

A COMPREHENSIVE METHOD FOR HOUSE PRICE SUSTAINABILITY ASSESSMENT IN THE CZECH REPUBLIC

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Abstract

The article describes approach proposed for the house price equilibrium assessment in the Czech Republic. It first explains why it is necessary to use multiple models simultaneously to correctly assess house price sustainability. It goes on to describe individual models proposed to estimate house price misalignment in the Czech Republic. Results given by these individual models are consonant in identifying periods of over- and undervaluation of house prices but slightly differ in the amplitude of the gaps. A method for aggregating the estimates produced by those approaches is then presented. It works on the premise that more correlated estimates may be evidence of a strong signal, while less correlated estimates may, on the other hand, bring additional information to the house price assessment. By using two sets of weights, it presents an interval of supposed under- or overvaluation of house prices. This method indicates that Czech house prices were roughly at their equilibrium level in mid-2014 following an extended period of slight undervaluation since the mid-2009. It also proves robust to the length of the sample used.

Keywords: house price, multiple models, Czech Republic

JEL Classification: R21, R31, C32

1. Introduction

The macroprudential policy tools currently applied in many developed and developing countries include forms of regulation of property market exposures. According to research results and international experience, however, these measures are only effective if introduced in good time (ESRB, 2014). The possibility of applying such tools where necessary to maintain financial stability puts authorities under pressure to monitor property prices and assess their sustainability. Advanced approaches to house price sustainability assessment in the Czech Republic have been described in articles by Hlaváček and Komárek (2009, 2010 and 2011). This article aims to update these approaches and describe newly developed approaches that complement them and formulate a method for aggregating the results of the various approaches.

The above macroprudential tools are intended to prevent financial institutions from suffering large credit losses at times of highly adverse economic conditions coupled

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The research behind this paper was supported by the Grant Agency of the Czech Republic under Project No. 13-06229S.

with a sharp drop in house prices. An indirect consequence of these tools is that they constrain growth in house prices *per se*. However, the objective of macroprudential policy is not to combat house price inflation, but to prevent systematic and credit-driven overvaluation, after which house prices have a tendency to drop sharply. Such events have grave implications for the real economy and the financial system. Identifying situations, where property prices are being determined by fundamental factors rather than expectations, *i.e.* identifying equilibrium prices, is a key problem in the assessment of house prices.¹

This article is organised as follows. Section 2 discusses differences in approaches used to assessing equilibrium house prices. Section 3 describes specific forms of these approaches proposed to estimate the house price gap in the Czech Republic. Section 4 presents a method for aggregate assessment of the results of such approaches. For the practical use the presented methodology should not be treated as fixed and final. The methods for assessing equilibrium residential property prices may be updated and further supplemented in response to market changes, as happens in most countries with a longer free housing market history than in the Czech Republic. The method presented in this article for the aggregate assessment of various estimates allows for such ongoing refinement.

2. The Benefits of Different Approaches to Assessing Property Prices

The estimation of equilibrium residential property prices is complicated by whole range of factors. These include (i) low data quality due to the heterogeneity of the underlying asset; (ii) the degree to which property purchases are debt-financed; (iii) the combined consumption and investment nature of housing, and (iv) the importance of the construction industry for economic activity. Property price sustainability assessment in the Czech Republic is also complicated by country specific factors, including (v) the convergence nature of the Czech economy, which has undergone rapid mortgage market development and housing market liberalisation; and (vi) rent deregulation, which continued until 2012 (see also Hlaváček and Komárek, 2009).

Equilibrium residential property prices should be explainable primarily by the determinants of supply and demand (*e.g.* prices of land and building work and the size of the housing stock on the supply side and demographic indicators, the income situation of households and interest rates on the demand side; see Approach I in Section 3). Potential errors in the valuation of residential property prices can arise in various ways and go in either direction. On the one hand, the omission of a significant fundamental house price factor can mean that the approach wrongly assesses house price growth driven by that factor as building up the bubble² even though this growth is fully balanced. On the other hand, if the factors explaining house price growth include one which itself contains a non-equilibrium component, that factor may contribute to house price growth being assessed as equilibrium growth. The degree of overvaluation is then being underestimated. The probability of such an error is higher if the relationship between house prices and this fundamental factor is endogenous, *i.e.* if these fundamentals are themselves driven by the emerging price bubble. In such case, even “wrong” house price growth may be mistakenly explained by fundamentals. Such

1 The definition of equilibrium house prices in Himmelberg *et al.* (2005).

2 Komárek and Kubicová (2011) define an asset price bubble as an explosive and asymmetric deviation of the market price of an asset from its fundamental value, with the possibility of a sudden and significant reverse correction.

a situation can arise, for example, when growth in residential property prices and increasing demand for housing generate excessive activity by property developers, who, in the search for yield, create a construction boom. The increased construction activity leads to faster economic growth and a related surge in wages. The rise in residential property prices is thus accompanied by an improvement in household income, even though the whole process was started by over-optimistic expectations about housing demand. For this reason, to correctly assess house price sustainability it is also vital to monitor aggregate economic relationships in a potentially overheating economy (see Approach II in Section 3).

