Composite index to assess housing price development in Slovakia

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The dynamic growth in residential property prices during recent years has raised questions, as to whether their development is still sustainable or a real estate bubble is beginning to form, similarly to mid-2008. Although an unambiguous answer does not exist, it is possible to quantify the risks associated with the current development of housing prices. A composite index, composed of selected representative partial indicators, can be included among instruments capable of such analysis. Based on the calculated values and defined scales, we can roughly estimate the risk rate of the housing price development in the reference period. Furthermore, we can measure the impact of selected factors on the total value of the composite index.

Introduction

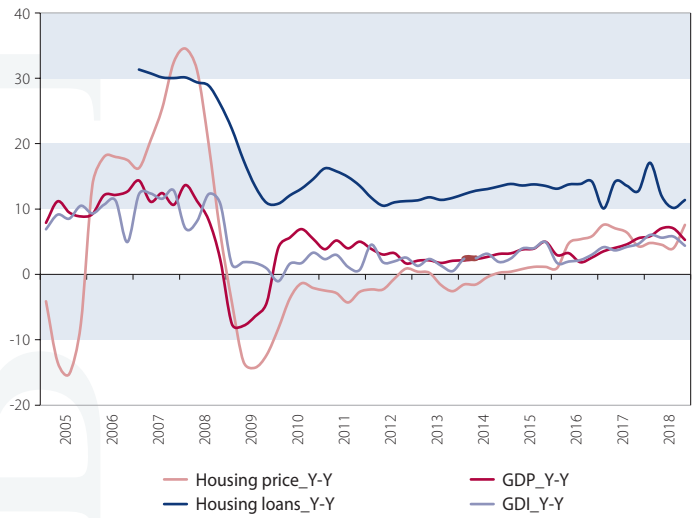
Housing is an area that everyone is confronted with at some point in their lives. The development of housing prices is of interest not only to those who are currently addressing the housing problem but also to many experts in the real estate market and in the financial sector.

In the relatively short history of the Slovak housing market we have been able to identify all phases of the real estate cycle. After 2002, when relevant data first became available, a period of very dynamic growth of the average housing price (expansion) occurred. The growth of housing prices peaked in mid-2008, when the highest average housing price was almost €1,550 per square meter (peak). The subsequent, relatively sharp downward correction of housing prices continued until the end of 2009 (recession). The supposed bottom was reached in the 2nd quarter of 2014 (€1,211 per square meter). In mid-2014 the real estate market in Slovakia started to recover slightly, but since 2016 housing prices have risen sharply again.

Slovakia saw turbulent development of the average housing price, especially in the first decade of the new millennium. This is evident from Chart 1, where the year-on-year housing price growth rates during this period were considerably different from the changes in the economy's performance as well as in the population's income development. In the following part of the real estate cycle in Slovakia, the differences between the year-on-year growth rates of housing prices and other selected indicators are less distinct. Therefore, the question regarding how much the development of housing prices is in line with the development of other characteristics of the supply and demand side of the housing market is on the mark.

In this paper, we briefly describe the methodology of composite index calculation to assess the sustainability of housing price development with respect to other related indicators. This approach will also allow us to distinguish between various levels of risk in the housing price development, ranging from a fall (or slump) to a real estate bubble.

Chart 1 Year-on-year changes of selected indicators



Source: NBS.

Background for the composite index

Upward spikes in housing prices cannot be always viewed as a real estate bubble. Sustainable housing price development requires the consistency of housing price dynamics with other closely related fundamental indicators, such as the general economic performance, income situation, rental rates, loan volumes, etc. on the demand side, as well as with the development of indicators on the supply side of the real estate market. Previous experience suggests that in most cases, housing price developments in Slovakia were mainly explained through demand factors.

