NBS Working paper
3/2021

Assessing real estate prices in Slovakia – a structural approach

Martin Cesnak, Ján Klacso

NATIONAL BANK OF SLOVAKIA
EUROSYSTEM

www.nbs.sk

research@nbs.sk

This publication is available on the NBS website
www.nbs.sk/en/publications-issued-by-the-nbs/research-publications

ISSN 2585-9269 (online)

Assessing real estate prices in Slovakia – a structural approach*

Martin Cesnak[a], Ján Klacso[b]

Abstract

In this paper, we apply the borrowing capacity approach and the intrinsic value approach to assess property prices in Slovakia. We estimate the maximum attainable house price for a given household. It means that we apply downpayment, DSTI or DTI parameters in line with the macroprudential limits implemented by the NBS. We consider the possible top-up in the form of a consumer loan for households not having enough own capital. Finally, we make use of an internal database of NBS of individual retail loan data that gives us a better picture of the average income of borrowers. Results based on the SBC approach point to a possible overvaluation during the pre-crisis period in 2007 and 2008. After the crisis, lowering interest rates and increasing income led to a robust increase of affordability. Since 2014, the implementation of borrower-based measures decreased the affordability, at least for households with not enough own capital. Based on the results, borrower-based measures could under some circumstances ease the upward pressure on house prices even in an environment of historically low interest rates, unemployment and increasing income.

JEL Code: G12, G18, E37

Keywords: house prices, borrowing capacity, borrower-based measures

* We are grateful to Martin Pažický, Miroslav Plašil and Štefan Rychtárik for their helpful comments.
[a] Research Department, National Bank of Slovakia. E-mail: martin.cesnak@nbs.sk.
[b] Research Department, National Bank of Slovakia. E-mail: jan.klacso@nbs.sk.

Introduction

Are real estate prices overvalued? What is the fundamental price of real estate? These are usual questions asked by policymakers, academics, professional investors or households basically all around the world. Slovakia is not an exception. As a small country with practically non-existing capital market, financial sector dominated by banks and a traditionally high home ownership rate, real estate market is even more important. Demand for real estate is very high, both for owner-occupied and, in the current environment of extremely low interest rates, also for investment purposes. After the banking sector was restructured in the early 2000's, the market with housing loans developed very quickly as well. This led to the situation where, at the end of 2020, housing loans represented one third of banks' balance sheet and half of total loans provided. Moreover, indebtedness of Slovak households more than doubled in the period 2006 – 2020 and is higher than in most other CEE countries, mainly due to the increase of housing loans.

As real estate prices, household indebtedness and housing loans are closely inter-connected, the development of real estate prices have serious financial stability implications. The National Bank of Slovakia is closely monitoring the developments in household indebtedness and the situation on the housing market and has activated several borrower-based measures to address systemic risks building up in the recent years. LTV, DTI, DSTI and maturity limits have been gradually introduced and tightened, having an implication on the availability of loans and potentially on real estate prices.

Due to the importance of the real estate market in Slovakia, assessing the development of house prices is a key task of the NBS. However, as reliable time series of real estate prices exist only since 2006 and so far, we have observed only one real estate cycle, one has to be careful when choosing from the available methods for house-price analysis. In this paper, we use the borrowing capacity approach and the intrinsic value approach introduced and used in Andrle and Plašil (2019a) and Andrle and Plašil (2019b). Both methods provide a useful tool for assessing house prices compared to some selected fundamental factors like income or interest rates and can be easily implemented also in countries with not so mature housing loan market and short time series of real estate prices[1].