Assessments of house price equilibrium can also differ depending on whether prices are assessed on the basis of consumption or investment demand for residential property. This applies even though the two types of demand are strongly interconnected (residential property investors buy property for others to “consume” by purchasing services, *i.e.* paying rent) and the general model of housing supply and demand thus usually contains their determinants already. From the perspective of demand for property for use (*i.e.* consumption demand), house price sustainability is assessed using the ratio of the property purchase price to the income of households. At any stage of the price cycle, this ratio tends to be so high that, given the need to pay for other essential goods,³ it constrains further growth in house prices to some extent (see Approach IV in Section 3). From the viewpoint of demand for housing as a product of permanent value (*i.e.* investment demand) residential property price equilibrium is evaluated by comparing the economic sense of home ownership with a suitable alternative. In the case of demand for housing for use, the cost of buying is compared with the cost of renting. From the investor perspective, the rental return is compared with the return on another, typically less risky asset. Such equilibrium residential property prices also satisfy the condition of arbitrage between alternative asset markets (see Approach III in Section 3).

So, one consequence of the nature of residential property is that there are numerous approaches to assessing equilibrium house prices. (To assess the role of individual approaches for house price sustainability assessment, see Figure 1.) A single approach would be too narrow both from the methodological perspective and because of the need to limit the number of variables given the length of the time series. Assessment of the effects of supply and demand-side factors typically leads to econometric approaches, whereas the pressures of consumer and investment demand independently are usually assessed statistically. The individual approaches to assessing residential property price equilibrium are not pure alternatives; each provides some additional information for evaluating price equilibrium.

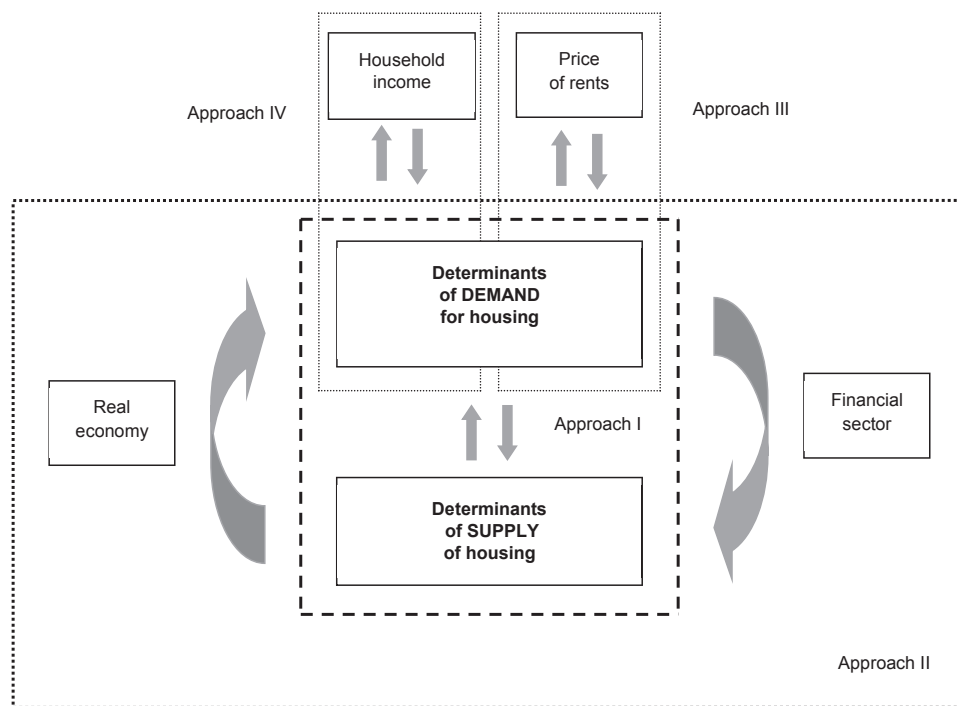
Central banks around the world differ widely in their approaches to assessing house price equilibrium. Some of them limit themselves to simple statistical indicators, which they combine analytically in a suitable manner. Others are phasing in econometric models, which are then regularly estimated and used to supplement statistical indicators. The Czech National Bank, like the Belgian, German, Italian and Irish central banks, for example,⁴ has so far used a combination of statistical and model-based approaches (see CNB, 2015,

3 The household expenditure structure is largely economy-specific. This means that international comparisons of the ratio of housing expenditure to the total budget of households cannot be used to assess residential property prices.

4 For a description of the models used by central banks, see, for example, Kajuth *et al.* (2013), Nobili and Zollino (2012) and McQuinn (2004). For an exhaustive survey of the existing methods for estimating and evaluating equilibrium house prices, including a list of applications to the Czech Republic, see Hlaváček and Komárek (2010).

pp. 84–85). Currently, the growing range of options for using macroprudential measures to safeguard financial stability is giving rise to a need to assess residential property price equilibrium information from various approaches on an aggregate basis and thereby reach clear conclusions on house price misalignment. However, we are aware of only two previous attempts to aggregate information on equilibrium house prices from multiple indicators and models. The first is the method of the European Central Bank (ECB), which uses four approaches to determine property price equilibrium – two model-based ones and two statistical ones. The price equilibrium information obtained in this way is evaluated as an average, taking other ancillary indicators into consideration (see ECB, 2011). The Austrian central bank (OeNB) created a fundamental residential property price indicator by first identifying key indicators of price stability from the perspective of households, investors and the economic system (*e.g.* real residential property prices, affordability, the price to rent ratio and the ratio of residential property prices to construction costs). These indicators are then aggregated into a house price sustainability index using the principal components method, and the fundamentally justified price is assessed in relation to the historic average value of this index (Schneider, 2013). Our approach intends to employ a combination of the two approaches described above to assess such information. In contrast to the OeNB's purely statistical approach, we propose to use both statistical and existing model-based approaches, as the ECB does. In contrast to the ECB, on the other hand, we attempt to set the weights for the aggregation of these approaches in a non-arbitrary way, as the OeNB tries to do.

