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Assessing Residential Real Estate prices in Slovakia: Possible Approaches and Indices

Martin Cesnak^a, Ján Klacso^b, Patrik Kupkovič^c, Andrej Moravčík^d, Štefan Rychtárik^e, Roman Vrbovský^f

Abstract

The residential real estate market in Slovakia is very important, both from the perspective of macroeconomy and financial stability. Home ownership is very high and housing loans form a large part of the banks' assets. Therefore, the National Bank of Slovakia follows thoroughly the development on this market. Residential real estate data are quarterly published, and the development of real estate prices is assessed in regular publications, such as the Economic and Monetary Developments or the Financial Stability Report. For a better understanding of the development on this market, different indices have been developed. The list includes composite indices, housing affordability indices and macroeconomic models estimating real estate prices or studying the impact of different shocks on these prices. This paper gives an overview of the recently used RRE-related indices and serves as a methodological note to the RRE dashboard that is available on the NBS website.

JEL code: G12, E37, R21, R31

Keywords: residential real estate prices, macroeconomic models, housing affordability, composite index, structural models

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Introduction

Residential real estate (RRE) is of a significant importance, both to financial and macroeconomic stability. Housing represents a major part of household wealth and bank assets (ESRB, 2022). Real estate bubbles and their burst is in general associated with economic and/or financial crises (Crowe, et al., 2013). Central banks, supervisory and macroprudential authorities are thus closely following the development on the real estate market.

Slovakia is not an exception. Housing is the main investment of the majority of Slovak households. Ownership rate is very high, nearly 90% (Cupák, et al., 2023). Household indebtedness is also steadily growing due to housing loans. In 2021, every fourth household and every second young household aged up to 44 years had a housing loan. These loans represent more than one third of the banks' assets and more than half of their loan portfolio, making them a key part of banks' business model.

The National Bank of Slovakia (NBS) publishes quarterly residential real estate prices¹ and comments on their development in regular publications, such as the Economic and Monetary Developments² or the Financial Stability Report³. For a better understanding of the development on this market, different indices have been developed within the NBS.

The list of indices includes composite indices, compiling information from a larger set of real estate-related variables, affordability indices assessing the affordability of real estate properties from a perspective of a household using external finance in form of a housing loan, but also more macroeconomic-based estimations of real estate prices or structural models studying the impact of macroeconomic shocks on these prices. In general, there is no single perfect measure or index of real estate prices that could answer the question of over- or undervaluation of the prices. Thus, it is important to maintain a whole list of useful valuation measures, as all of them can shed light on the actual development from a bit different angle and perspective.

This paper gives an overview of the recently used RRE-related indices. The paper lists the data used for the construction, discusses the methodology and the economic interpretation of the respective indices. The paper serves as a methodological note to the RRE dashboard that is available on the NBS website.

¹ <https://nbs.sk/en/statistics/selected-macroeconomics-indicators/residential-property-prices/>

² <https://nbs.sk/en/publications/economic-and-monetary-developments/>

³ <https://nbs.sk/en/publications/financial-stability-report/>

The paper is organized as follows. The next section gives an overview of the composite index used at the NBS. It describes the data used, the methodology and gives a brief economic interpretation of the index. Sections 2 to 4 are related to the description of various housing affordability indices. Section 5 is dedicated to the macroeconomic approach of estimating real estate prices while section 6 introduces a structural VAR model used for the assessment of different economic and financial shocks on these prices. Finally, we conclude.

1 Composite index

Composite indices are widely used tools to easily present a broad range of information gathered from different data and indices. They are created to conduct analysis, measure economic trends, or forecast (market) activity. As they combine different type of information, they are also a natural candidate to assess the development of real estate prices.

1.1 Data used

The aim of the Composite index is to relate house price dynamics to other, closely connected fundamental indicators in a simplified way. To capture the development of fundamentals, five partial indicators are considered:

- **real house price:** ratio of nominal real estate price in EUR per square meter and final consumer expenditure of households deflator⁴
- **price-to-rent ratio:** nominal real estate price in EUR per square meter to average monthly rent in EUR
- **price-to-income ratio:** nominal real estate price in EUR per square meter to gross disposable income per capita in EUR
- **housing loans-to-GDI ratio:** the volume of housing loans to gross disposable income
- **residential construction-to-GDP ratio:** the volume of residential construction to GDP⁵

More details about the respective data used (source of the data, access to data if publicly available) can be found in Appendix A.

⁴ There are various suitable choices for the price level measure that can be used, such as HICP or CPI. We opted for final consumer expenditure of households deflator, based on the OECD methodology. The deflator is provided by the Statistical Office of the Slovak republic.