Compiling a proper composite index for a given topic assumes the choice of suitable partial indicators. Our selection of indicators has embraced

the philosophy of the composer of the Swiss Real Estate Bubble Index.[1]

The five partial indices[2] used to create our composite index are:

- real average house price per square meter (ratio of nominal price in EUR per square meter and final consumer expenditure of households deflator);
- the price-to-rent ratio (nominal price in EUR per square meter to average monthly rent in EUR);
- the price-to-income ratio (nominal price in EUR per square meter to gross disposable income per capita);
- the housing loans-to-GDI ratio (the volume of housing loans to real gross disposable income);
- the residential construction-to-GDP ratio.

All variables, respectively the partial ratios used to generate the composite index were detrended to ensure their stationarity (using the Hodrick-Prescott filter with $\lambda = 1600$). As a result, the absolute values of the index at individual points in time may vary after additional observations are added.[3] At the same time, the resulting time series represent deviations from long-term trends. The individual variables were then standardized (by subtracting their mean from their empirical values and dividing them by standard deviations). After that, the methods described below were used.

The first indicative information that can be obtained from the development of the original values of the selected partial indicators is the direction (growth or dampening) in which the individual partial indicators affect the total value of the composite index. The values of the majority of the selected partial indicators (except the residential construction-to-GDP ratio) in both the third and fourth quarter of 2018 tended to dampen the resulting composite index value. The most pronounced tendency to reduce the overall value of the composite index during this period was attributed to the indicator of housing loans to gross disposable income.

In order to create a composite index of housing price development, we use the principal components analysis (PCA) and the method of minimizing predictive errors (RMSE). With respect to the obtained results, we will choose one of the methods to assess the history of current housing prices in Slovakia.

Principal Component Analysis (PCA)

The PCA is one of the methods of dimension reduction. The basic idea is to transform a large number of interdependent variables (indicators) into a smaller number of new variables. At the same time, there is an effort to keep as much of the variability in the original data as possible. The resulting variables, referred to as the main components, are then uncorrelated and sorted in such a way so that the first few components contain the maximum proportion of variance of the original variables.

A technical explanation of this procedure is, for example, provided by Jolliffe (2002). Let us assume that x is a vector of n variables. The main component method is looking for the linear function $\alpha^T_1 x$ of the elements x having the largest possible variance that can be written as:

$$\alpha^T_1 x = (a_{11} \dots a_{1n}) \begin{pmatrix} x_1 \\ \vdots \\ x_n \end{pmatrix} =$$

$$= \alpha_{11} x_1 + \alpha_{12} x_2 + \dots + \alpha_{1n} x_n = \sum_{i=1}^{n} \alpha_{1i} x_i$$

The next step is to look for the $\alpha^T_2 x$ function that will not be correlated with $\alpha^T_1 x$. After k iterations, we will obtain the function $\alpha^T_k x$, which will be uncorrelated with all the previous functions, each of which will contain the maximum possible variance. The $\alpha^T_k x$ variable is then referred to as the k^{th} component. In general, it is possible to construct up to n components, but having in mind that the goal is to reduce the dimension of data (number of variables), we usually deal with m components, where $m < n$.

The calculation of the index itself is based on the correlation matrix of variables x*[4], which were generated by standardizing the original variables. This means that the average of the individual variables was deducted and the partial differences obtained were divided by the respective standard deviations. The element of the correlation matrix (i, j) represents the correlation coefficient between the i^{th} and j^{th} elements of the vector x* and on the diagonal are ones (sample correlation matrix is typically used in practice). For $k = 1, \dots, n$, the k^{th} main component is in the form of $z_k = a^T_k x$, where a_k is the eigenvector of the correlation matrix corresponding to the k^{th} largest eigenvalue λ_k (since the correlation matrix will always be positive-semidefinite, all eigenvalues will be non-negative). If the size of the eigenvectors is normalized to unity (mathematically, $a^T_k a_k = 1$), the variance of each component will be equal to its eigenvalue ($var(z_k) = \lambda_k$).

Since our goal is to create one composite index based on selected partial indicators, only the eigenvector belonging to the largest eigenvalue is taken into account. Elements of this vector will then represent the weights of each standardized variable within the index.