Figure 1 | Approaches to House Price Sustainability Assessment and Their Importance within the Structure of the Housing Market



Source: Authors

3. Approaches to Assessing Equilibrium Property Prices in the Czech Republic

Owing to the high degree of heterogeneity of the family house and apartment block segments, house price sustainability is assessed on the apartment segment only. Approaches I, II and IV use data on apartment transaction prices published by the Czech Statistical Office (CZSO), which are available at quarterly frequency since 1999. Approach III draws on asking prices of apartments from the Institute for Regional Information (IRI), for which there are also corresponding data on rents. These data are available since 2000 at annual frequency and since 2007 at quarterly frequency. For each approach, we use the longest available data sample to assess equilibrium property prices taking into account the length of the time series of the variables considered. Use of house price misalignment estimates from all four approaches simultaneously is possible from the second quarter of 2000 onwards.

3.1. Approach I: General supply and demand model

The first approach to assessing equilibrium residential property prices, described in detail in Hlaváček and Komárek (2009),⁵ is a housing supply and demand model. As the measure of house price misalignment is that part of the price, which is not explained by the fundamental variables considered in the model, this approach is based on including as many housing supply and demand determinants as possible (see Table 1 for a list of the variables included). Compared to the model presented in Hlaváček and Komárek (2009), an important piece of information – the size of the housing stock *per* 1,000 inhabitants – had to be omitted from the explanatory variables due to a break in publication of the number of cancelled apartments by the CZSO. The updated model therefore includes the number of apartment completions *per* 1,000 inhabitants.⁶

Given the number of variables included in the model, equilibrium apartment prices are estimated by means of a single equation by linear regression, without including lags for the explanatory variables. Owing to the properties of the time series (some of which were assessed as stationary and others as integrated in first differences), the variables were incorporated into the model in logarithmic levels or differences (for a description of the transformations of the variables, again see Table 1). For this reason, the explained variable is apartment price growth and the degree of misalignment is calculated from the residuals of the estimate.

Similarly to Hlaváček and Komárek (2009)⁷, this supply and demand model indicates that apartment prices were overvalued in 2000 Q2–2004 Q4, in 2007 Q1–2008 Q3 and from

5 A similar model is presented by Égert and Mihaljek (2008) and by Hlaváček and Komárek (2011), regional approach is presented in Hlaváček and Komárek (2011).

6 The number of apartment completions may affect rather the price level because new apartments tend to be more expensive than older ones with similar characteristics.

7 A comparison of the estimated coefficients and basic model characteristics between our actualised approach and original approach by Hlaváček and Komárek (2009) is presented in an Appendix. In general actualised model repeats significance of the building plots prices and rents (coefficients even point to slightly stronger relationship), while the significance of the other variables disappeared. This is surprising for the wage growth, where the one-off structural breaks in the data (caused by tax changes) could have spoiled our results. Nevertheless, the overall model characteristics seem to be similar to the original model.

2013 Q3 to the present, and undervalued in 2005 Q1–2006 Q4 and in 2008 Q4–2013 Q2. The model estimates negligible overvaluation of 0.26% for 2014 Q2.

Table 1 | Variables Used in Supply and Demand Model (Approach I)

Supply determinants	Demand determinants
Land prices (d)	Marriage rate
Construction output price index	Divorce rate
Number of completed apartments excluding ABs	Natural population growth
Number of completed apartments excluding ABs / 1,000 inhabitants (d)	Unemployment rate
	Rate of economic activity
	Vacancies / labour force
	Monthly wage (d)
	Loans for house purchase (d)
	Interest rate (1Y PRIBOR)
	Ratio of FDI to GDP
Prices of rents (d)	

Note: “d” denotes first differences.

ABs – apartment buildings

FDI – foreign direct investment

GDP – gross domestic product

Source: Authors

A disadvantage of this model is that the large number of variables precludes the estimation of multiple equations. Consequently, this model cannot capture the endogenous links between house prices and some variables (such as land prices and rents) and may thus underestimate the deviation of prices from equilibrium. One advantage, by contrast, is that it includes supply factors, the omission of which from similar models in other countries is often criticised.

3.2 Approach II: Accelerator model

The second approach to estimating the gap in apartment prices is based on the long-run relationship between the business and credit cycle and the house price cycle (see, for example, Tsatsaronis and Zhu, 2004; Zhu, 2005, and Borio and McGuire, 2004). In simplified terms, higher economic growth fosters an increase in demand for housing *via* the income effect. Rising property prices meanwhile boost economic growth through

rising construction activity. The significance of loans is that they facilitate the purchase and construction of property and thus support this process. This effect is amplified by the improving income situation of loan applicants and the rising value of loan collateral.