In case of the borrowing capacity approach, the house price is implied by the capacity of the (liquidity-constrained) household to borrow from a bank. We are interested in the maximum amount of the loan a household can take given its income and the actual interest rates, while we also control for the household satisfying all the limits set by the NBS: LTV, DTI, DSTI and maturity limits. Thus, we do not use average or assumed downpayment or DSTI, but rather assume that the household opts for the maximum amount of loan available within the limits. As usually there is a share of newly granted loans that can exceed these limits, this assumption is not unreal when considering an average household. Beside controlling for these limits, we also

[1] The design of these methods does not allow to capture the supply side effects on the estimated attainable property prices. Nevertheless, these effects are equally important as supply side factors such as slow adjustment to changes in demand and constraints in new building can significantly affect property prices.

consider that a household can take a consumer loan for top-up purposes if only the LTV limit is binding. However, all other limits, DTI, DSTI and maturity limits, have to be satisfied on the pair of granted loans[2].

Another field where we adjust the calculation is the assumption about the household income. While we estimate attainable house prises using average nominal income for benchmarking purposes, we make also use of an internal NBS database consisting of individual retail loans. This database gives us a better sense of what is the average income of households having housing loans, as in general the income of these households is higher than the income of an average household. We provide the results for the borrowing capacity approach for Slovakia and for Bratislava region.

The second, intrinsic value, approach allows us to add a valuation dimension to the analysis. This approach assumes that real estate prices should reflect the net present value of the income stemming from these properties in the form of periodic rental income. Note, however, that traditional "textbook" valuation is adapted to reflect specific features of small retail investors that do not tend to stay leveraged indefinitely. As this approach needs a liquid rental market for the proper calculation, we provide results only for capital city, Bratislava. The approach is based on the comparison of costs related to the housing loan and other costs and the income in the form of rental income. Naturally, borrower-based measures should be taken into account here as well.

The paper is structured as follows. In section 1 we provide an overview of the relevant literature. Section 2 and 3 describes the application of the borrowing capacity approach and the intrinsic value approach. In section 4 we provide the description of time series used and the results for Slovakia and Bratislava. Finally, we conclude.

[2] While attainable property prices based on average LTV, DTI or DSTI could be closer to the observed average house prices, these averages can change over time. Also, in this paper, we are focusing on the maximum attainable price. Clearly, the closer are average property prices to these maximum attainable prices, the higher is the probability of price correction on the market.

1. Literature review

As house price fluctuations are in the centre of interest for policymakers, a wide variety of studies can be found that deals with the question of assessing fundamental house prices. In general, four different approaches are widely used in different forms and specifications:

- some form of affordability index comparing the ratio of house prices/housing indices to some measurement of income (e.g. real disposable income or GDP per capita) to the long-term average of this ratio,
- price-to-rent ratio relative to its long-term average, reflecting an asset pricing approach,
- price-to-rent ratio relative to the long-term real interest rate, that compares housing investment to other, alternative investment opportunities,
- model-based measurement of imbalances in housing valuation using error-correction models or VAR models. Real house prices are usually regressed on selected demand and supply side factors like GDP per capita, population, real interest rates. Sometimes housing credit is included as well, at least in the autoregressive part of the model. This approach gives space for a lot of different specifications and hypotheses.

An overview of results for selected groups of these models for EU and euro area countries can be found in Gattini and Hiebert (2010), ECB (2011), ECB (2015) or Philiponnet and Turrini (2017). All these approaches are looking for long-term equilibrium values of selected ratios to determine whether current values are over or under these long-term estimates. However, in order to have a reliable estimate of the long-term equilibrium, long time series and usually several cycles are needed.

A comprehensive econometric study estimating a long-run cointegrating relationship for 20 advanced OECD countries can be found in Geng (2018). Plenty of the literature is focusing on multi-country estimations or panel techniques, however, the literature is rich also on dealing with individual countries. From peer countries, econometric models assessing demand and supply side factors and models based on the relationship between the business and credit cycle and the house price cycle are available in Hejlová et al. (2017). A comprehensive discussion with literature review on the Hungarian real estate market can be found in Harnos (2018). A discussion on the development of property prices and their importance for financial stability in Poland can be found in Trojanek (2011) and Olszewski (2012). There are also several studies focusing on the Slovak real estate market. Rychtárik and Krčmár (2010) introduce a housing affordability index that is a simple index constructed from house prices, income and interest rates. At the end of 2019 the index, available in NBS (2019a) pointed to an increasing housing affordability, mainly due to decreasing interest rates. A fundamental price of real estate is estimated in NBS (2019b) using the results of a linear regression model where the explanatory variable of the potential demand is constructed from the number of workers in Slovakia, average wage in economically active age cohorts and debt-servicing expenditures. The estimation points to a potential overvaluation of real estate prices since approximately end-2016.

