A COMPREHENSIVE METHOD FOR HOUSE PRICE SUSTAINABILITY ASSESSMENT

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This article describes the house price equilibrium assessment process used by the CNB in its decision-making on macroprudential measures intended to mitigate risks associated with loan financing of residential property purchases. It first explains why it is necessary to use multiple models simultaneously to correctly assess house price sustainability. It goes on to describe the approaches the CNB currently applies to estimate house price misalignment and discusses their results. It then presents a method for aggregating the estimates produced by those approaches and provides an aggregate assessment of the results. 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 third quarter of 2009.

1. INTRODUCTION

The macroprudential policy tools currently applied in European countries include forms of regulation of property market exposures.[1] 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, assess house price sustainability and refine the methods they use for such assessments. The CNB has been assessing the evolution and sustainability of property prices in its Financial Stability Reports since the first FSR 2004. Advanced approaches have been described in articles by Hlaváček and Komárek (2009, 2010, 2011). This article sets out to update the previously applied approaches to assessing residential property prices, describe newly developed approaches 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 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.[2] One example of the "right" sort of property price growth is the case of a positive technology shock, with rising productivity leading to growth in wages and housing demand and, in turn, to growth in house prices. An example of the "wrong" sort of growth is a situation where the initial "right" property price growth is misperceived by households and leads to expectations of future price growth. Fearing a further rise in prices, or seeking a "good" investment, households increasingly buy housing on credit. This pushes prices up further, above the level caused by the initial rise in productivity. 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.[3]

This article is organised as follows. Section 2 discusses differences in approaches to assessing equilibrium house prices. Section 3 describes specific forms of these approaches as used by the CNB to estimate the house price gap. Section 4 presents a method for aggregate assessment of the results of such approaches. Some approaches to assessing house prices have been described in previous Financial Stability Reports. However, these methods have gradually been updated and new ones have been added as the Czech property market has developed. Even so, the methodology is not 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 the Czech Republic. The method presented in this article for the aggregate assessment of various estimates allows for such ongoing refinement.

1 The most common are limits on the loan-to-value (LTV) and loan-to-income (LTI) ratios and increased risk weights for the calculation of capital requirements for loans. For a description of these measures, see section 5.4 of FSR 2013/2014, pp. 99–102.

2 "*The job of macroprudential policies is to ensure that the financial system does not become so vulnerable that the shocks ultimately cause financial instability in the form of a crisis.*" (Frait and Komárková, 2011)

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

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 convergence nature of the Czech economy, which has undergone rapid mortgage market development and housing market liberalisation; (iii) rent deregulation, which continued until 2012 (see also Hlaváček and Komárek, 2009), (iv) the importance of the construction industry for economic activity, (v) the degree to which property purchases are debt-financed, and (vi) the combined consumption and investment nature of housing.

Equilibrium residential property prices should be explainable primarily by the determinants of demand (e.g. demographic indicators, the income situation of households and interest rates) and supply (e.g. prices of land and building work and the size of the housing stock; see Approach I applied by the CNB). 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 potentially significant fundamental house price factor can mean that the approach wrongly assesses house price growth driven by that factor as equilibrium growth. 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 and the degree of overvaluation 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 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.[4] 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 applied by the CNB).

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,[5] it constrains further growth in house prices to some extent (see Approach IV applied by the CNB).

From the viewpoint of demand for housing as a good 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 applied by the CNB).

So, one consequence of the nature of residential property is that there are numerous approaches to assessing equilibrium house prices. 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.

4 A well-known recent example with negative impacts on the real economy and the financial system is the construction boom in Spain.

5 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.