The long-run equilibrium relationship between the business and credit cycle and the house price cycle is estimated using a vector error correction model (VECM).⁸ In this model, the cycles are proxied by GDP, loans for house purchase and the transaction price index, respectively. The VECM structure ensures that all three variables are explained as being endogenous, *i.e.* as influencing each other. The model involves estimating both the long-run equilibrium relationship between the variables and the short-run dynamics, whereby the variables return to equilibrium after straying from it. The long-run relationship is estimated in the model by the Johansen cointegration technique, which makes it possible to identify multiple relationships of this type in a system of more than two variables.

The misalignment of residential property prices is measured as the difference between the current price and the price given by this long-run relationship, *i.e.* as the deviation from the long-run equilibrium price. In this case, we depart from the methodology applied by some other authors that use VECMs to assess equilibrium house prices (*e.g.* ECB, 2011) and consider the residuals of these models as representing the departure of prices from equilibrium. As we are evaluating property price equilibrium from the perspective of the impact of house prices on household and bank balance sheets, which tend to contain such property for long periods (very often at least for the maturity of the mortgage in the case of banks and for a large part of the client's lifetime in the case of households), we consider it more appropriate to abstract from the short-run equilibrium dynamics estimated by VECMs.

Given the properties of the time series, we opted for a VECM with a linear trend in both the long-run relationship and the short-run dynamics. The inclusion of this linear trend is motivated by the convergence of house prices to the long-run equilibrium level, which started with the deregulation of property prices and to some extent will persist for the entire period of convergence of the Czech economy. As GDP has a lagged effect on wages and other relevant variables, we then had to incorporate a sufficient number of lags into the model. In light of the data frequency, a lag of four quarters was chosen. The estimated house price gap takes the form of:

$$gap_t = 13.12 + hp_{t-1} - 0.75 \log_{0.50} gdp_{t-1} - 0.34 \log_{0.09} cred_{t-1} + 0.01 trend_{t-1} + \varepsilon, \quad (1)$$

Where *hp* denotes house price index, *gdp* denotes gross domestic product and *cred* is household credit on housing. Standard errors are in parenthesis.

The model defined above, much like the preceding one, indicates that apartment prices were overvalued in 2002 Q2–2004 Q3, in 2007 Q3–2009 Q3 and from 2013 Q3 to the present, and undervalued in 2000 Q4–2002 Q1, in 2004 Q4–2007 Q2 and in 2009 Q4–2013 Q2. The model again indicates overvaluation of 2.1% for 2014 Q2.

The results reveal a relative narrowing of the estimated deviations of apartment prices from equilibrium over time, closer to the estimates obtained using Approach I (supply and demand model). This is probably due partly to the estimation method, as the speed of this house price convergence (which, due to the use of a linear trend, is implicitly

8 For applications of similar models, see Gimeno and Martinez (2010) for Spain and Iacoviello (2002) for European countries.

considered constant) is falling in reality because the bulk of the equalisation process has already occurred (the speed of adjustment probably falls as the gap in long-run equilibrium prices narrows). For this reason, earlier overvaluations and undervaluations estimated by the model may be larger and smaller, respectively, than they were in reality, whereas for more recent periods the opposite may apply (*i.e.* the overvaluations and undervaluations estimated by the model may be smaller and larger, respectively). However, another possible explanation is a “bottom-up” price bubble, with fundamentals temporarily slowing down and lagging behind apartment prices.

3.3 Approach III: Economic sense of home ownership

A metric frequently used by central banks to assess whether investing in residential property makes economic sense is the ratio of the apartment price to the annual rental costs (the price to rent ratio). This tells us the number of years a household would spend renting before being better off owning.⁹ However, some authors (see, for example, Himmelberg *et al.*, 2005, and Poterba, 1984) point out that this metric overestimates the benefits of investing in residential property, as it fails to take account of many of the other costs associated with property ownership over and above the purchase price. They propose comparing the annual costs of renting with the annual costs of owning. The latter include, among other things, mortgage interest costs net of tax deductions, property taxes, depreciation and the opportunity cost of the capital invested, less anticipated capital gains (Himmelberg *et al.*, 2005).

Given the prevalence of mortgage financing of residential property purchases in the Czech Republic and the tax deductibility of mortgage interest payments, we feel it is appropriate to consider other costs and savings when assessing the financial benefits of investing in residential property. However, when assessing house price misalignment we cannot rely solely on the aforementioned authors’ approach, as it expresses the overvaluation of the annual costs of owning and not the overvaluation of the total costs associated with owning. The approach involves “annual” incorporation of interest costs into the total costs of owning without allowing us to differentiate the varying distribution of the costs of owning over time. It therefore fails to reflect an important aspect of owner-occupied housing as a store of value: the costs associated with owning may be high at first, but fall substantially over the life of the mortgage.