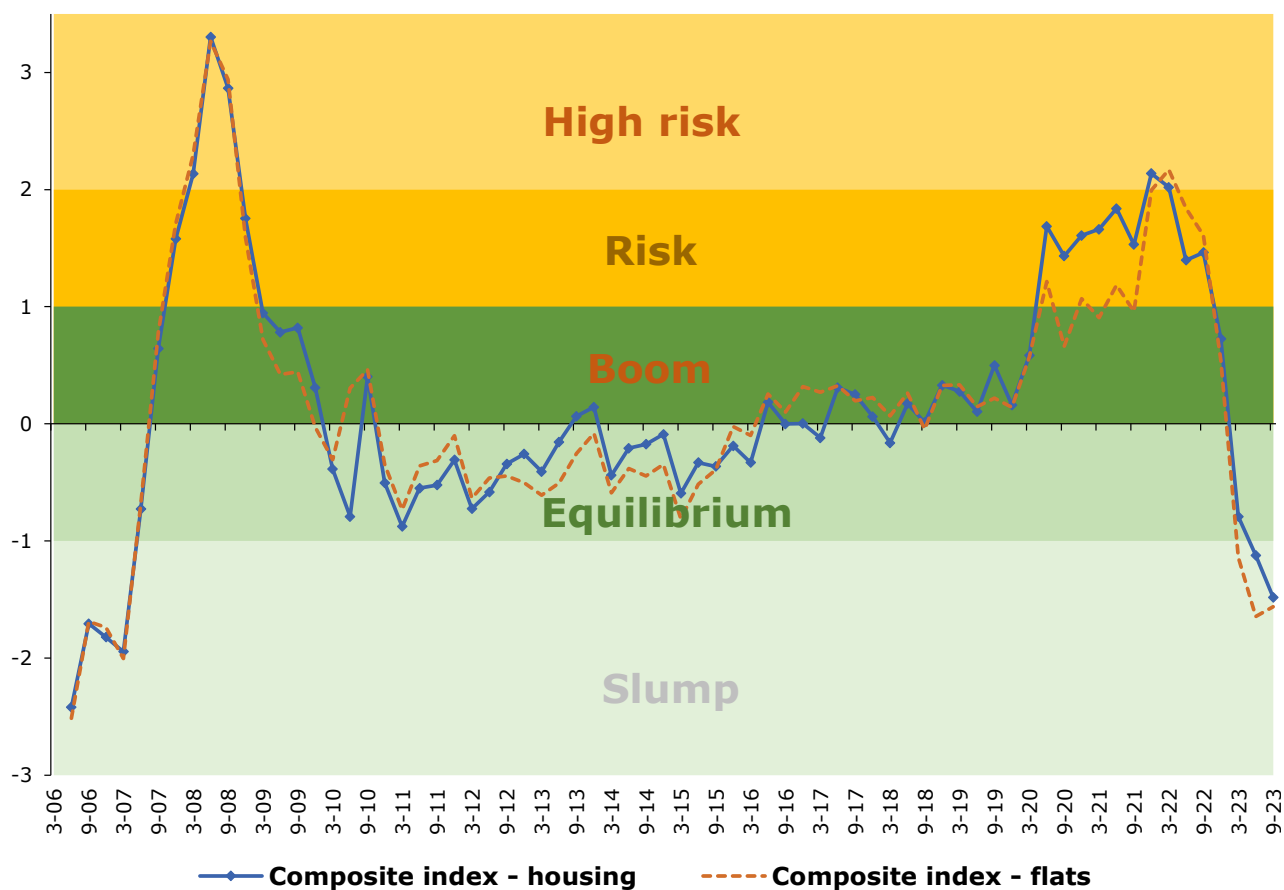
⁵ Construction of residential buildings is a subindex of construction production index. Data are provided by the Statistical Office of the Slovak republic.

1.2 Methodology

To ensure stationarity, all partial indicators are detrended using Hodrick-Prescott filter⁶. Also, all the indicators are standardized to zero mean and standard deviation equal to 1. The composite index is a linear combination of the described five detrended and standardized indicators. To estimate weights, principal component analysis was used. Therefore, they are based on the eigenvector of the highest eigenvalue of the correlation matrix of the indicators.

It is important to notice that seasonal adjustment and revisions done by the Statistical office as well as detrending in previous steps affect past values of the composite index. To compensate for these adjustments, NBS typically publishes only the latest point estimate, while the previous values remain fixed. More details about the methodology are available in (Cár & Vrbovský, 2019).

Chart 1 Composite index



Source: NBS, NARKS, SO SR, and United Classifieds.

⁶ A standard smoothing parameter, $\lambda = 1600$, is used.