Root Mean Square Error (RMSE)

When compiling a composite index composed of multiple variables, it is necessary to determine the extent to which the factors will contribute to the index value. In addition to the above-mentioned PCA, one-dimensional ARMA models can be used for this purpose, separately for each of the original variables. In particular, a model that minimizes the root of mean squared error (RMSE) is automatically selected for each partial indicator. In other words, for each variable, we look for a combination of AR, MA, SAR and SMA components that is able to provide the best predictions. Each model is estimated on a truncated sample, and the deviations of the actual values from incremental one-step-ahead predictions are calcu-

1 *The quarterly published UBS Bubble Swiss Real Estate index consists of six sub-indices. More details are available at: http://www.ubs.com/global/en/wealth_management/wealth_management_research/bubble_index.html.*

2 *Contrary to the UBS composite index we did not use the indicator labelled as the share of investment loans for housing (i.e. of loans intended for purchasing a property for the purpose of its further lease) due to the unavailability of the necessary data.*

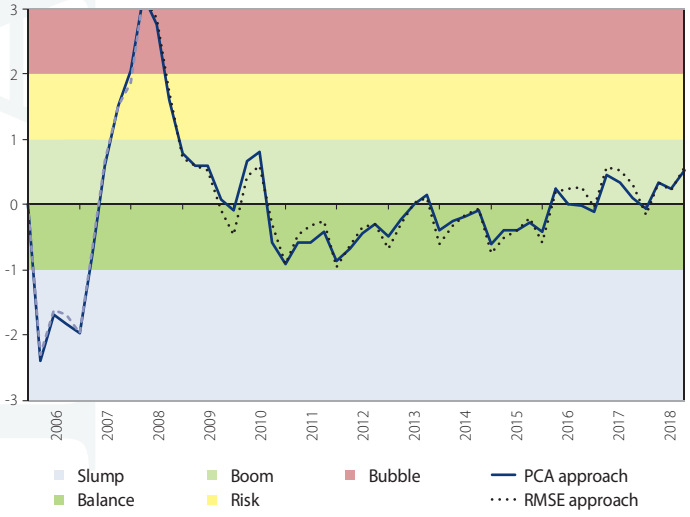
3 *Empirical evidence suggests that a revision of values can be observed at a maximum of 10-12 periods in the past.*

4 *Alternatively, a covariance matrix can be used. Jolliffe (2002), however, states that while working with variables not expressed in the same units, it is more appropriate to standardize these variables and to continue to work with their correlation matrix.*

lated. RMSE then represents the root of the mean of these deviations. The weight of a given variable within the composite index will be computed by the inversion of RMSE. In this way, individual variables will be represented proportionally according to how well we are able to predict their development without using exogenous factors.

In addition to the described approaches to compiling the composite index to assess the sustainability of the average housing price development, many others can be found. Usually, they tend to be based on econometric models and to be purpose-oriented. For example, the approach applied at the ECB is aimed at detecting non-standard price developments in the property market and examining their impact on financial stability. In the European Commission, the benchmark approach was used to assess the impact of selected indicators on housing price developments[5]. Both approaches rely on error correction models and linear regressions, which work with similar variables and indicators as the composite index presented in this paper. Based on practical experience, we have come to the conclusion that model approaches have certain limits, especially when working with relatively short time series and with considerably turbulent housing price development, as a dependent variable is necessary.

Chart 2 Development of composite index values according to the PCA and RMSE



Source: NBS.

Table 1 Weights of partial indicators used

Variable	PCA	RMSE
Real housing price	0.29	0.32
Housing price-to-income ratio	0.28	0.28
Housing price-to-rent ratio	0.22	0.10
Residential construction-to-GDP ratio	0.16	0.23
Housing loans-to-GDI ratio	0.04	0.07

Source: Own calculations.

EMPIRICAL ASSESSMENT OF HOUSING PRICE DEVELOPMENT USING A COMPOSITE INDEX

Using the two approaches described above (PCA and RMSE), selected partial indicators and available data, we calculated the values of the composite index in order to measure the sustainability of the current average housing price development in Slovakia from the beginning of 2005 up to the fourth quarter of 2018.