For this reason, to assess the house price gap we opt for a method based on the ratio of the rent to the purchase price. However, we adjust this metric for mortgage servicing costs net of tax deductions for mortgage interest. We call this the “adjusted price to rent ratio”. For this purpose, we consider a “standard” mortgage with an LTV of 65% and a repayment period of 20 years.¹⁰ Based on these parameters, we use the market interest rate on loans for house purchase and the current income tax rate to calculate interest costs net of tax deductions. Together with the purchase price, these costs make up the total housing costs. The formula for such adjusted price to rent ratio (PR_{adj}) can be summarized as follows:

$$PR_{adj} = \frac{PP + IP(LTV = 65\%, M = 20Y)_{net\ of\ tax\ deductions}}{income}, \quad (2)$$

⁹ The inverse thus represents the investor’s rental return on the property.

¹⁰ The Belgian central bank, for example, employs similar assumptions (LTV 80%, repayment period 20 years) to assess the affordability of housing (NBB, 2012).

where *PP* denotes purchasing price, *IP* denotes interest payments, *LTV* is loan to value ratios, *M* is maturity and *Y* denotes years.

Unlike Himmelberg *et al.* (2005), we do not consider anticipated capital gains, the opportunity cost of the capital used to purchase housing or the tax costs associated with property ownership. The rapid rate of convergence of property prices to their long-run equilibrium levels makes it hard to set a realistic figure for anticipated capital gains. When developing this approach, we replaced the anticipated capital gain rate with the average rate of growth of apartment prices for the available time series, with the moving average of the annual rate of growth for a period of certain length, and with the rate of growth obtained by smoothing the property transaction price data using the Hodrick-Prescott filter with a high smoothing parameter. However, all these attempts produced unsustainable anticipated capital gains figures, confirming that this approach is not suitable for application to the Czech Republic. We additionally assume that when the return required by investors is held constant, growth in residential property prices is gradually reflected in an increase in rents and hence is not a factor that favours either alternative – housing or investment. Next, a decision to rent does not turn capital that would otherwise have been invested in buying a home into completely free funds. Instead, this capital is gradually consumed on rent, so the opportunity costs are also smaller in the long run. The property transfer tax rate was constant for most of the period under review and is therefore not relevant to the method for assessing this indicator.

A standard way of assessing statistics such as this is to determine their deviations from the supposed equilibrium level. The average for a sufficiently long and suitably chosen period or the trend obtained by means of the HP filter is usually chosen as the equilibrium value. We opt for the latter because the equilibrium levels of the indicator can also vary over time, just like they vary across countries and regions (Himmelberg *et al.*, 2005). In such case, results determined on the basis of a constant value would be significantly biased. In any case, the HP filter remains the only currently viable way of assessing the price to rent ratio for the Czech Republic, mainly because of a lack of data and the aforementioned short history of the free housing market in the Czech Republic. In addition, the timing of property market liberalisation differed from that of rent deregulation until 2012.

Our assessment of the price-to-rent ratio using this method indicates that apartment prices were overvalued in 2000 Q2–2002 Q1, in 2007 Q3–2010 Q3 and from 2013 Q3 to the present, and undervalued in 2002 Q2–2007 Q2 and 2010 Q4–2013 Q2. Following two quarters of slight overvaluation in 2013 Q3 and 2013 Q4, the model again indicates undervaluation of –3.19% for 2014 Q2.

One drawback of this approach, we feel, is that the entire deviation of the metric from the trend is attributed to non-equilibrium house prices. In reality, however, the markets for owner-occupied and rented housing are complements (a decrease in the share of owner-occupied housing leads to a rise in the share of rented housing), so it is reasonable to assume that if prices diverge from equilibrium in one market they will automatically do the same in the other. In our opinion, this approach may thus overstate the true deviation of housing prices from equilibrium.

3.4 Approach IV: Affordability of housing

The most common metric used by central banks to assess property price sustainability is the ratio of the apartment price to the annual income of households (the price to income

ratio). This tells us how long it takes the average household to earn enough to buy a home.¹¹ As in the case of Approach III (adjusted price to rent indicator), we consider the interest costs of an illustrative mortgage net of tax deductions in addition to the apartment purchase price. We refer to this metric analogously as the “adjusted price to income ratio”. As we lack data on the number of households updated at least on an annual basis, we consider individual income (in the form of the real wage) instead of household income.

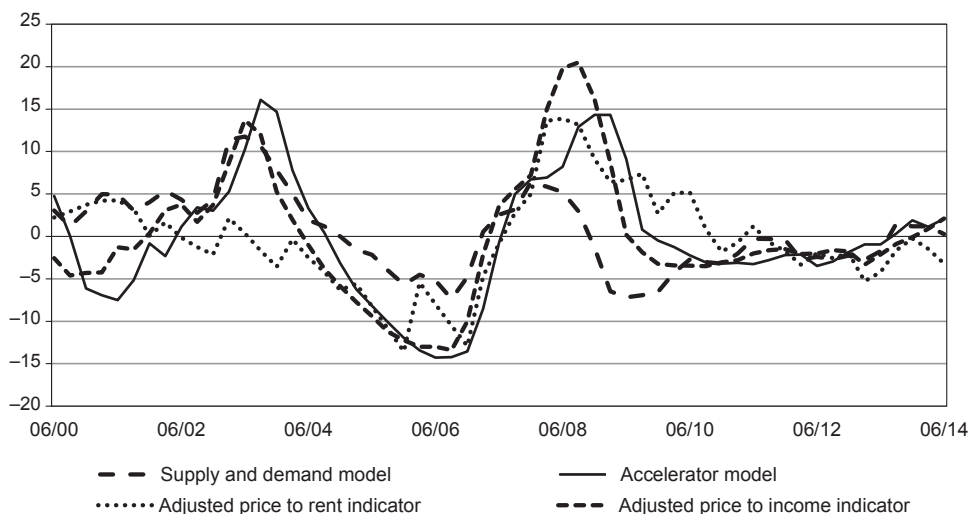
This metric is considered to be more stable over time than the price to rent ratio, but even in this case the equilibrium value can vary over time. However, the short data history for calculating the long-run average again leaves the deviation from the trend obtained using the HP filter as the only possible method for assessing this indicator.