A composite index of real estate prices is described in Cár and Vrbovský (2018). The index consists of five variables: price-to-rent ratio, price-to-income ratio, real house prices, housing loan stock to gross disposable income ratio and housing stock to GDP ratio. The value of the index can lay in one of five territories: bubble, risk, increase, equilibrium and burst. Based on authors' calculations, the index was at the end of 2017 in the territory of increase.

While there is a wide variety of approaches to the assessment of real estate prices, most of them require sufficiently long time series and most of the authors agree that multiple valuation methods are necessary to provide robust conclusions. In this paper, we apply two methods available for estimating structural real estate prices published and applied on real estate prices on Prague in Andrle and Plašil (2019a) or in Andrle and Plašil (2019b), where authors apply the valuation approaches on Canadian cities. The first method is the borrowing capacity approach that estimates attainable real estate prices based on the value of housing loan available for the household. The second, intrinsic value, approach, provides the net-present value of the property, given current and expected market conditions.

Both methods are useful when only short time series are available. Another advantage is that property prices are not used within the calculation at all, therefore the potential outcome of over- or undervaluation is not based on any long-run average value of observed property prices. Last but not least, these methods can capture nonlinear effects of interest rates on property prices better than commonly used econometric models.

Within the paper, we estimate the maximum attainable house price for a given household. It means that we do not use any assumed or average values for downpayment, DSTI or DTI but, within the available limits provided by the borrower-based measures of the NBS, we expect the household opts for the maximum available loan. Also, we consider the possible top-up in the form of a consumer loan assuming only the LTV limit is binding for a household. Third, we make use of an internal database of NBS of individual retail loan data that gives us a better picture of the average income of borrowers.

2. Borrowing Capacity approach

2.1. Static Borrowing Capacity (SBC) approach

The SBC approach estimates the house price based on the maximum size of the mortgage loan that a household can borrow with respect to its disposable income, mortgage interest rates, and the size of the mortgage payments, taking possible borrower-based measures into account. Consequently, the household's available downpayment, together with the mortgage loan, determines the attainable house price for the household. As borrower-based measures, e.g. LTV limits, can affect the maximum amount of mortgage loan available, we distinguish between two types of possible downpayments. The first is in the form of own capital, the second is in the form of consumer loan. The latter is considered as in case a household cannot get the necessary amount of mortgage loan, e.g. due to LTV limits, they can ask for a consumer loan for a so-called top-up if they classify for such a loan. These two options give us two different affordable house prices, representing practically a lower and upper bound for the household[3].

SBC with own capital (Method 1)

The household uses a fraction of its monthly income Y_t as mortgage payment:

$$A_t = \alpha \times Y_t. \tag{1}$$

Given the mortgage loan interest rate i_t p.a. and the initial size of the mortgage payments A_t, the size of the mortgage loan L_t with N years maturity is explicitly defined as:

$$L_t = \left[\frac{z_t(1 - z_t^{N\times 12})}{(1 - z_t)}\right] \times A_t; \quad z_t \equiv \frac{1}{1 + i_t^m}, \tag{2}$$

where i_t^m is the monthly interest rate. The expression in brackets in (2) can be understood as a function dependent on maturity N and interest rate i_t (from which the values of i_t^m and z_t are explicitly derived). Hence, the formula (2) can be written in the following form:

$$L_t = f(i_t, N) \times \alpha Y_t. \tag{3}$$

Let's suppose, that the household holds sufficient amount of own capital, which is used as downpayment D_t, together with the mortgage loan, to purchase a property for the price $P_t^{SBC} = L_t + D_t$, or:

$$P_t^{SBC} = f(i_t, N) \times \alpha Y_t + D_t. \tag{4}$$

The LTV ratio then determines the portion of the house price funded by the mortgage loan:

