis). This explains why Latvian price-to-rent ratios look more misaligned than the Lithuanian or Estonian ones.

prices were decreasing faster than the rents. Therefore, the housing prices, according to the imputed rents framework, started to seem misaligned from their fundamentals, i.e. the framework suggested that the housing markets were overheating.

The misalignments visible in Figure 24 can be expressed in percentages. This is done by measuring the percentage deviation of the actual normalized price-to-rent ratios from the estimated normalized price-to-rent ratios. The procedure can be easily applied to all the variants of imputed rents but in order to achieve a cleaner visual representation it is done only for the baseline in Figure 25. However, the main messages do not change if the exercise is repeated with the alternative estimates of imputed rents.

Figure 25. Deviations of housing prices from the fundamentals according to the user cost approach

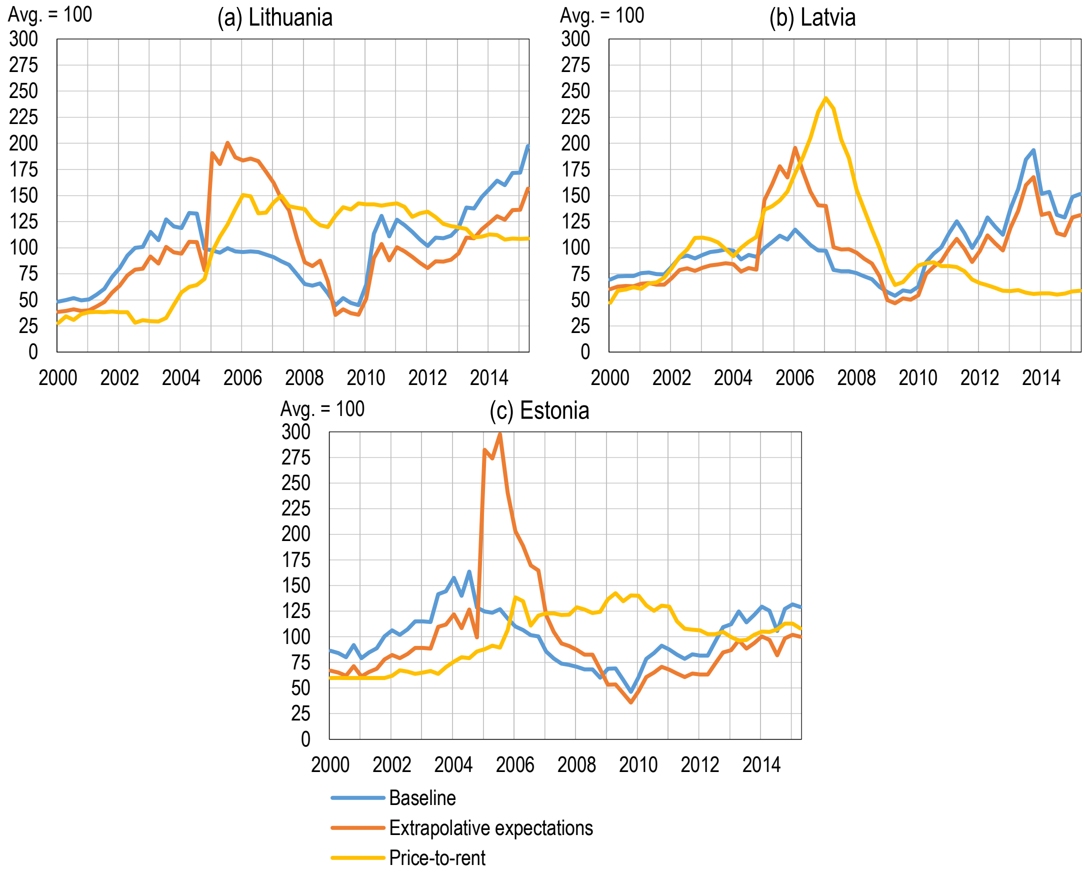


Source: author's calculations.

As can be seen from the figure, the results of housing price misalignments are broadly in line with the results obtained from the error correction models in Section 5.3. However, the overheating period, according to the imputed rents approach, started a bit later in Estonia, i.e. just before 2006. The turning points of the housing cycle are also a bit different. The imbalances, according to the imputed rents method, started to unwind in Latvia as early as in 2007, while they continued to build up in Lithuania and Estonia up until 2009. While we know that an earlier date seems more likely than the latter, it might just show that the user costs changed faster than the actual price-to-rent data during that period.

From the households' perspective such developments at the time might have appeared reasonable. We know from Case and Shiller (2003) and Shiller (2007) that when it comes to housing markets, households base their forecasts on the developments witnessed in the previous periods. Since the housing prices were increasing rapidly over the period of 2004–2007 (e.g. the nominal prices tripled in Lithuania over the mentioned period), it is reasonable to suspect that households expected larger capital gains from their housing assets than the assumed growth of 4 percent (see Section 4). Figure 26 plots the imputed-to-actual rents ratios with augmented expectations so that the annual expected house price increase was equal to 7 percent in Lithuania and Latvia and 6 percent in Estonia[19] in 2005–2008.

Figure 26. Price-to-rent, imputed-to-actual rent and imputed-to-actual rent ratios with extrapolative expectations normalized to their 15-year averages



Source: author's calculations.

[19] Expectations of 7 percent annual nominal house price growth in Estonia yields negative user costs in some periods. Under the user costs framework this means that for households it becomes reasonable to pay an infinite amount for a dwelling instead of renting it.

It is immediately visible that such changes in expectations makes higher price-to-rent ratios seem reasonable at least for additional couple of years. However, gradually increasing interest rates still depressed the imputed-to-actual rent ratios and in 2008 the residential real estate in the Baltics looked overpriced again. With the benefit of hindsight, it is now possible to tell that the expectations of high price growth were not grounded because the developments in the fundamentals themselves were unsustainable.