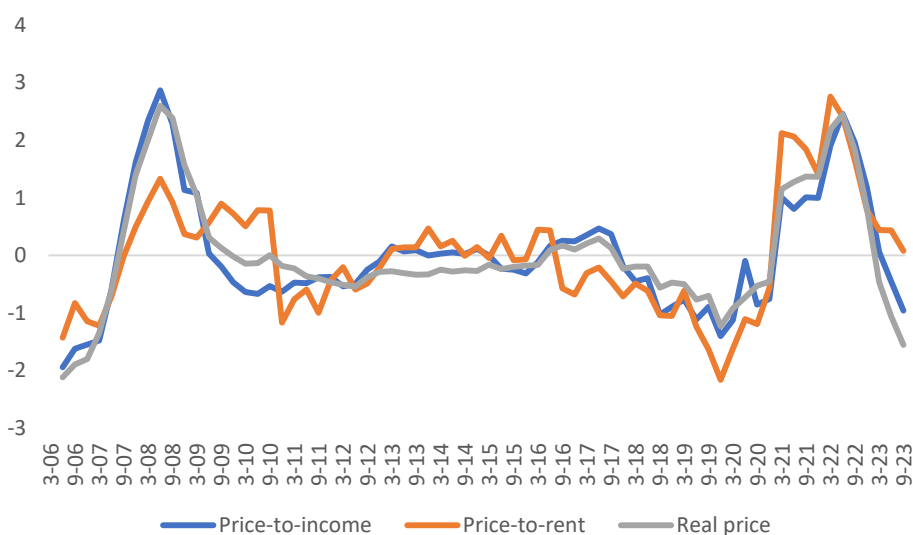
1.3 Economic interpretation

Each subindex relates property prices to other relevant fundamental variables. Real house price explains how expensive is to buy a property in terms of households' consumption expenditure. The price-to-rent ratio is a standard indicator proxying how expensive is to hold a property compared to renting it and vice versa. While in Slovakia the rental market is in general underdeveloped, it has some explanatory power, especially in the Bratislava region. Price-to-income is another standard measure of how expensive the property is compared to the average income in the economy. As currently a large share of properties is gained through housing loans, the next indicator, housing loans-to-GDI ratio is a proxy of how saturated the market with housing loans is. When there is strong demand for real estate and prices are increasing, one can expect also robust construction activities. This is captured by the last index, residential construction-to-GDP.

In all cases, the higher is the value of the respective subindex, the less space is left for property prices to grow. Therefore, also in the case of the Composite index, higher values indicate more "overheated" property prices. The most impactful indicators are subindices containing the residential property price itself: price-to-rent, price-to-income, and real price (Chart 2).

The values of the subindices should be interpreted as deviations of the ratio indicators from their long-term trend. Therefore, it is important to note that the index does not tell anything about the sustainability of these trends. In the case of the Composite index, instead of interpreting the values as being "n-standard deviations away from the long-term trend", non-technical labels ranging from "High risk of price correction" to "Slump" were adopted. The labels are arbitrary and potentially may be subject to change in the future.

Chart 2 Main subindices



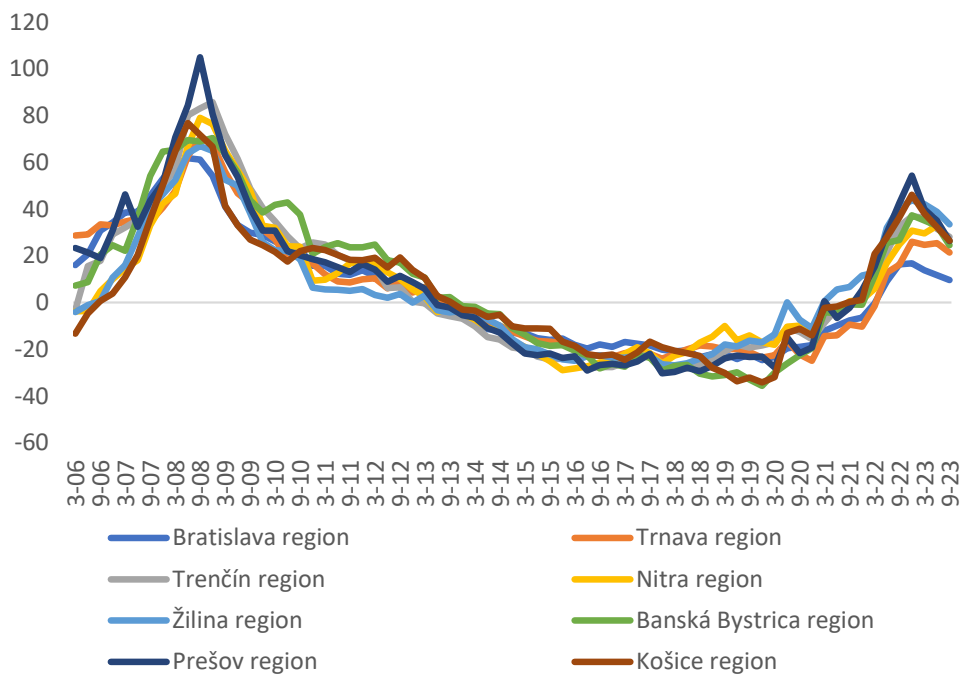
Source: NBS, NARKS, SO SR, and United Classifieds.

2 Regional housing affordability index

Housing loans are increasingly used when buying a property. Based on the latest HFCS⁷ data, one quarter of the Slovak households and every second young household aged up to 44 has a housing loan (Cupák, et al., 2023). It is therefore also important to assess, how manageable is to own a property with the help of a housing loan. This assessment can be done using so called housing affordability indices. These indices do not consider only the value of the property and the income of the households, but also different features of the housing loan, like pre-payment, maturity, interest rate, etc. The NBS is currently using 3 different types of housing affordability index, the first explained in this section.

2.1 Data used

Chart 3 Housing affordability index



Source: NBS, NARKS, SO SR, and United Classifieds.

Note: Deviations from long-term mean. The graph compares Housing affordability index in respective Slovak regions.