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 CNB, like the Belgian, German, Italian and Irish central banks, for example,[6] has so far used a combination of statistical and model-based approaches. It has always tried to make maximum use of equilibrium house price information (see the previous discussion and Approaches I–IV applied by the CNB).[7] However, 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 ECB, which uses four approaches to determine property price equilibrium – two model-based ones and two statistical ones.[8] 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). The CNB intends to employ a combination of the two approaches described above to assess such information. In contrast to the OeNB's purely statistical approach, the CNB plans to use both statistical and existing model-based approaches, as the ECB does. In contrast to the ECB, on the other hand, it attempts to set the weights for the aggregation of these approaches in a non-arbitrary way, as the OeNB tries to do.

3. APPROACHES TO ASSESSING EQUILIBRIUM PROPERTY PRICES USED BY THE CNB

The CNB has published results of equilibrium property price assessments in its Financial Stability Reports regularly since 2004. It currently employs four approaches – two model-based ones and two statistical ones.

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 CZSO, which are available at quarterly frequency since 1999. Approach III draws on asking prices of apartments from the Institute for Regional Information, for which there is 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 FSR 2008/2009 (Hlaváček and Komárek, 2009),[9] 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 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 in the model). Compared to the model presented in FSR 2008/2009, 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. If this series is resumed, information on the number of apartments will be included in the model again, as we believe that

6 For a description of the models used by other central banks, see, for example, Kajuth et al. (2013), Nobili and Zollino (2012) and McQuinn (2004).

7 In this article we focus on comparing approaches to assessing house price equilibrium for macroprudential policy decision-making. 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).

8 The CNB uses the same number of approaches. As residential property markets are largely country-specific, price sustainability assessment approaches tend to differ from country to country. The ECB method described above is applied to eight countries. Given the universal application of the same approaches to all those countries, however, the resulting estimates obtained using the individual approaches within each country differ widely.

9 A similar model is presented by Égert and Mihaljek (2007).

excess demand/supply explains apartment price dynamics better than the currently used information on apartment completions.[10] The model therefore temporarily includes at least the number of apartment completions per 1,000 inhabitants.

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 in the model, 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.

This supply and demand model indicates that apartment prices were overvalued in 2000 Q2–2004 Q4, in 2007 Q1–2008 Q3 and from 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.

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.

A similar model is estimated using panel regression on annual data for the individual regions of the Czech Republic. This allows us to capture the heterogeneity of property prices across regions.[11]

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 (see the thematic article *The central bank's primary objectives and the interaction of monetary and macroprudential policies in the pursuit of those objectives* in this Report).

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).[12] 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

TABLE 1

VARIABLES AND THEIR TRANSFORMATIONS IN THE HOUSING SUPPLY AND DEMAND MODEL (APPROACH I)

Supply determinants	Demand determinants
Land prices (d)	Marriage rate
Construction output price index (d)	Divorce rate
No. of completed apartments excluding ABs	Natural population growth
No. 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
Apartment prices (d)	
Rents (d)	

Source: Authors' calculations based on CNB, CZSO, IRI and MRD data
Note: "d" denotes first difference.

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

11 See Hlaváček and Komárek (2010) and Mikhed and Zemčík (2009).

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

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 central banks 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 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. 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 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.[13] 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

13 The inverse thus represents the investor's rental return on the property.

a repayment period of 20 years.[14] 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. 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 HP 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.[15] As in the case of Approach III, 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

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

15 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.

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 Chart 1). 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.

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

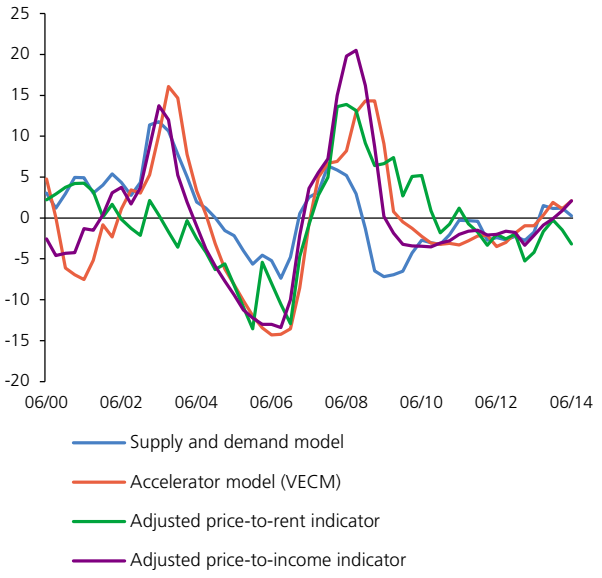
A key issue as regards aggregating the house price misalignment estimates generated by the various approaches is how to set the weights for each of them. This task is complicated by the fact that the true deviation of house prices from equilibrium is not observed ex post and cannot be approximated either. 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 send 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