When the house prices indeed plummeted, with the exception of Latvia, it was accompanied by similar developments in the rents. Therefore, the price-to-rent ratio remained more or less constant in Lithuania and Estonia after the crisis of 2008–2009. In Latvia the price-to-rent ratio readjusted to sustainable levels in 2009 and did not change much afterwards. In other words, roughly constant actual price-to-rent ratios mean that changes in housing prices were accompanied by proportional changes in rental prices in the Baltic States after 2009.

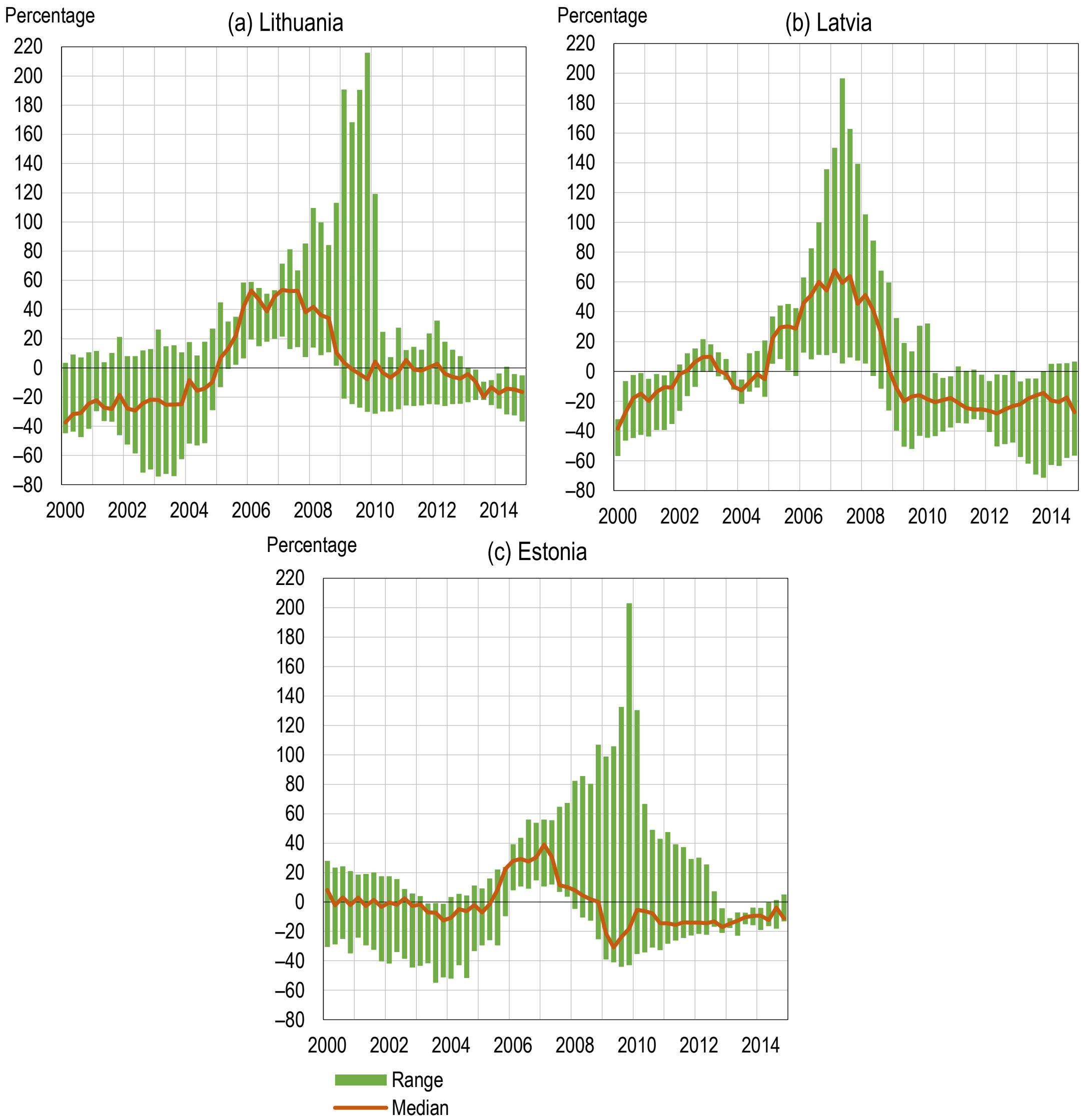
However, as the effects of extremely accommodative monetary policy fed in, the mortgage and risk-free interest rates fell to the lowest levels on record (the mortgage interest rates in the second quarter of 2015 were equal to 1.8% in Lithuania, 3.4% in Latvia and 2.3% in Estonia). This lead to decreases in the user costs: at the end of the sample the price-to-rent ratios found themselves well below the levels suggested by the imputed rents framework in all of the Baltic countries. This means that there is a considerable pressure for the house price appreciation (i.e. increase in actual price-to-rent ratios).

Should the residential real estate prices increase, they would come under downward pressure once the extremely loose monetary policy normalizes. Himmelberg et al. (2005) argues that house prices are more sensitive to real interest rate changes when the interest rates are already low. The effect is further increased if the expected price growth is large. Thus, when the interest rates change, house price volatility will be larger in markets where the user cost of housing is low. This should be kept in mind when conducting macroprudential policy or assessing residential real estate price changes in the low interest rates environment because a sustainable price increase today may lead to harmful house price volatility in the future.

5.4. Combined estimates of housing price misalignments

Though the estimates from all the methods used above follow similar patterns, contradictions do occur. Therefore, it would be difficult to tell which of them has the most desirable properties based purely on the analysis done so far. To make the task of arriving to clear conclusions easier, the information obtained from the long-term equation and user cost approach is combined with the indicators discussed in Section 5.1. This information is synthesized graphically in

Figure 27. Residential real estate price deviations from fundamental values in the Baltics



Source: author's calculations.