⁷ Household Finance and Consumption Survey. More details about the survey are available at the [NBS website](#).

Housing affordability index compares the value of the adequate income, needed to purchase a residential property, to the average monthly wage in each Slovak region⁸. The calculation of the adequate income is based on the following data:

- current house prices (from United Classifieds and NARKS)
- interest rates for new housing loans (NBS data).

Data are disseminated by the Statistical Office of the Slovak Republic; the series are subsequently seasonally adjusted.

2.2 Methodology

In the calculation of the adequate income, we assume that the borrowing household will be taking mortgage for 20 years, with interest rate corresponding to the current interest rates for new housing loans. We assume that the loan will cover 70% of the buying price of the dwelling, which is the size of 60 m². The price of the dwelling is based on NBS residential property prices in EUR per square meter per region. Furthermore, we assume that only one quarter of the household income should be dedicated to the payment of the mortgage, i. e. that the debt service-to-income ratio, DSTI is equal to 25%. The adequate income is then compared to the nominal monthly wages per region, multiplied by the average number of economically active persons in a household per region (census data). More technical details of the calculation are provided in Appendix B.

2.3 Economic interpretation

The ratio of adequate income to the actual income is presented as a deviation from long-term mean. The higher is the value of the index, the less is the assumed 60 m² property affordable to an average household in a given region, using housing loans with the assumed parameters. The past values are subject to corrections, due to seasonal adjustment of wages.

3 Inverse housing affordability index

Inverse housing affordability index is defined as the share of the disposable household income and the debt service that is required to repay a notional loan for the purchase of a flat. While in case of the previous index, the adequate income was expressed as a share of average monthly

⁸ Regional data structure is the main reason why we decided to use wages instead of disposable income. For simplicity, we use gross wages.

wage, here the monthly income is expressed as a share of the debt service needed. It means that higher values of the index point to higher affordability.

3.1 Data used

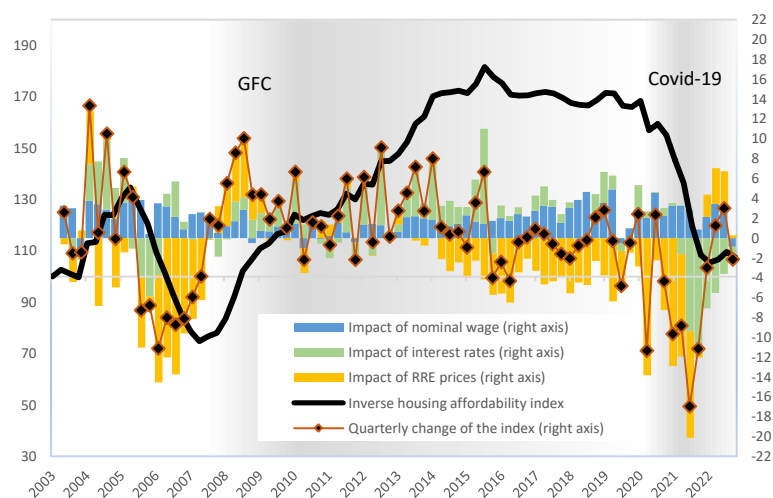
Disposable household income is calculated as the average net income of two working people in Slovakia after deduction of subsistence minimum and reduction by 40%. The average net income is calculated from the average monthly wage published by the Statistical office. Official NBS statistics about flat prices (from United Classifieds and CMN) and interest rates for new housing loans (NBS data) enter the calculations.

3.2 Methodology

Again, it is assumed that the household will co-finance the purchase of a flat with a housing loan. The maturity of the housing loan is assumed to be fixed for the whole period and equal to 23 years. The interest rate corresponds to the average interest rate for new housing loans. The loan will cover 90% of the price of the flat, i. e. LTV = 90%. The assumed size of the flat is 80 m². The debt service of such a loan can be calculated as discussed in Appendix B, using the assumed parameters provided above.

Disposable household income consists of two net average wages which are reduced by subsistence minimum and by 40%. It means that the assumed DSTI based on income adjusted by the subsistence minimum is 60%. The impact of the 3 individual factors (average wage, interest rate and real estate price) can be expressed as a share of the change in the index. It is important to note that while there are some differences in the parameters assumed for the calculation of the two housing affordability indices, these have an impact mainly on the level of the indices and not on the trends.

Chart 4 Inverse housing affordability index



Source: NBS, CMN, SO SR, and United Classifieds.

Note: Loan amount and maturity are fixed. GFC – Global Financial Crises.

3.3 Economic interpretation

The share of the disposable household income that is required to repay the loan for the purchase of a flat expresses the ratio of mortgage payment on disposable household income. Higher values indicate that the affordability is improving, i. e. that a household with two average wages can more easily afford an 80 m² flat using the assumed housing loan in case they have the necessary down payment.