[3] Another option for the household is to postpone the investment and save money to have more own capital and thus to be less constrained by the LTV limit. This decision can have an impact on house prices on the macro level if a large number of households decide to postpone the investment as it can change the demand. However, using the SBC method, we are interested in the attainable house price for a given assumed household. For such a selected household, this decision only postpones the time when the household is asking for the loan, but the results remain within the range of the house price calculated based on the above listed options.

$$LTV_t = \frac{L_t}{P_t^{SBC}}. \quad (5)$$

Thus, the remaining part of the house price is funded by the household's own capital $D_t = (1 - LTV_t) \times P_t^{SBC}$.

SBC with consumer loan (Method 2)

Now let us assume that the household doesn't hold any capital and in order to fund the remaining part of the property decides to take a consumer loan with monthly payments:

$$B_t = \beta \times Y_t. \quad (6)$$

Given the consumer loan interest rate r_t p.a. and the monthly payments B_t, the size of the consumer loan C_t with M years maturity is explicitly defined as:

$$C_t = f(r_t, M) \times B_t. \quad (7)$$

The attainable house price is then $P_t^{SBC} = L_t + C_t$, or:

$$P_t^{SBC} = [\alpha f(i_t, N) + \beta f(r_t, M)] \times Y_t, \quad (8)$$

while the LTV ratio defines the proportion of both loans individually to the final price of the house:

$$L_t = LTV_t \times P_t^{SBC}; \quad C_t = (1 - LTV_t) \times P_t^{SBC}. \quad (9)$$

This option of SBC approach calculation is included also based on information that more than half of the households in Slovakia have capital reserves covering their living costs for not more than 6 months[4]. It means that, in case a household applies for a housing loan, there is a non-negligible probability that the household will opt for top-up, if possible.

2.2. Borrower-based measures

After the introduction of macroprudential policy, more and more central banks have introduced different limits applied on housing or consumer loans, in general called borrower-based measures. Therefore, both SBC methods have to take possible borrower-based measures set by the regulator into account. In this paper we consider prudential limits applied by the National Bank of Slovakia (NBS)[5].

The total amount of the monthly payments is set with respect to Debt Service-To-Income limits:

[4] https://www.nbs.sk/_img/Documents/_komentare/AnalytickeKomentare/2020/AK78_Financne_rezervy_domacnosti.pdf

[5] https://www.nbs.sk/_img/Documents/_Dohlad/Makropolitika/UnB-opatrenie_prehlad-EN.pdf
https://www.nbs.sk/_img/Documents/_Dohlad/Makropolitika/SU-opatrenie_prehlad-EN.pdf

$$DSTI_t = (\alpha + \beta) \leq DSTI_t^{max} \tag{C1}$$

(in case of SBC method 1, we set $\beta = 0$).

The next measure considers the possible increase of mortgage interest rates in the future. It is assumed that an increase in mortgage interest rate may cause difficulties for the household to meet their monthly payments in the future. Therefore, the DSTI limit has to be met also with an extended maturity of 30 years and a 2 percentage points higher interest rate (with an upper limit of 6% on the interest rates). If this value is higher than the original one, it has to be taken into account in the final calculations. In our case, the size of the mortgage loan is not explicitly given but is calculated. Therefore, for the same value of monthly payments we calculate the loan size for both scenarios (with the original and increased interest rate) and consider the lower one in next calculations:

$$L_t = min\left(L_t^{noShock}, L_t^{shock}\right), \tag{C2}$$

where $L_t^{noShock}$ is calculated using formula (3) and $L_t^{shock} = f(i_t + 2p.p, 30Y) \times A_t$. If $L_t = L_t^{shock}$, we get a new (lower) size of initial mortgage payments $A_t = L_t / f(i_t, N)$.