Note: "Range" covers the minimum and the maximum values of housing price over- or under-valuation from the price-to-rent and price-to-income ratios, the deviations from Hodrick-Prescott trend, the user cost approach and the estimates from the error-correction models. "Median" represents the median value of those indicators.

Figure 27. Since "EC3" in Table 8 is without statistically insignificant parameters, it is used in the figure to represent the estimates from long-term equations. The user costs approach estimate is calculated as the percentage difference of the normalized to its long-term average actual price-to-rent ratio and the normalized to its long-term average baseline price-to-rent ratio estimates (see Figure 25).

The bars in the charts cover the range from the minimum to the maximum out of all the indicators used in this thesis for measuring housing price misalignments. This means, that the lowest point of each bar correspond to the minimum value out of measures obtained from price-to-rent ratio, price-to-income ratio, Hodrick-Prescott filter procedure, the error correction model and the user cost approach. Similarly, the highest point of each bar corresponds to the maximum value out of the same indicators. The line represents the median for the same estimates at each point in time.

For all three Baltic States Figure 27 is able to tell a 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[20]. Although the ranges tend to get wide, in all cases even the minimum values leave no doubt of housing assets being traded considerably above their long-term equilibrium prices.

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[21] (e.g. due to changes in population) and close the under- or overvaluation gap without any apparent movement in the actual prices (see Gelain and Lansing, 2014). For example, the actual housing prices in Lithuania did not change much

[20] Of course, real-time usefulness of the framework is not clear from the charts provided in this Section, since its performance could have been worse with shorter time series. However, it is not the case as shown in Section 5.5.
[21] The fundamental variables are treated as exogenous in this thesis. It has to be kept in mind that the developments of those variables might be unsustainable in themselves. However, gauging the exact effect of fundamentals overshooting their equilibrium (sustainable) values falls out of the scope of this thesis.

after the correction in 2009–2010 but the misalignment widened because the levels of equilibrium prices adjusted in response to the developments of the fundamentals.

Judging by the performance of Figure 27, this framework could be used for making judgements about price misalignments rather successfully. Although in the fourth 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. There is no reason 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.

5.5. Fundamental price measurements with restricted data sample

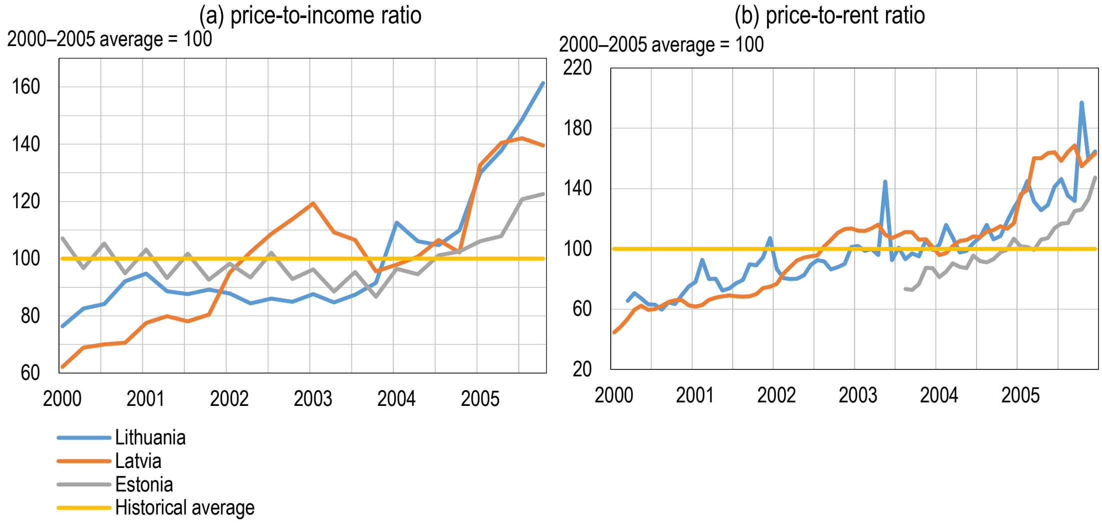
The framework developed in this thesis could only be useful for the systemic risk analysis and macroprudential oversight in the residential real estate sector if it is able to detect mounting imbalances early on. This section investigates if the approach proposed in Section 5.4 would have been able to detect housing price imbalances in real time during the 2005–2008 episode of market overheating. For this purpose, all the calculations that were done in this thesis are repeated with the sample restricted to end at the beginning of 2006.

This means that the last available data point for calculations is the fourth quarter of 2005. This particular date for restricting the sample was chosen on the grounds that at that date there had been a full year of data available to signal mounting imbalances in the Baltic residential real estate sectors. If the framework is able to identify the beginning of the overheating with this restriction, it, arguably, could be used in practice for monitoring housing valuations in the Baltic States and making judgements if the price developments require policy intervention (e.g. preventive policy measures).

First of all, the price-to-income and price-to-rent ratios are recalculated. The results are plotted in Figure 28. The calculation procedure is identical to the one described in Section 3.3.