4 Borrowing capacity indicator

4.1 Data used

The borrowing capacity indicator (BCI), originally developed by (Andrle & Plašil, 2019), assesses house prices based on maximum attainable volume of loan(s) for a given household. To assess house prices in Slovakia, we use several variables from different sources:

- Time series of average gross wage from the Statistical Office of Slovak Republic is seasonally adjusted. **Net income** is then calculated based on the assumption of fixed share of taxes (19%) and other deductions (13.4%).
- **Subsistence minimum** is based on applicable legislative framework at the time.⁹
- We use **average interest rates on new housing and consumer loans** granted in the given quarter. The source of the data is NBS.
- We also take **borrower-based measures (BBMs)** introduced by NBS into account with respect to their gradual tightening. More precisely, we use debt service-to-income (DSTI) limit (including interest rate buffer of 2 p.p. above the applicable rate), loan-to-value (LTV) limit, debt-to-income (DTI) limit and maturity limits (30 years for mortgage loans and 8 years for consumer loans, both fixed for the whole analysed period).¹⁰
- To obtain **average real estate prices**, we multiply the average price in EUR/m² in a given quarter by the average size of properties for the whole period. Both time series are taken from the NARKS (until 2021) and United Classifieds (since 2021) databases.

The BCI estimation starts from 2005Q1 due to different lengths of time series.

⁹ Available on the webpage of the Ministry of Labour, Social Affairs and Family of the Slovak Republic: <https://www.employment.gov.sk/sk/rodina-socialna-pomoc/hmotna-nudza/zivotne-minimum/>.

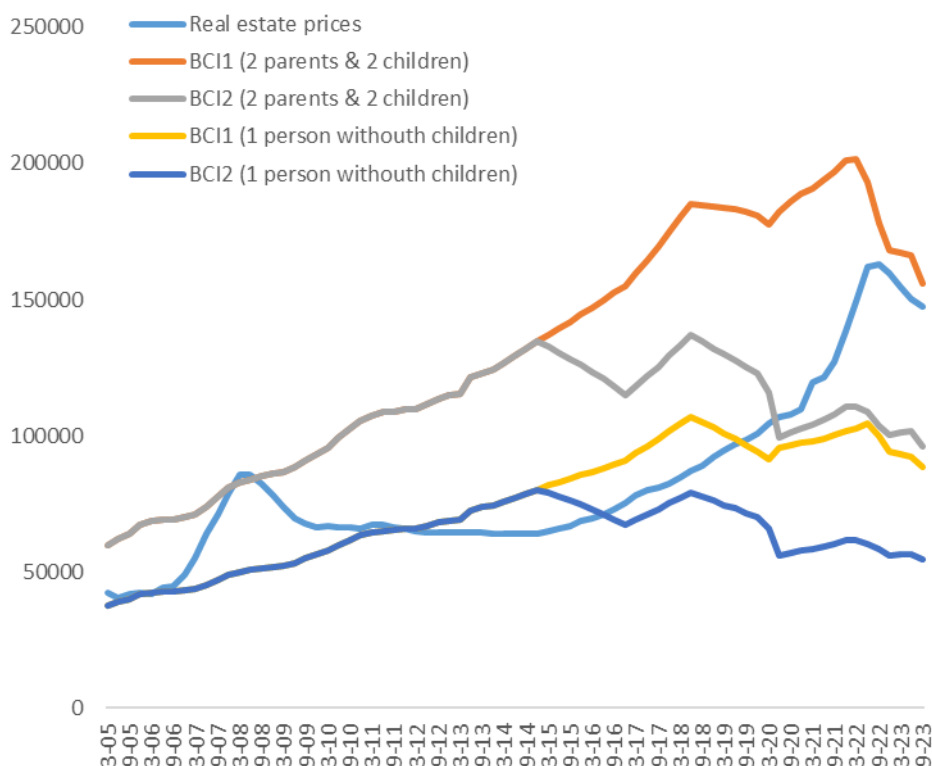
¹⁰ See (Cesnak, et al., 2021) for an overview of borrower-based measures implemented by the NBS. Current setting of financial stability instruments in Slovakia: <https://nbs.sk/en/financial-stability/fs-instruments/>.

4.2 Methodology

We calculate the maximum size of the mortgage loan that a household can borrow with respect to its disposable income, market interest rates, loan maturity, the size of the mortgage payments and applicable BBMs at the time. The mortgage loan together with available down payment determines the affordable house price for the given household.

We consider two marginal options of down payment. The first option assumes that the household has enough savings to use own capital as down payment. The second option assumes that the household has no savings and is therefore forced to finance the rest of the house price using a consumer loan. However, taking the consumer loan creates an additional burden in terms of DTI and DSTI and thus pulling house price affordability downwards.

Chart 5 Borrowing capacity indicator



Source: NBS, NARKS, United Classifieds, SO SR, author's calculations.

Note: Figure shows results of BCI for Slovak household with average income compared to average house prices in Slovakia. BCI1 = approach assuming household using own capital for down payment; BCI2 = approach assuming household using consumer loan for down payment.

The structure of household affects the household subsistence minimum that lowers the volume of attainable loan via the DSTI channel. We consider two different types of households – household with two parents having two children and single adult household without children. We assume each adult having the same level of income.

Due to high volatilities during tightening periods, resulting BCA estimates are smoothed using simple moving averages.¹¹ For more detailed description of the methodology and assumptions see (Cesnak & Klacso, 2021).