Our assessment of the price to income ratio using this approach indicates that apartment prices were overvalued in 2001 Q4–2004 Q1, in 2007 Q2–2009 Q2 and from 2014 Q1 to the present, and undervalued in 2000 Q2–2001 Q3, in 2004 Q2–2007 Q1 and in 2009 Q3–2013 Q4. The model indicates overvaluation of 2.11% for 2014 Q2.

3.5 Comparison of estimates across approaches

The estimates obtained using Approaches I–IV largely agree on the periods of house price overvaluation and undervaluation. The only major differences occur at the start of the period under review, when flaws in modelling the convergence nature of the housing market are apparent for some of the approaches (see Figure 2). However, given that the approaches are supposed to reliably estimate the degree to which houses are misaligned at present, these historical discrepancies do not matter too much.

Figure 2 | Apartment Price Gap Estimates Obtained Using Different Approaches (in %)



Source: CNB, CZSO, IRI, Ministry of Regional Development (MRD), European Commission (EC), authors' calculations

¹¹ As with the price to rent ratio, the annual costs of owning can be considered instead of the total costs of owning. In such case, the ratio tells us what proportion of their income households have to spend on housing. To assess equilibrium property prices, however, we have to use total costs.

The approaches differ more widely in their estimates of the magnitude of the deviations. However, the relations between them conform to the assumptions made in Section 2. The smallest deviations are estimated by the general supply and demand model, which also considers the widest range of explanatory variables. The accelerator model indicates larger deviations confirming the synergistic interaction of property prices, economic activity and debt financing. The approaches based on assessing the economic sense and affordability of home ownership also generally estimate larger deviations than the general supply and demand model. This is because these models abstract from other property price factors.

4. Aggregate Assessment of Equilibrium House Price Information

A key issue as regards aggregating the house price misalignment estimates generated by the various approaches is how to set the weights for each of them. This task is complicated by the fact that the true deviation of house prices from equilibrium is not observed *ex post* and cannot be approximated either. In practice, therefore, we get into a situation where some estimates of price misalignment are “nearer” than others. On the one hand, this may be taken to mean that the former sent out strong signals about the deviation of prices from equilibrium, while the latter are not necessarily entirely accurate. On the other hand, the “farness” of the latter estimates may indicate that the former left out fundamental factors that are important price determinants or that the results were influenced to some extent by the estimation method.

The key factor in our choice of aggregation method was the belief that each of our chosen approaches yields additional information and that some of them (especially Approach III adjusted price to rent indicator and Approach IV adjusted price to income indicator) omit other important house price determinants. Our proposed aggregation method therefore employs two sets of weights reflecting the mutual “nearness” or “farness” of the individual estimates. By weighting the estimates from the various approaches by the two sets of weights separately we obtain two different aggregate estimates of the gap in apartment prices. Between these aggregate estimates, we obtain a range within which we believe the true deviation of prices from equilibrium lies. The “nearness” of the estimates is measured using correlation coefficients and their “farness” is obtained as the complement-to-one of the correlation coefficients. The first set of weights assigns a greater weight to the estimates the more correlated they are with the other estimates. As there is direct proportionality between the mutual correlations and the weight, we will provisionally denote the limit of the resulting interval obtained by weighting the estimates by this set of weights as “+”. The other set of weights assigns a greater weight to the estimates the less correlated they are with the other estimates. In this case the weights are indirectly proportional to the correlations between the individual estimates, so we denote the limit of the resulting interval obtained by weighting the estimates by this set of weights analogously as “-” (see Table 2). We can use the average of the upper and lower limit of this interval as a single piece of information for communication purposes.

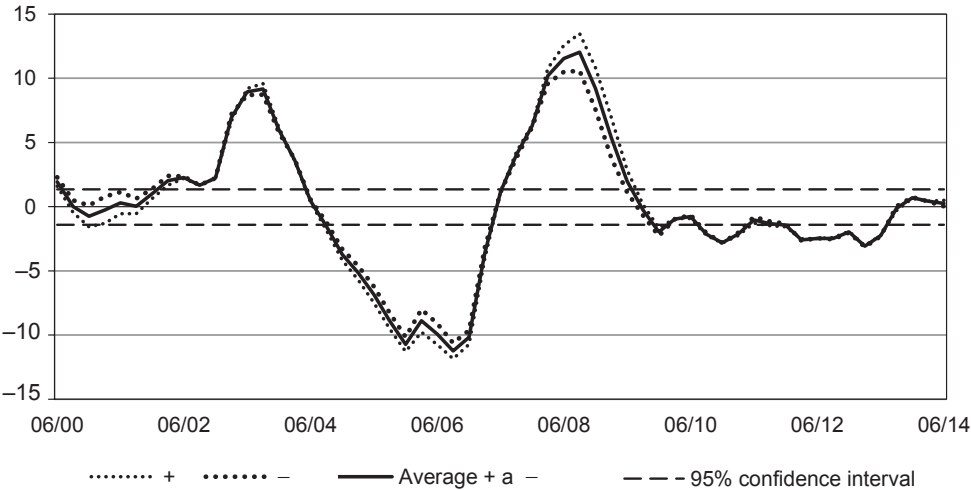
Given the inaccuracy inherently associated with assessing equilibrium house prices, we consider it important to set a band within which a slightly positive/negative apartment price gap is not regarded as an overvaluation/undervaluation. This “equilibrium house price band” was set as the 95% confidence interval based on the realistic assumption that the deviations of house prices from equilibrium are normally distributed.