As can be seen from the figure, both the price-to-income and price-to-rent

Figure 28. Price-to-income and price-to-rent ratios in the Baltics restricted to data available until the end of 2005



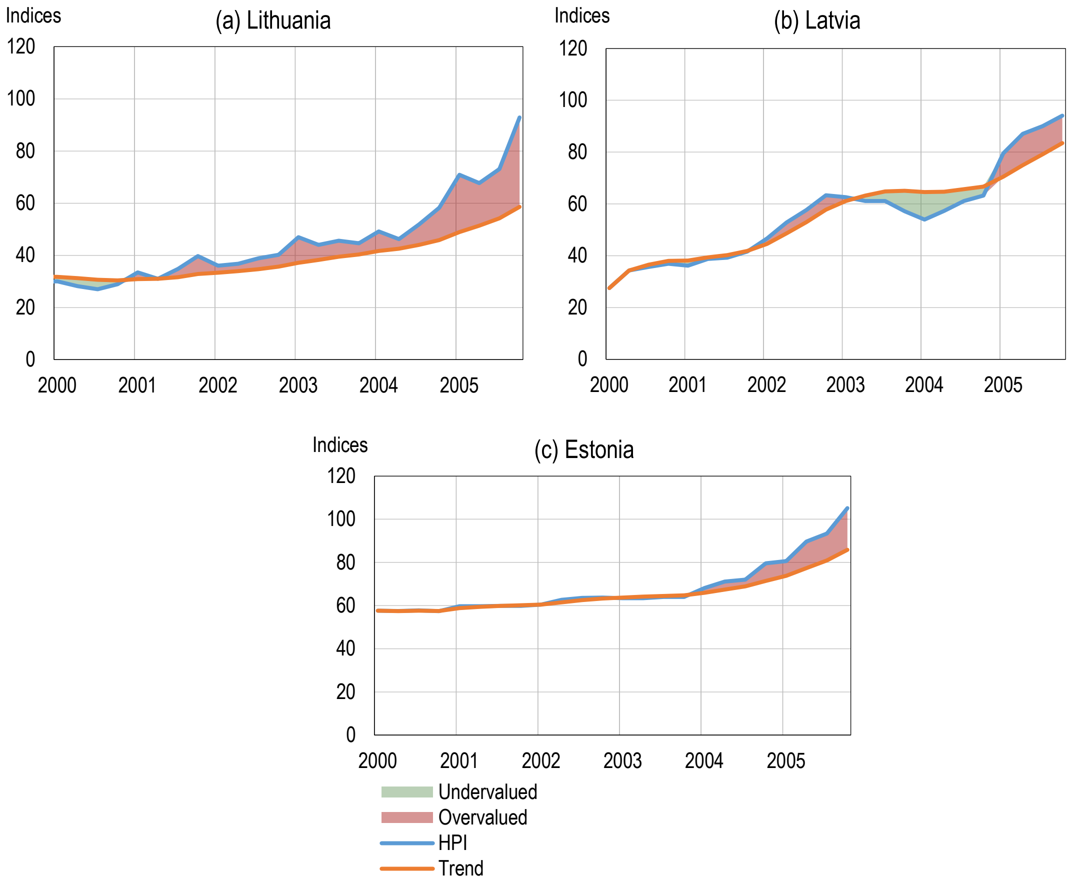
Sources: author's calculations based on Eurostat, Statistics Lithuania, UAB Ober-Haus, Estonian Land Board, Latio Real Estate data.

ratios did deviate from their long-term averages in late 2004 or early 2005. This means that at those dates these fairly simplistic measures were signalling that the properties in the Baltic residential real estate markets were being traded above their equilibrium values. According to the price-to-income ratios, houses were above their equilibrium values to the tune of around 60 percent in Lithuania, 40 percent in Latvia and 20 percent in Estonia at the end of 2005. At the same time, the price-to-rent ratios signalled overvaluation of around 60 percent in Lithuania and Latvia and 50 percent in Estonia.

Of course, it would be naïve to expect action on this information alone, thus, other measures developed in this thesis should also be investigated. Hodrick-Prescott exercise described in Section 5.1 is repeated in Figure 29. Just as before, the housing prices used for the calculation here are deflated by harmonized consumer price indices.

Figure 29 shows that the estimates derived from Hodrick-Prescott filter would have also signalled imbalances in the Baltic countries' housing markets. In Estonia the estimates started signalling overheating in 2004, in Latvia – in 2005. In Lithuania there were some signs of overheating visible as early as in 2002 because the time series used for Lithuania start earlier than for other Baltic countries, i.e. 1995. However, the deviation started getting more significant only

Figure 29. Housing price deviations from Hodrick-Prescott filter (one-sided) trend ($\lambda = 100\,000$, restricted sample)



Source: author's calculations.

in mid-2004.

At the end of the restricted sample, the estimates obtained from the Hodrick-Prescott filter exercise suggested that the housing prices were approximately 58 percent above their equilibrium value in Lithuania. The corresponding figure for Latvia stood at around 13 percent. Finally, according to Hodrick-Prescott estimates, in Estonia housing prices seemed around 23 percent above their long-term average. The figure for Lithuania stands out only because of the longer time series which provides the filter with more information on how should the long-term trend look like.

So the Hodrick-Prescott filter would have also ringed some alarms in early 2006 if it had been used for measuring housing price misalignments. Next, the error-correction models are re-estimated with the same specifications as outlined in Table 8 in Section 5.2. Since in order to be accurate econometric models usually require rather long time series, this technique will probably suffer the most as compared to other methods used in this thesis. Short time series reduce the power of statistical tests such as those used to test for parameter significance and become unreliable.

Table 10 below reports the estimation results with the restricted sample. As can be seen from the table, it would have been near impossible to come up with the same equation specifications in 2006 as almost all equations would have been plagued by statistically insignificant parameters. In addition, there would have been evidence of error correction only in EC3.res case. It is, therefore, safe to assume, that such model would have been impossible to construct due to data limitations. However, for the sake of comparison to the full sample results, the results from the restricted sample error-correction equations are plotted in Figure 30.