Loan-to-Value ratio can't exceed the maximum LTV ratio set by NBS:

$$LTV_t = \frac{L_t}{P_t^{SBC}} \leq LTV_t^{max}. \tag{C3}$$

The last measure we consider in this paper is the DTI limit that sets the maximum loan value with respect to the overall yearly income of the household:

$$\frac{L_t + C_t}{Y_t^{net} \times 12} \leq DTI_t^{max} \tag{C4}$$

(in case of the SBC method 1, we set $C_t = 0 \ \ \forall t$).

The calculation of SBC method 1 is straightforward, since we first calculate the value of attainable mortgage loan without BBMs and then we adjust it, so the resulting value satisfies all prudential conditions (C1) - (C4). At the end we use the new LTV_t ratio to calculate the attainable house price.

SBC method 2 is more difficult to calculate, as we consider two different types of loans for one household. It is an optimization problem, where the task is to find the optimal combination of both loan sizes, so that the desired LTV_t ratio is preserved, the $DSTI_t$ limit is not exceeded and all prudential conditions (C1) - (C4) are satisfied.

Due to DTI condition (C4) and shock condition (C2) the final value of DSTI ratio can decrease, which results in a lower attainable house price, but also with a larger amount of financial reserves saved by households every month. This is the main idea behind these limits – to have enough available financial reserves if bad times occur.

More details about the computations are available in Appendix A.

2.3. Dynamic Borrowing Capacity (DBC) Approach

In addition to the SBC approach, the DBC approach seeks the maximum attainable house price with respect to the expected development of future interest rates and household income. This method is relevant for mortgage loans with variable interest rate, where every K years the mortgage interest rate is changed, affecting the size of the mortgage payment. With this type of loan, it is important, from a prudential point of view, to consider whether the household income growth is able to cover changes in the debt service in the future.

The DBC approach is an extension of the SBC approach. While the outcome of the SBC approach guarantees that the DSTI limit (C1) is not violated at the current (initial) time, the outcome of the DBC approach guarantees that this limit is not violated even in any time in the future during the mortgage loan repayment period. Naturally, this is conditional on the fulfillment of expectations about future income dynamics and interest.

The starting point for this method is the size of the mortgage loan implied by the SBC method. Using forecasts of the development of mortgage interest rate and household income and using amortization table created based on the mortgage interest rate re-sets, we check if the DSTI condition is violated at some point during the mortgage loan repayment period. If there is at least one violation, the initial loan size must be decreased to a value, at which the DSTI condition is satisfied in every point in the future. If we consider the result of the SBC method 2 (with a consumer loan) as a starting point for the DBC method, then in case of the DSTI limit violation, we decrease the sizes of both loans in a way to preserve the value of the desired LTV_t ratio.

It is now clear that the maximum attainable house price reached by the SBC approach is the upper bound of the possible attainable house prices achievable by the DBC approach:

$$P_t^{DBC} \leq P_t^{SBC} \tag{10}$$

More details about the computations are available in Appendix A.

3. Intrinsic-value Approach

Using intrinsic-value approach we assess house prices through the eyes of a credit constrained retail investor. The real estate is considered to be an asset, the value of which is calculated as a discounted net present value of future incomes that the asset provides.

We use a notation of the future monthly values as follows:
$TS_{t+i,m|t}$ = the value of time series TS in m-th month of period from $t+i$ to $t+(i+1)$ (i denotes the number of years passed), expected at the current time t.