4.3 Economic interpretation

The assessment is based on comparing the estimated house prices via BCI with the actual house prices. The closer the house price is to the estimated price, the more an average household needs to go to the given BBM limits to get a loan that enables to buy an average property. If the actual house price exceeds the estimated one, the respective household cannot afford to buy such an average property.

The biggest advantage of this approach is its flexibility. The estimation is feasible even with a single data point, and so it is applicable on short time series. Moreover, it is possible to do the assessment for any type of real estate as well as for any type of household in relation to its income, structure, savings, or region. The second big advantage is that the property prices do not enter the estimation calculations. Therefore, the estimation is independent of the long-run house price value and might be applicable on time series with lack of complete housing cycle. BCI allows multiple exercises including counterfactual analyses, forecasting or inclusion of expectations, and can be updated on a regular basis. Due to seasonal adjustment of average wages, the past values are subject to correction.

5 Macroeconomic model of RRE prices

In the previous sections, housing affordability concentrated on the affordability for individual households. In this section, the potential price of the residential real estate property is estimated using a macroeconomic approach and considering the potential overall demand in the respective regions or in the whole country.

5.1 Data used

We use a demand-side macroeconomic model for the estimation, hence all data used are focused to explain potential demand for house purchase. Potential demand is determined by:

- Number of employed individuals by different age cohorts (Statistical office)

¹¹ Due to volatilities in the beginning of the time series, we use centered moving average of length 5 in period 2005Q1 – 2013Q1. To smooth out the breaks resulting from BBMs introduction and their tightening, we use one-sided moving average of length 7 with gradual phase-in since 2013Q2 and gradual phase-out after 2020Q1. One-sided moving average ensures that the required properties of the estimate are preserved.

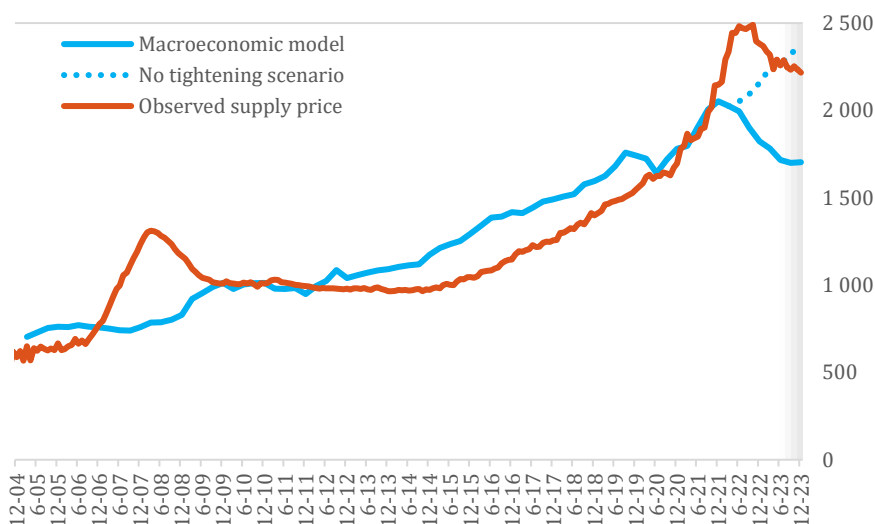
- Average disposable income (Statistical office)
- Average debt service to income ratio (NBS)
- Average interest rate on all existing household debt (NBS)
- Average maturity of new housing loans (NBS)
- Average interest rate on new housing loans (NBS)
- Stock of all household debt (NBS)
- Average price of flats in Slovakia (United Classifieds/CMN)

Potential demand is calculated as the product of the number of workers and the average wage in the given age cohort, less living costs and current debt servicing expenditure. The calculation is based on current flat prices (from United Classifieds and CMN) and interest rates for new housing loans (NBS data). The average wage is published by the Statistical office.

5.2 Methodology

The potential demand for house purchase is determined by the difference between the disposable income (determined by the number and age of the workforce, average income, and average DSTI) and the existing debt burden (macroeconomic DSTI for all existing debt). This difference can be interpreted as purchasing capacity for new housing, taking into account interest rates on new mortgage loans, average observed DSTI and maturity attributable to the respective age cohorts. Fundamental price is then estimated from the long-run linear relationship between prices of flats and the above-defined potential demand. More details are provided in Appendix C.

Chart 6 Macroeconomic model for RRE prices



Source: NBS, United Classifieds, CMN and SO SR.

Note: No tightening scenario – estimation of fundamental price with interest rates remaining at their February 2022 level, Observed supply price – Market price of flats for sale.

5.3 Economic interpretation

The estimation of the real estate prices is affected mainly by the size of the potential purchasing capacity. Demand for flats is buoyed by favourable labour market developments and solid nominal wage growth. The estimation is largely affected by interest rates. Households' potential demand for flats is subdued by rising interest expenses and vice versa. Higher rates make not only new mortgages more expensive, but they also increase households' existing debt servicing costs. The difference between the macroeconomic model and the observed supply price shows the deviation of supply prices from selected fundamentals.