Composite index values based on the PCA and RMSE are shown in Chart 2. Our composite index values are categorized into one of five levels based on the current value: slump trend (< –1), balance (> –1 and < 0), boom (> 0 and < 1), risk (> 1 and < 2) and bubble (> 2). Thus, index values can be integrated into five different scales ranging from a slump to a bubble.[6] Chart 2 shows that the two approaches to evaluating housing price developments using the composite index provide similar results in terms of both the trend and the level of the individual values of this index.

Table 1 lists the weights of the individual variables in percentages depending on the approach used. The decisive weights in both approaches have the following partial indicators: the real average housing price and the housing price-to-income ratio. The housing price-to-rent and residential construction-to-GDP ratios have different weights in both approaches and their contribution to the composite index is slightly lower. The impact of the housing loans-to-GDI ratio is minimal in both approaches. The weights of individual partial indicators are relatively more evenly distributed in the PCA approach than in RMSE.

In selecting the appropriate approach to assessing the sustainability of the average housing price with respect to the selected partial indicators, we have taken into account several facts. An important criterion for choosing the appropriate approach was the weighting of individual selected partial variables on the resulting composite index value.

From this point of view, we prefer the PCA approach, since housing price development is relatively evenly influenced by four selected partial indicators and only marginally by the housing loans-to-GDI ratio. In the RMSE approach, one third of the housing price development is attributed to both the real housing price and to the housing price-to-income ratio, while other partial indicators show less impact. A certain advantage of the PCA approach is also a relatively simpler procedure for computing the composite index than in the case of RMSE. A significant advantage of the PCA approach is the option to create a simple decomposition of contributions of individual components to the total value of the composite index.

The calculated values of the composite index for assessing housing price development signal a downward trend in housing prices in Slovakia by mid-2007. Subsequently, by the end of 2007, the index values were in the equilibrium housing price band. Composite index values exceeded

5 *More details about the approach applied at the ECB are available at: https://www.ecb.europa.eu/pub/pdf/fsr/financialstabilityreview201106en.pdf?67f34e7e836d680bac7aca-4ca931f709 (pp. 57-58) and https://www.ecb.europa.eu/pub/pdf/other/financialstabilityreview201511.en.pdf (pp. 45-47). For the European Commission, see: https://ec.europa.eu/info/publications/economy-finance/assessing-house-price-developments-eu_en.*

6 *Boundary bands are based on the UBS Swiss Real Estate Bubble Index. The index is calculated as the average of trend adjusted and standardized indicators, weighted using a principal component analysis. It seems that such approach and range of bands are also well-suited to Slovak conditions.*

the risk band during the first quarter of 2008 and moved into the real estate bubble zone, where they remained until the end of 2008, with the peak reached in the second quarter of 2008. The subsequent gradual correction of the average housing price ended in about 2010. From the end of 2010 up to the first half of 2016, according to the composite index, housing prices in Slovakia were in the area of relative equilibrium. Then the values of the composite index began to increase gradually. The value of the composite index for the housing price development is currently in the ascending zone. However, it is still below the risky development band and relatively far from the real estate price bubble.

The size of the contributions of the individual partial indicators to the total value of the composite index is determined to a decisive extent by the weights of the analysed components. According to the PCA approach, the historical contributions of four sub-indices to the total value of the composite index are relatively evenly matched, while the contribution of housing loans to GDI is hardly observable.

Chart 3 shows that during periods of significant changes (increases and decreases) of the composite index values, the contributions of the individual partial indicators operate mostly in the same direction and in relatively similar proportions. At times when the values of the composite index oscillate around zero (periods of relatively stabilized housing prices), the contributions of the individual partial indicators may be contradictory. In recent quarters, the only indicators with a negative contribution to the total value of the composite index have been the housing loans-to-GDI and residential construction-to-GDP ratios.