Table 10. Long-term relationships (restricted sample)

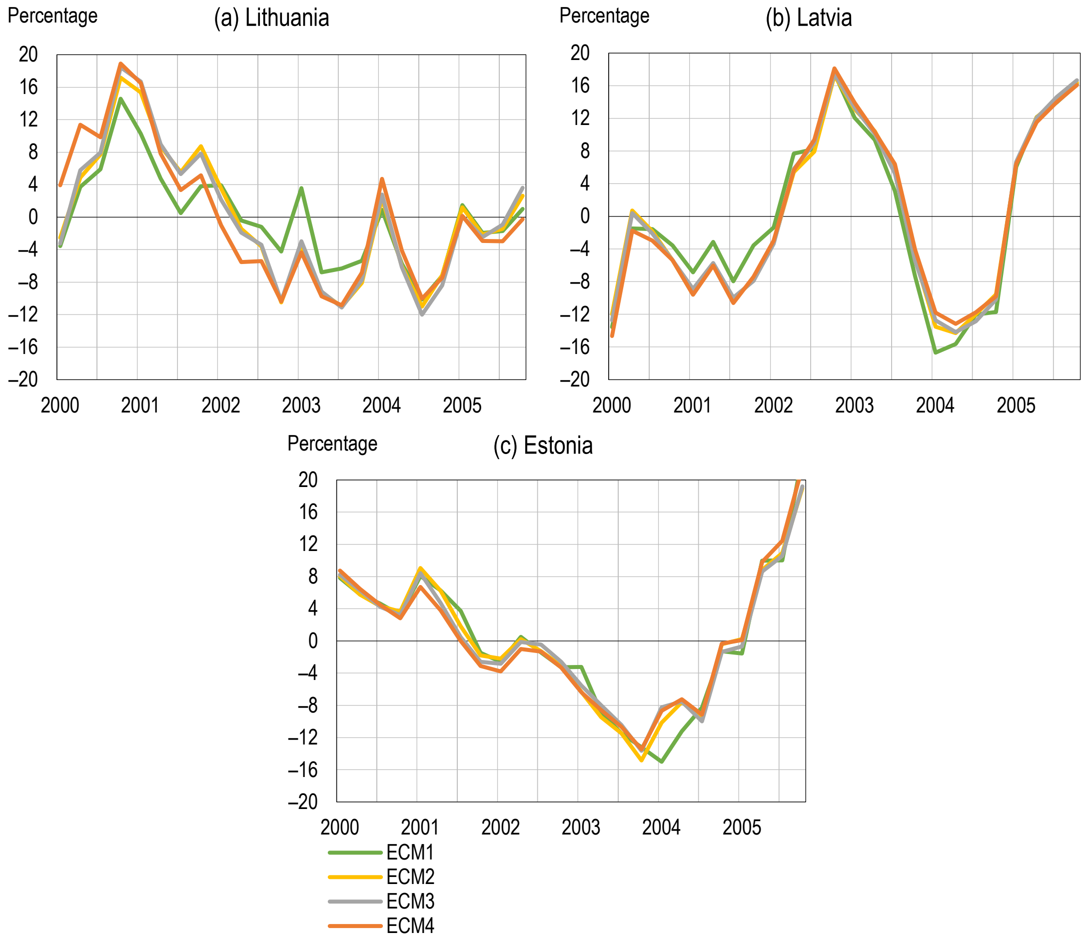
	EC1.res hpi	EC2.res hpi	EC3.res hpi	EC4.res hpi
$ccpi$	0.547933 (0.400671)	0.545932 (0.421305)	0.446651 (0.350794)	0.529214 (0.347045)
inc	−0.729487 (0.555506)	−0.737708 (0.584090)	−0.764621 (0.574544)	−0.580807 (0.554816)
R	−18.39406 (7.329736)	0.007441 (0.017048)	− (−)	− (−)
pop	0.008105* * (0.016218)	−17.20539* * (7.663185)	−15.94287* * (7.019578)	−21.52780* * (4.494945)
$cred$	0.053112 (0.130892)	0.118685 (0.129930)	0.129328 (0.126242)	− (−)
$remit$	0.130915 (0.086201)	− (−)	− (−)	− (−)
SoA	−0.146231 (0.083450)	−0.153703 (0.079929)	−0.158752* * (0.079501)	−0.140001 (0.078518)

Source: author's calculations.

Notes: standard errors of the parameters are presented in parenthesis. Stars indicate statistical significance as follows: "**" – 99%, "*" – 95%. "SoA" is the speed of adjustment parameter (the parameter near the error correction term).

The figure shows that in case of Lithuania the estimates from error-correction model provides little guidance on how well aligned housing prices are with their fundamentals. While they were above the equilibrium level at the end of the restricted sample, they were fluctuating around it up until that point and would not have sent a strong enough signal to mobilize policy action. However, in case of Latvia and Estonia, the models are able to signal overheating in the housing market starting with early 2005. According to the models, at the end of

Figure 30. The estimated housing price deviations from equilibrium in the Baltics (restricted sample)



Source: author's calculation.

the restricted sample the housing prices were some 16 percent above the values justified by the fundamentals in Latvia and around 20 percent – in Estonia.

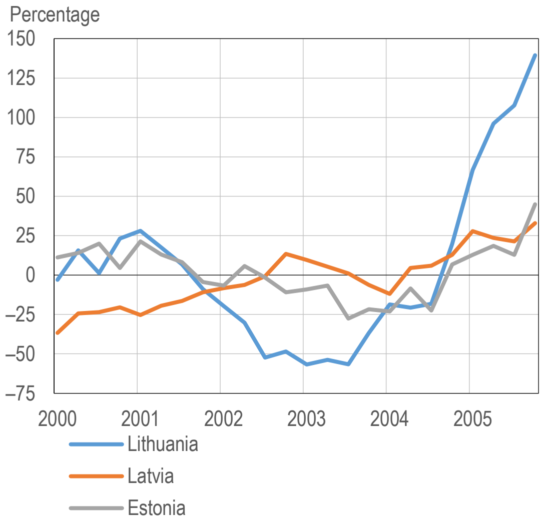
Out of the methods used in this thesis, the estimates of housing price misalignments from the user cost approach should be the most robust to sample selection. However, since the measure of percentage deviation from equilibrium requires calculation of long-term averages, there is some risk that a shorter sample would produce different results. The calculation procedure is repeated with the restricted sample and the results are plotted in Figure 31.