6 House price growth decomposition

In the previous sections different indices were introduced that can be useful when discussing the potential over- or undervaluation of real estate prices. In this section, a structural model is introduced that studies the impact of different economic shocks on real estate prices. This can be useful in understanding potential driving forces behind the observed development of real estate prices. While to some extent it can be also used for forecasting future price developments, it is mainly helpful in understanding potential driving forces behind the observed development of real estate prices. More details of the model are provided in (Kupkovič & Cesnak, 2023).

6.1 Data used

Real house price growth is decomposed into the effects of individual structural drivers using the structural VAR methodology. The following variables are used for this decomposition:

- Real residential investment: Gross fixed capital formation, Housing, Volume, EUR (SOSR, OECD)
- Real house prices: Real average house price EUR/m^2 (NBS)
- Real mortgage loans: New housing loans, EUR (NBS)
- Lending rate: Lending rate on new housing loans, % *p. a.* (NBS)
- 10-year bond spread: Slovakia – Germany, *p. p.* (NBS, Eurostat)
- Real disposable income: Household gross disposable income, EUR (SOSR)
- Core inflation: Index (NBS, SOSR, OECD).

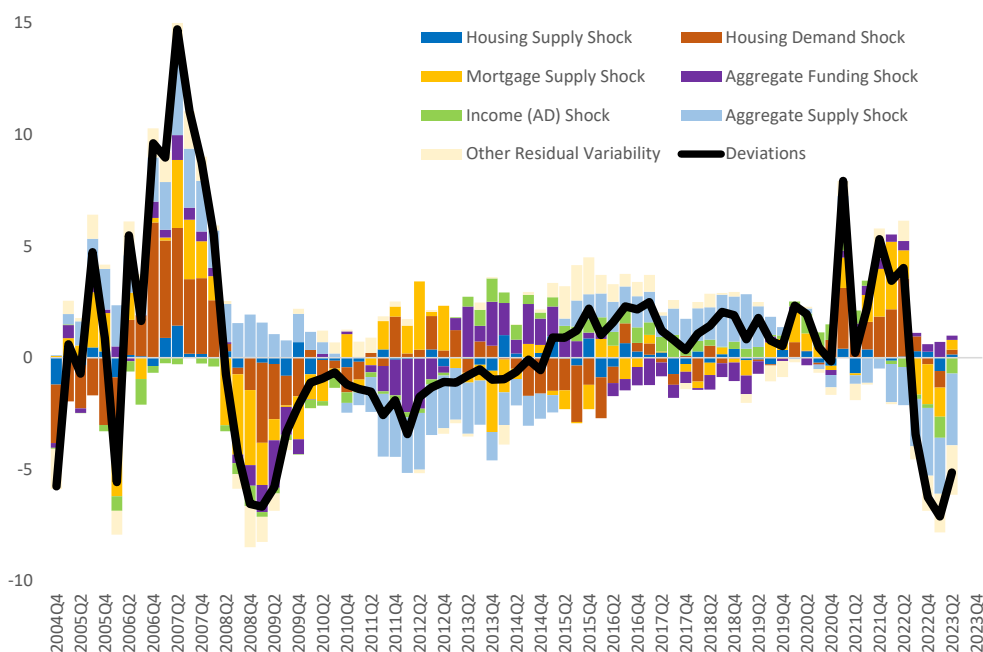
The sample starts in 2004Q1. All series are transformed into quarterly percentage changes (except interest rates and spreads) to ensure stationarity. In the reduced form, the VAR model is estimated with two lags and an intercept in each equation.

6.2 Methodology

The primary motivation for using the structural VAR methodology is that all relevant sectors of the housing market (production sector, households, financial sector, and policy environment) are interlinked. Therefore, we need to model this endogeneity explicitly¹².

We identify structural drivers based on three markets. The first is the housing market, where the production sector is a source of housing supply. The second market is the mortgage market, where households represent mortgage (housing) demand and banks represent mortgage supply. Finally, the aggregate market characterizes the whole economy, where shocks to aggregate demand (consumption, investment, fiscal policy, external demand), aggregate supply (technology, productivity, oil price, commodity price, labor supply), and aggregate funding (monetary policy, unconventional monetary policy, country-specific macroeconomic policies) are sources of standard business cycle fluctuations.

Chart 7 House price growth decomposition



Source: Authors' own computation.

Note: Real house price growth is shown as a deviation from baseline growth. Stacked colored columns show the contribution of each structural factor.

From an econometric perspective, we use the following two categories of short-run restrictions for the above-mentioned structural identification: (i) timing (zero) restrictions, as housing market shocks take time to feed through to the real economy, and (ii) co-movement (sign)

¹² In this case, single equation analysis is insufficient and can be misleading, while the full structural DSGE model is not yet operational at the NBS. Structural VAR models are a natural solution to these problems.

restrictions, as shifts in demand (supply) move price and volume in similar (opposite) directions.

6.3 Economic interpretation

Chart 7 shows the decomposition of real house price growth into the effects of individual structural factors in deviations from baseline growth¹³. The economic interpretation comes from comparing the historical and relative importance of each structural factor.

More specifically, the first period covers the volatile years from the introduction of the standardized mortgage market in 2004 to the end of the Global Financial Crisis, when household demand for housing and bank supply of mortgage loans drove the housing market.