Table 2 | Correlation Coefficients between House Price Gap Estimates and Weights Entering the Aggregate Estimate

	Correlation coefficient				Estimated gap	Weight	
	Approach	Approach	Approach	Approach	Individual (%)	+	-
	I	II	III	IV		(%)	(%)
Approach I	1				0.3	18.0	36.2
Approach II	0.47	1			2.1	27.5	21.1
Approach III	0.28	0.70	1		-3.2	24.0	26.7
Approach IV	0.59	0.87	0.80	1	2.1	30.6	16.1
Estimated gap Aggregate						0.5	0.0

Source: Authors' calculations

Figure 3 | Aggregated Apartment Price Gap Estimate (in %)



Note: "+" denotes the weighted average where the estimates from the various approaches are assigned a greater weight the more correlated they are with the other estimates, and "-" denotes the weighted average where the estimates from the various approaches are assigned a greater weight the less correlated they are with the other estimates.

Source: CNB, CZSO, IRI, MRD, EC, authors' calculations

The above method for aggregating estimates from multiple approaches is essentially very similar to the one chosen by the OeNB. Both aggregation methods are based on a co-

relation matrix between the data intended to be aggregated. The OeNB bases its assessment solely on indicators associated with house price sustainability, which it first aggregates into an overall indicator and only then assesses that indicator in relation to the long-run average. For this reason, the OeNB applies the principal components method to filter out the part of the variability in the input indicators which is not associated with the deviation of house prices from equilibrium. By contrast, our approach uses a combination of statistical and model-based approaches. This means that some indicators associated with house price sustainability and other variables first enter models that filter out the part of their variability which is not associated with the deviation of house prices from equilibrium and provide information directly on property price misalignment. The two statistical approaches are handled similarly, with both effects (smoothing and assessment) being achieved using the HP filter. Our approach thus involves aggregating equilibrium house price information that has already been smoothed and assessed, so we do not need to apply the principal components method to each estimate of the deviation of prices from equilibrium. Consequently, the correlation matrix can be used for the aggregation approach that assigns more weight to more and less correlated estimates respectively, as described in the previous section.

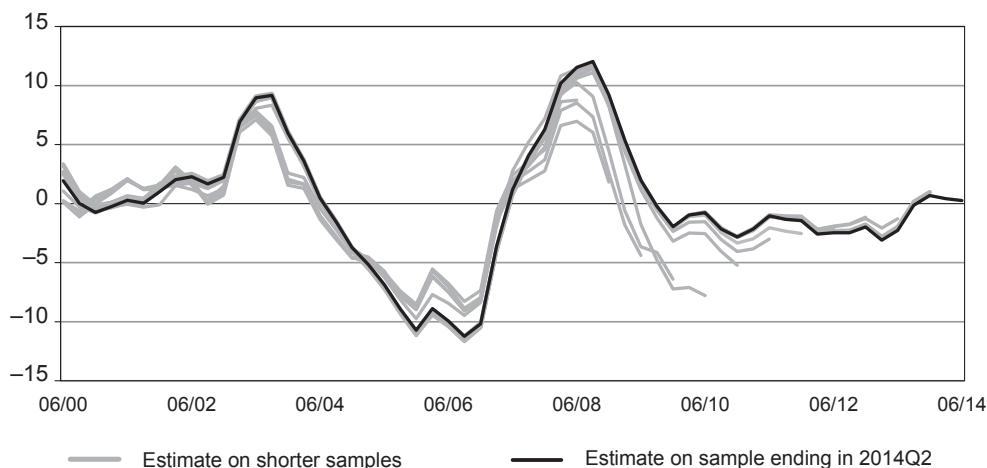
As the estimates obtained from the different approaches yield very similar information, the interval for the probable deviation of prices from equilibrium obtained in this way is not wide at the moment (see Figure 3). However, the advantages of our aggregation method are fully realised when the individual estimates differ more substantially. Using this comprehensive method for evaluating equilibrium prices, we assess prices as having been overestimated in 2002 Q1–2004 Q1 and 2007 Q3–2009 Q2, and undervalued in 2004 Q4–2007 Q1 and in 2010 Q3–2013 Q2. In 2014 Q2, apartment prices are assessed as being approximately at their equilibrium level.