CHART 1

APARTMENT PRICE GAP ESTIMATES OBTAINED USING DIFFERENT APPROACHES

(%)



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

information and that some of them (especially Approaches III and IV) 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.

TABLE 2

CORRELATION COEFFICIENTS BETWEEN HOUSE PRICE GAP ESTIMATES AND WEIGHTS ENTERING THE AGGREGATE ESTIMATE

	Correlation coefficient				Weight	
	Approach I	Approach IV	Approach III	Approach II	+	-
Approach I	1				18.0%	36.2%
Approach IV	0.59	1			30.6%	16.1%
Approach III	0.28	0.80	1		24.0%	26.7%
Approach II	0.47	0.87	0.70	1	27.5%	21.1%

Source: Authors' calculations.

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.

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 correlation 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, the CNB 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.

The CNB's approach 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

CHART 2

AGGREGATED APARTMENT PRICE GAP ESTIMATE

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

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 Chart 2). 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

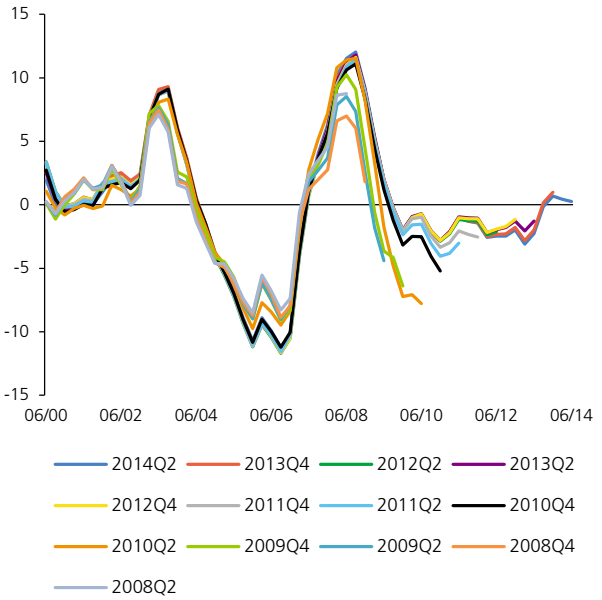
(until 2014 Q2) and another 14 periods, each of them two quarters shorter than the last. The period up to 2010 Q2 was the shortest one for which the deviation of prices from equilibrium was obtained using all four approaches. This period is so short that when it is shortened by a further two quarters the number of observations is not sufficient to estimate the accelerator model using the VECM, which thus generates unrealistic results.[16] 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. Chart 3 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.

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.

CHART 3

ROBUSTNESS ANALYSIS OF THE AGGREGATED ESTIMATE OF THE APARTMENT PRICE GAP

(%)



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

Note: The data in the legend refer to the final quarter of the data sample considered. 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.

5. CONCLUSION

In this article we described various methods for assessing equilibrium property prices and a way of evaluating the results of these models in aggregated form. The results indicate that residential property prices in the Czech Republic are currently close to their equilibrium level. The different approaches are sending out very similar signals. As pointed out in similar analyses of house price sustainability conducted by other central banks, 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. It is important to know the drawbacks of each model used (such as end-point bias) and to assess their significance at the given moment.

16 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.

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