The next period was characterized by the European debt crisis, with real house prices falling steadily due to negative aggregate funding and aggregate supply structural shocks. This was followed by slightly above-baseline growth due to positive aggregate supply and demand shocks, which was interrupted by the recent period of increased volatility.

During the global COVID-19 pandemic, house prices grew at an elevated pace due to high demand for housing and favourable mortgage supply from banks. This situation reversed more recently as high inflation and rising interest rates manifested themselves through a series of negative aggregate supply and mortgage supply shocks.

Conclusions

This paper gives an overview of the RRE-related indices currently available at the NBS and serves as a methodological note to the RRE dashboard available at the NBS website. The list of indices consists of one composite indicator, three housing affordability indices and two macroeconomic models, one estimating RRE prices and the other assessing the impact of structural shocks on these prices. There is no perfect model answering the question of the possible over- or undervaluation of RRE prices. However, all these indices can help to understand the actual development, as they all provide information from a bit different angle and perspective. Naturally, all indices and models are subject to possible future enhancement and the currently available toolkit can change over time.

¹³ Here we assume that, in the absence of shocks, real house price growth is constant at a long-run level and that the model dominantly captures the short-run dynamics. However, this is only an approximation, and one could model the long-run trend using the vector error correction (VEC) method in addition to the short-run dynamics studied here.

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Appendix A Data list

Data name	Source	Available at
Average debt service to income ratio		
Average maturity of new housing loans		
Average monthly rent	United Classifieds/NARKS	Publicly not available
Average monthly wage	Statistical Office of the Slovak Republic	SO SR
Core inflation	Statistical Office of the Slovak Republic	SO SR
Final consumer expenditure of households deflator	Statistical Office of the Slovak Republic	SO SR
Gross disposable income per capita (nominal/real)	Statistical Office of the Slovak Republic	SO SR
Interest rate for new housing loan	NBS official reporting	NBS website
Interest rate on all household debt		
Residential real estate investment	Statistical Office of the Slovak Republic/OECD	SO SR
Residential real estate prices	United Classifieds/NARKS	NBS website
Stock of all household debt		
Subsistence minimum	Ministry of Labour, Social Affairs and Family of the Slovak republic	SK only
Volume of residential construction	Statistical Office of the Slovak Republic	SO SR
10-year bond spread: Slovakia – Germany	NBS, Eurostat	

Appendix B Housing affordability index

The monthly payments, or the debt service, needed to buy a property is calculated as

$$DS = N \frac{r(1+r)^n}{(1+r)^n - 1}$$

where DS is the debt service, N is the notional amount, or the granted value of the housing loan, r is the interest rate on the housing loan and n is the number of periods. To estimate the debt service, the following assumptions are used, as already described in Section 2:

$N = LTV * Property\ price$, where LTV, the loan-to-value, is set to 70%. It means that the household pays 30% of the property using own funds and the remaining 70% is covered by the loan.

$Property\ price = 60\ m^2 * Property\ price/m^2$, i. e. the property is assumed to have 60 m² and the official NBS price in EUR / m² and per region enters the calculation.

The maturity of the loan is assumed to be 20 years, so the number of payments is $n = 20 * 12 = 240$.

The debt service-to-income is assumed to be 25%, i. e. one quarter of the income is used to pay back the loan. The adequate income is therefore calculated as $4 * DS$.

Appendix C Macroeconomic model of RRE prices

The purchasing capacity for new housing is estimated as:

$$\text{purchasing capacity (PC)} = \text{aggregate disposable income} - \text{existing debt burden (DB)}$$

aggregate disposable income = *disposable income* * *adjusted number of working people aged more than 25 years*

The adjusted number of working people aged more than 25 years is the number of working people in the respective age cohorts, where the adjustment reflects the potential decreasing demand for new housing by increasing age. The following share of the overall number of working people is considered from the respective age cohorts: 25 – 34 years – 100%, 35 – 44 years – 80%, 45 – 54 years – 20%, more than 55 years – 0%.

$$\text{disposable income} = 0.75 * \text{average monthly income in the economy per capita}$$

Existing debt burden, or debt service is calculated from the overall amount of loans granted to households:

$$DB = VL \frac{r(1+r)^n}{(1+r)^n - 1}$$

where DB is the existing debt burden, VL is the outstanding volume of loans granted to households, r is the average interest rate on this stock of loans and the assumed residual maturity is 24 years, i. e. $n = 24 * 12 = 288$.

The potential demand is then estimated as the volume of loans attributable to the purchasing capacity:

$$PD = PC \frac{(1+r)^n - 1}{r(1+r)^n}$$

where PD is the potential demand, PC is the purchasing capacity, r is the interest rate on newly granted housing loans and with the assumed 30 years maturity $n = 30 * 12 = 360$.

The fundamental price is then estimated by multiplying the potential demand with an adjustment coefficient,

$$\text{Fundamental price} = \alpha PD$$

where the adjustment coefficient, α is estimated by OLS from the historical relationship between flat prices and the potential demand. For the estimation, quarterly time series are used since 2006Q4.