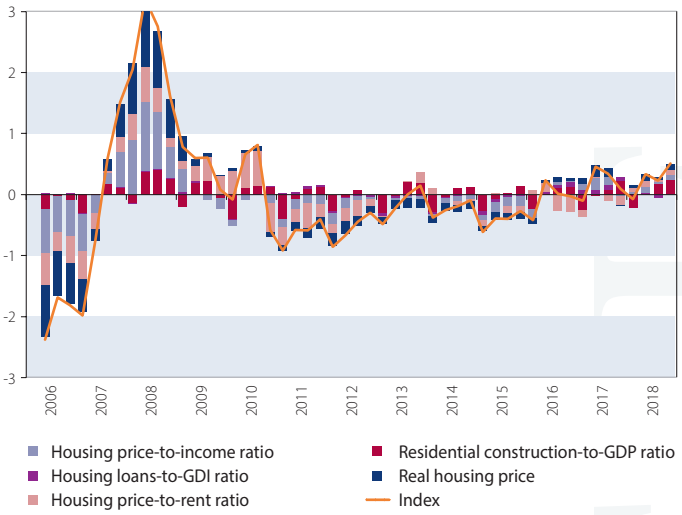
The calculated values of the composite index for assessing the development of housing prices in the history of the Slovak housing market have been seemingly logical (relatively to the development of the nominal housing price) in all possible ranges from a fall to a bubble. This gives us hope that we will be able to apply the selected composite index to assess the risk in the development of housing prices in the following periods as well.

Additionally, we developed a customized version of the above-mentioned approaches provided by the ECB and the European Commission (EC). Chart 4 compares these alternatives with a composite index based on the PCA method. Although all three time series follow the same trends (and fit the real estate cycles in Slovakia adequately), significant differences can be observed in scaling. The distance between the peak in mid-2008 and the current values is much lower with the ECB and EC approaches than with the composite index. In order to resolve this issue, different scaling would have to be proposed.

Conclusion

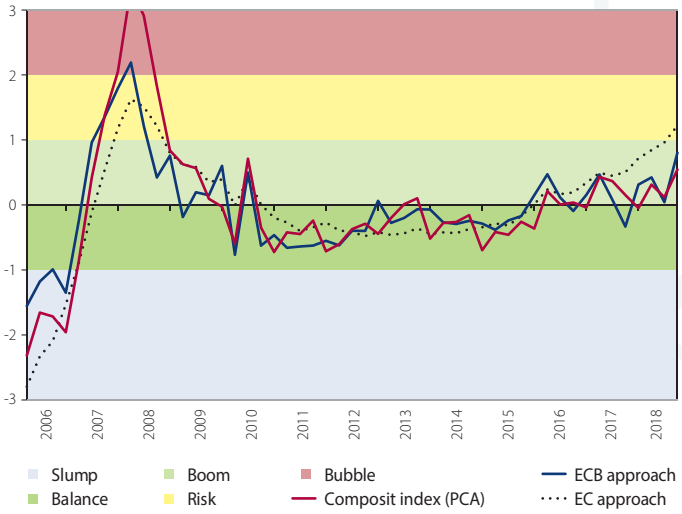
Although the composite index is a sophisticated tool, it is only one possible approach to assess the sustainability of housing prices development.

Chart 3 Contributions of partial components to the total value of composite index



Source: Own calculations.

Chart 4 Comparison of alternative approaches



Source: Own calculations.

There is no universal or "most reliable" approach to assessing the development of housing prices under the given conditions. The choice of approach can also be strongly determined by the purpose of a specific researcher or an institution and their objectives regarding the housing price development.

The sustainability of the housing price development in Slovakia is evaluated by the NBS on a quarterly basis, using a composite index based on the principal component analysis from the third quarter of 2016. Previous experience shows that the chosen approach and the scaling of risk bands is appropriate for Slovak conditions.

The value of the composite index for the housing price development in Slovakia is currently in the ascending or boom zone. However, it is still below the risky development band and relatively far from a real estate price bubble.

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