As mentioned earlier, however, the true overvaluation of property prices is not observable even *ex post* and its determination is complicated by other difficult-to-estimate factors such as the rate of growth of property prices due to the convergence of the Czech economy. For these reasons, methods that can potentially generate end-point bias are employed to estimate the deviation of house prices from equilibrium. To ascertain whether such bias is present, the full method for assessing property prices was applied to a total of 15 time samples – the entire period under review (until 2014 Q2) and another 14 periods, each of them two quarters shorter than the last. The period up to 2010 Q2 was the shortest one for which the deviation of prices from equilibrium was obtained using all four approaches. This period is so short that when it is shortened by a further two quarters the number of observations is not sufficient to estimate the accelerator model using the VECM, which thus generates unrealistic results.¹² The aggregated estimates for the period up to 2009 and shorter periods are thus obtained using the three remaining approaches only. Assessing the significance of end-point bias involves inspecting whether the results for the final quarters of each period were more significantly “revised” by estimation on longer data samples. Figure 4 shows that the aggregated estimates for the individual quarters after 2010 do not differ when estimated on progressively longer data series, so our comprehensive approach to assessing property price misalignment is consistent over time.

12 For this reason, the aggregated result for the shortest period on the longer data sample is also the most significantly “revised”, since the VECM has proved to be relatively inaccurate on short samples.

However, if we were to conduct an analogous analysis of the “revision” of the estimates on longer data samples in each approach, we would observe less stable estimates at the ends of the periods under review for the adjusted price-to-rent and price-to-income ratios, larger revisions for the supply and demand model and increased inaccuracy for the VECM. The more robust results obtained after aggregating these estimates thus further emphasises the advantages of assessing property price sustainability using a combination of approaches.

Figure 4 | Robustness Analysis of the Aggregated Estimate of the Apartment Price Gap (in %)



Note: Given the low number of observations available for estimating the accelerator model (VECM) for data samples ending in 2009 Q4 and earlier, the aggregated estimate is calculated using the three remaining approaches only.

Source: CNB, CZSO, IRI, MRD, EC, authors' calculations

5. Conclusion

In this article we describe various methods proposed for assessing equilibrium property prices in the Czech Republic and a way of evaluating the results of these methods in aggregated form.

The methods include (i) demand and supply model, (ii) financial accelerator model and (iii) adjusted price to rent and (iv) adjusted price to income indicators, both adjusted for user costs specific to the Czech Republic. As such, each of the approaches addresses one of the structural features of market with housing, which are i) the mutually reinforcing effect between house prices, real economy and financial sector, ii) the role of budget constraints and credit conditions related to the property purchase and iii) the dual character of housing as a consumption good and investment asset. In this way, the methods complement each other and provide complex information for house price sustainability assessment.

The aggregation method then takes into consideration both the strength and diversity of information obtained from individual approaches. On the one hand, similar results obtained from individual approaches point at higher probability that the true house price under- or overvaluation is of the given size. On the other side, more diverse results favour use of various approaches with additional information possibly embedded in each of them.

The results indicate that residential property prices in the Czech Republic are currently close to their equilibrium level or slightly overvalued. The different approaches are sending out very similar signals and are robust to length of the data sample. As pointed out in similar analyses of house price sustainability conducted by other authors, the complex structure of the residential property market means that each of the methods has its drawbacks, so the aggregate assessment of their results should also be taken only as a guide. Although the empirical approaches to assessing equilibrium property prices presented in the article provide new insights into the evolution of house prices, assessing property prices still requires expert judgement and is inevitably somewhat subjective.

Appendix

Results of Approach I (general supply and demand model)

Variable	Model by Hlaváček, Komárek (2009)		New estimate	
Period	1Q 1998–2Q 2009		1Q 1998–4Q 2014	
Apartment prices ^a	Coefficient	Std. dev. ^b	Coefficient	Std. dev. ^b
Building plot prices ^a	0.481*	0.240	0.849*	0.502
Construction output price index ^a	−0.576	0.504	−0.941	0.743
Completed apartments ^{a, c}	0.000	0.000	0.000	0.000
No. of apartments per 1,000 inhabitants ^d	0.000	0.001	0.668	1.269
Marriages ^c	0.963	0.968	0.303	0.643
Divorces	0.120	0.496	0.260	0.586
Natural population growth ^c	0.665	0.528	−0.188	0.338
Net migration	0.100*	0.057	0.006	0.147
Unemployment rate	0.004	0.006	−0.007	0.009
Economic activity	−0.0055	0.006	0.000	0.002
Vacancies/labour force	0.101**	0.049	0.016	0.071
Average monthly wage ^{a, c}	1.215***	0.424	0.104	0.272
Rent per month ^a	0.459**	0.195	0.492***	0.117
Loans ^a	0.048	0.061	0.064	0.153
1Y Pribor	0.003	0.003	−0.002	0.004
Ratio of FDI to GDP	0.000	0.001	0.000	0.001
Adjusted R ²	0.540	–	0.530	–
Durbin-Watson statistics	1.780	–	1.200	–

Note: ^a differences, ^b Newey-West HAC standard deviations, ^c seasonally adjusted, ^d for “new” model Number of completed apartments excluding apartment buildings/1,000 inhabitants

Source: CZSO, IRI, Hlaváček and Komárek (2009), authors’ calculations

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