The figure reveals that the user cost approach would have started signalling housing price imbalances in the middle of 2004. In case of Lithuania, it would have signalled overvaluation that equalled around 140 percent at the end of the restricted sample. At the same time, for Latvia the estimate of the price deviation stood at approximately 33 percent, while for Estonia – at some 45 percent.

Therefore, the user costs approach would have successfully identified overheating that was happening in the Baltic residential real estate markets rather early on.

Nevertheless, the real question is whether the graphical framework presented in Section 5.4 that combines all the methods used in this paper is able to identify unsustainable housing price developments in real time. To answer this question, the same exercise with the sample restricted to end at the beginning of 2006 was repeated. The results are plotted in Figure 32.

Figure 31. Deviations of housing prices from the fundamentals according to the user cost approach (restricted sample)

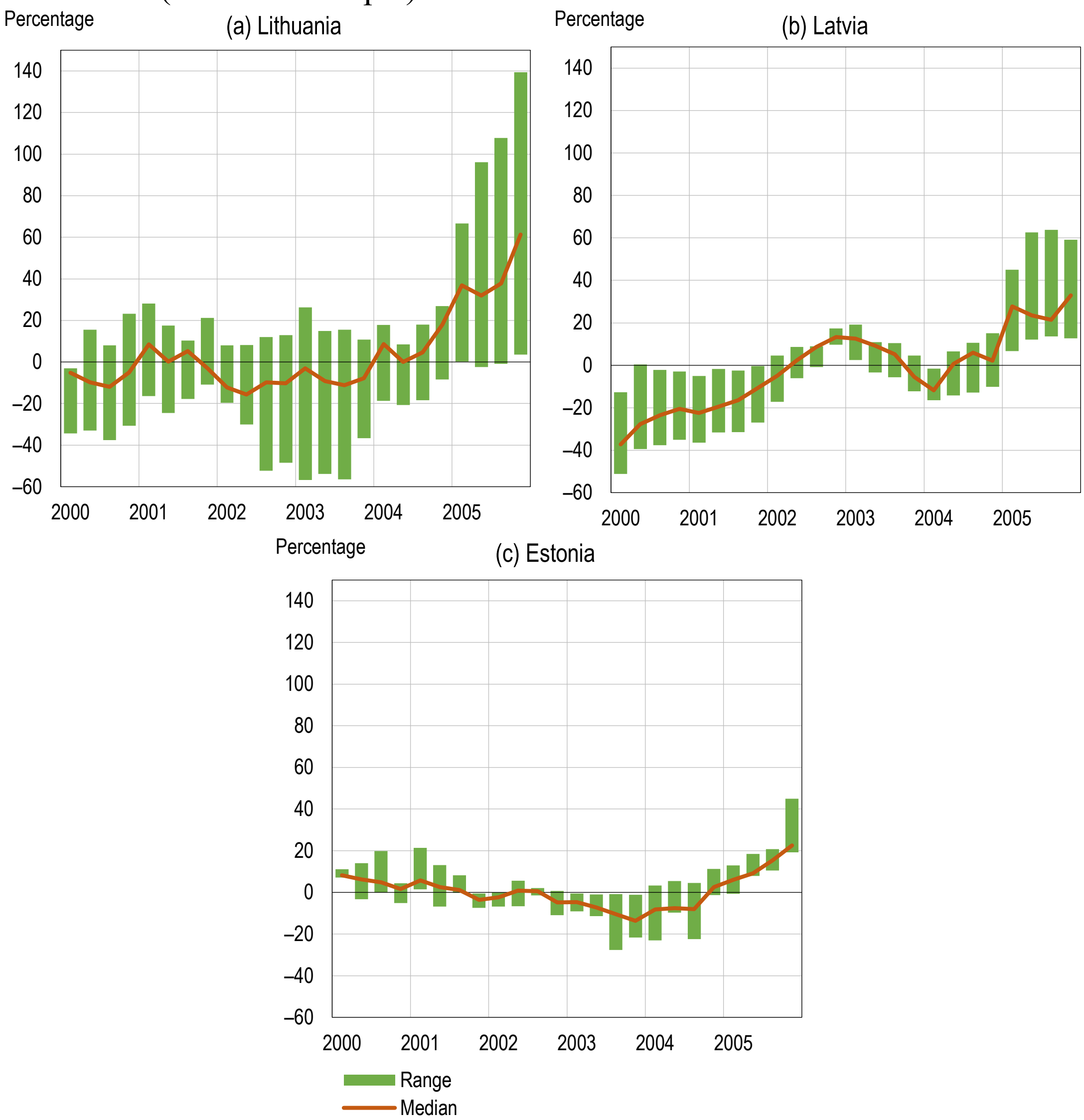


Source: author's calculations.

As evident from Figure 32, at the end of 2005 one would have been able to conclude that the housing prices have departed from their fundamental values in all three Baltic States. In cases of Latvia and Estonia, the framework is able to give rather clear message of housing price overvaluation. In case of Lithuania the uncertainty is still high as error-correction model estimates were inconclusive[22]; however, the median of the measures would have still convincingly signalled overvaluation. Of course, given the short time series available in 2006, relying on this framework alone would have been careless at the time. Only with

[22] It must be noted that due to short time series the error correction models discussed in this paper would have been near impossible to come by in 2006, see the discussion near Table 10.

Figure 32. Residential real estate price deviations from fundamental values in the Baltics (restricted sample)



Source: author's calculations

Note: "Range" covers the minimum and the maximum values of housing price over- or under-valuation from the price-to-rent and price-to-income ratios, the deviations from Hodrick-Prescott trend, the user cost approach and the estimates from the error-correction models. "Median" represents the median value of those indicators.

the benefit of hindsight, we now know that the signals the framework would have sent would have been correct. Currently as well as in the future, data limitations problems, arguably, are not going to be as bad as they were in 2006, thus, the framework could be useful for detecting over valuation in real time, i.e. as the data becomes available and could empower policymakers to act against the risk build-up.

6. Conclusions

This thesis showed that the fundamental prices in the Baltic States could be successfully measured in a consistent analytical framework. In order to make inferences about housing price misalignments it combined the price-to-rent, price-to-income ratios, deviations from Hodrick-Prescott trend, the user cost approach and estimates from error-correction models into a system. The framework could have detected the imbalances in the Baltic residential real estate markets that were accruing prior the crisis of 2008–2009 early on, i.e. as they happened.

It is shown in the thesis that the housing prices in the Baltics developed more or less in line with the equilibrium prices up until 2006. Later on the prices started to diverge from the levels compatible with fundamentals. The divergence continued to build up until the crisis of 2008–2009 which led to large correction in the housing markets. The estimates also capture that this correction overshot the fundamentals (housing assets became undervalued). Since then, housing prices have been converging to their equilibrium values.

Despite having recovered somewhat after the crash, residential property was still undervalued at the end of the sample. The main reason behind this finding lies within low interest rates environment as decreasing mortgage and risk-free interest rates compressed the user costs substantially. Therefore, at the end of the sample, i.e. in the fourth quarter of 2014 or in the second quarter of 2015 (depending on the method employed in this thesis) the fundamental house prices in the Baltic States were significantly higher than the actual ones (the median of measures shows the undervaluation of 16.7% in Lithuania, 11.1% in Estonia and 27.4% in Latvia). This means that the residential real estate prices were under considerable pressure to increase.

While the increase would be supported by the current fundamentals, it has to be kept in mind that the fundamentals might not be at their natural levels. 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 a bit given variation in fundamental determinants. For example, the mortgage and deposit interest rates are well below their historical averages, thus, have a lot of scope for a rebound ounce the monetary policy normalizes. This suggests that the macroprudential policy makers should monitor closely the developments of housing prices in the Baltics and be ready to act despite the fundamentals being in favour of housing price increases.

The result implies that there are no immediate systemic risks arising from the residential real estate markets in the Baltic countries. Looking further, the framework developed here can be used to supplement macroprudential oversight, risk identification and analysis. While the framework is not designed to calibrate policy instruments or identify if such instruments are needed, it can still be useful in policymaking process to answer questions of whether imbalances in the housing market are mounting up.

The limitations of the framework presented in this thesis suggest at least three 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 examine what drives the long-term (equilibrium) and short-term housing price movements (e.g. by performing impulse response and variance decomposition analysis using panel VECM). 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 future housing price changes.

Second, some of the time-series used in this thesis 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 limitations faced by this study were eliminated. Moreover, some time series that would have benefited this study could not have been extrapolated accurately, 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 thesis), this research direction is not something that can be taken up immediately.

Third, the user cost framework presented in this thesis could be augmented to account for the expected future developments of the fundamentals. This would allow deriving more accurate estimates of the equilibrium housing prices. However, such an extension comes with its own caveats and complexities. For example, for a well calibrated discount horizon the dataset would have to be extended to include data on the average maturity of mortgage loans. While such data could be collected, computing the expected evolution of some variables such as rental prices over the next 20 years would be much more complicated.

Annex 1. 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-Olesen et al. (2013), ECB (2011), Andrews et al. (2011), Case and Shiller (2003), European Commission (2012), Leika and Valentinaitė (2007)
Income	Kuttner and Shim (2013), Corradin and Fontana (2013), Huynh-Olesen 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. (2015), European Commission (2012), Favara and Imbs (2015), Galinienė et al. (2006), Claussen et al. (2011), Leika and Valentinaitė (2007), Stepanyan et al. (2010), Bukevičiūtė and Kosicki (2012)
Interest rate	Kuttner and Shim (2013), Huynh-Olesen et al. (2013), Callesen (2013), Himmelberg et al. (2005), ECB (2011), Andrews et al. (2011), Towbin and Weber (2015), Levin and Wright (1997), Case and Shiller (2003), Chen et al. (2013), Fletcher et al. (2015), Thwaites (2015), European Commission (2012), Claussen et al. (2011), Leika and Valentinaitė (2007)
Rental prices[1]	Himmelberg et al. (2005), ECB (2011), Glaeser and Nathanson (2015), Zhu (2014), Towbin and Weber (2015), Fletcher et al. (2015), Micheli et al. (2014), European Commission (2012), Favara and Imbs (2015), Leika and Valentinaitė (2007), Bukevičiūtė and Kosicki (2012)
Credit	Huynh-Olesen et al. (2013), Andrews et al. (2011), Zhu (2014), European Commission (2012), Favara and Imbs (2015), Leika and Valentinaitė (2007)
Construction costs	Huynh-Olesen et al. (2013), Case and Shiller (2003), Chen et al. (2013), Leika and Valentinaitė (2007)
Residential investment	Towbin and Weber (2015), European Commission (2012)
Housing starts	Case and Shiller (2003)
Remittances	Huynh-Olesen et al. (2013), Stepanyan et al. (2010)
Taxes and regulation	Callesen (2013), Andrews et al. (2011), Micheli et al. (2014)
Households' wealth	Claussen 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.*

Annex 2. Estimated user costs in the Baltic States

Table A. Estimated user costs in the Baltic States: annual imputed rents as a percentage of the house value (percentages)

	Baseline			LTV			LTV with additional opportunity cost		
Date	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia	Lithuania	Latvia	Estonia
2000 03	10.15	10.55	4.39	13.28	16.64	9.20	13.28	16.64	9.20
2000 06	9.85	10.12	4.51	12.95	15.92	9.17	12.95	15.92	9.17
2000 09	9.51	10.05	4.74	12.27	14.96	9.42	12.27	14.96	9.42
2000 12	9.89	10.08	4.13	12.36	14.63	9.49	12.36	14.63	9.49
2001 03	9.74	9.70	4.80	10.97	14.63	9.11	10.97	14.63	9.11
2001 06	8.90	9.62	4.47	10.12	14.42	8.63	10.12	14.42	8.63
2001 09	8.12	9.84	4.28	9.52	13.90	8.11	9.52	13.90	8.11
2001 12	6.83	9.85	3.78	8.16	12.73	7.36	8.16	12.73	7.36
2002 03	6.11	8.96	3.57	8.09	12.27	7.18	8.09	12.27	7.18
2002 06	5.31	8.08	3.72	7.36	11.65	7.09	7.36	11.65	7.09
2002 09	4.93	7.93	3.54	6.97	11.22	7.08	6.97	11.22	7.08
2002 12	4.88	8.17	3.30	6.58	10.27	6.62	6.58	10.27	6.62
2003 03	4.26	7.87	3.30	5.85	10.11	6.19	5.85	10.11	6.19
2003 06	4.59	7.66	3.32	5.50	9.71	5.45	5.50	9.71	5.45
2003 09	3.86	7.58	2.68	4.98	9.39	5.19	4.98	9.39	5.19
2003 12	4.08	7.47	2.63	5.02	9.17	5.20	5.02	9.17	5.20
2004 03	4.14	7.56	2.41	4.97	9.89	5.13	4.97	9.89	5.13
2004 06	3.69	8.25	2.71	5.03	9.61	4.83	5.03	9.61	4.83
2004 09	3.70	7.89	2.32	5.03	9.26	4.57	5.03	9.26	4.57
2004 12	4.97	8.05	2.95	5.10	8.85	4.21	5.10	8.85	4.21
2005 03	5.05	7.38	2.21	4.94	8.74	4.09	5.05	8.74	4.09
2005 06	5.16	6.96	3.07	4.43	7.50	3.83	5.16	7.50	3.83
2005 09	4.94	6.58	2.99	4.28	7.46	3.97	4.94	7.46	3.97
2005 12	5.09	6.80	3.22	4.51	7.39	4.04	5.09	7.39	4.04
2006 03	5.12	6.25	3.45	4.69	7.85	4.32	5.12	7.85	4.32
2006 06	5.10	6.68	3.56	5.11	8.02	4.58	5.11	8.02	4.58
2006 09	5.13	7.15	3.73	5.52	8.40	4.87	5.52	8.40	4.87
2006 12	5.26	7.52	3.79	5.83	8.74	5.19	5.83	8.74	5.19
2007 03	5.41	7.55	4.42	6.03	8.82	5.64	6.03	8.82	5.64
2007 06	5.65	9.34	4.81	6.49	9.49	5.95	6.49	9.49	5.95
2007 09	5.87	9.48	5.15	6.79	9.82	6.32	6.79	9.82	6.32
2007 12	6.59	9.45	5.23	6.86	10.16	6.41	6.86	10.16	6.41
2008 03	7.53	9.69	5.38	6.63	9.60	6.08	7.53	9.69	6.08
2008 06	7.73	10.11	5.56	7.01	9.82	6.22	7.73	10.11	6.22
2008 09	7.45	10.49	5.56	7.29	10.46	6.75	7.45	10.49	6.75
2008 12	8.74	11.78	6.31	7.17	11.32	6.25	8.74	11.78	6.31
2009 03	10.94	12.72	5.52	6.75	9.89	5.05	10.94	12.72	5.52
2009 06	9.51	13.60	5.48	6.06	9.07	4.53	9.51	13.60	5.48
2009 09	10.46	12.41	6.56	5.82	8.12	4.38	10.46	12.41	6.56
2009 12	10.90	12.71	8.20	5.90	8.20	4.17	10.90	12.71	8.20
2010 03	7.62	11.68	6.25	5.59	7.80	4.31	7.62	11.68	6.25
2010 06	4.33	8.52	4.84	5.31	7.52	4.22	5.31	8.52	4.84
2010 09	3.77	7.77	4.51	5.34	7.42	4.23	5.34	7.77	4.51
2010 12	4.43	7.30	4.16	5.26	7.02	4.16	5.26	7.30	4.16
2011 03	3.88	6.43	4.33	5.21	7.01	4.14	5.21	7.01	4.33
2011 06	4.05	5.86	4.59	5.17	6.83	4.15	5.17	6.83	4.59
2011 09	4.27	6.43	4.84	5.21	6.90	4.18	5.21	6.90	4.84
2011 12	4.56	7.36	4.58	5.10	6.97	4.14	5.10	7.36	4.58
2012 03	4.84	6.57	4.65	4.87	6.87	4.04	4.87	6.87	4.65

2012 06	4.48	5.70	4.65	4.61	6.54	3.80	4.61	6.54	4.65
2012 09	4.50	6.11	3.97	4.33	6.20	3.62	4.50	6.20	3.97
2012 12	4.40	6.52	3.47	4.05	6.19	3.49	4.40	6.52	3.49
2013 03	4.12	5.33	3.38	3.89	6.50	3.47	4.12	6.50	3.47
2013 06	3.55	4.70	3.04	3.84	6.13	3.45	3.84	6.13	3.45
2013 09	3.57	3.98	3.32	3.83	6.05	3.46	3.83	6.05	3.46
2013 12	3.31	3.79	3.13	3.73	6.08	3.48	3.73	6.08	3.48
2014 03	3.15	4.84	2.93	3.77	6.40	3.46	3.77	6.40	3.46
2014 06	2.99	4.78	3.03	3.72	6.55	3.50	3.72	6.55	3.50
2014 09	3.07	5.58	3.59	3.54	6.59	3.37	3.54	6.59	3.59
2014 12	2.87	5.70	2.98	3.33	6.46	3.20	3.33	6.46	3.20
2015 03	2.86	4.94	2.89	3.26	6.53	3.23	3.26	6.53	3.23
2015 06	2.49	4.85	2.94	3.13	6.41	3.28	3.13	6.41	3.28

Source: author's calculations.

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