The investor has an opportunity to invest his available capital D_t with a return of i_t^e percent p.a. However, the investor decides to use it as a downpayment, together with the mortgage loan L_t (2), to buy a house ($P_t = L_t + D_t$) and offer it for rent. Thus, the future income flows the house provides are the expected monthly rent payments $R_{t+i,m|t}$. We assume that the mortgage interest rate can be re-set every $K < N$ years, which results in a change of the expected size of the monthly mortgage payments $A_{t+i|t}$ and therefore the change in monthly paid interests, $INT_{t+i,m|t}$. In some countries, the amount of paid interests can be deducted from the taxable income at the tax rate τ.

The intrinsic-value approach formula is based on annual values, therefore the values of annual rents, mortgage payments and the interests paid is calculated as:

$$\begin{aligned} rent_{t+i|t} &= \sum_{j=1}^{12} R_{t+i,j|t}, \\ mpay_{t+i|t} &= 12 \times A_{t+i|t}, \\ intcost_{t+i|t} &= \sum_{j=1}^{12} INT_{t+i,j|t}. \end{aligned} \tag{11}$$

The value of house $V_{t|t}$ is then calculated as the net present value of the net rental income, discounted by the opportunity cost i_t^e:

$$V_{t|t} = \sum_{i=0}^{\infty} \frac{net\ rental\ income_{t+i|t}}{\prod_{j=0}^{i}(1+i_{t+j|t}^e)}. \tag{12}$$

The net rental income consists of after-tax rental income, $(1-\tau)rent_{t+i|t}$, decreased by the size of mortgage payments, $mpay_{t+i|t}$, and increased by the tax deductible part of interests paid, $\tau \times intcost_{t+i|t}$. Hence, the formula (12) can be written in the form:

$$V_{t|t} = \sum_{i=0}^{K-1} \frac{(1-\tau)rent_{t+i|t} - mpay_{t+i|t} + \tau \times intcost_{t+i|t}}{\prod_{j=0}^{i}(1+i^{e}_{t+j|t})} + \\ + \sum_{i=K}^{2K-1} \frac{(1-\tau)rent_{t+i|t} - mpay_{t+i|t} + \tau \times intcost_{t+i|t}}{\prod_{j=0}^{i}(1+i^{e}_{t+j|t})} + \cdots \\ \ldots + \sum_{i=k*K}^{N-1} \frac{(1-\tau)rent_{t+i|t} - mpay_{t+i|t} + \tau \times intcost_{t+i|t}}{\prod_{j=0}^{i}(1+i^{e}_{t+j|t})} + \\ + \frac{1}{\prod_{j=0}^{N}(1+i^{e}_{t+j|t})} \frac{(1+gn) \times (1-\tau)rent_{t+N|t}}{i^{e} - gn}, \tag{13}$$

where k denotes the number of re-sets of the mortgage interest rate: $k = \lfloor {}^{N}/_{K} \rfloor$, gn denotes the steady-state long-run value of the rental growth and i^{e} denotes the long-run value of the opportunity cost.

The first part of the formula (13) represents the first K years, when the size of the mortgage payments is on its initial value, the growth of rental payments are in line with the expected economic development and the amount of annual interests is decreasing as the debt is being repaid. The following parts are similar to the first part, except of the size of mortgage payments and the amount of interests, which can be different due to mortgage rate re-sets. The last part represents the period, when the mortgage loan is fully repaid, so there are no costs associated with it. The rental income growth has already stabilized on its long-run value gn, and the opportunity cost has also stabilized on its long-run value i^{e}.

The calculation of intrinsic-value method is based on finding the optimal value of the initial mortgage payments A_t, so that corresponding value of the mortgage loan (2) and the value of house (13) are in line with the desired value of LTV ratio: $LTV_t = L_t / V_{t|t}$, while respecting the LTV ratio limit (C3). We assume the investor to be solvent enough not to violate the other three prudential limits, when taking the resulting values of mortgage loan payments and the size of mortgage loan into account. All calculations are done with respect to the available time series, given values of parameters and expected development of the economy.

More details about the computations are available in Appendix A.

4. Empirical analysis

4.1. Time series

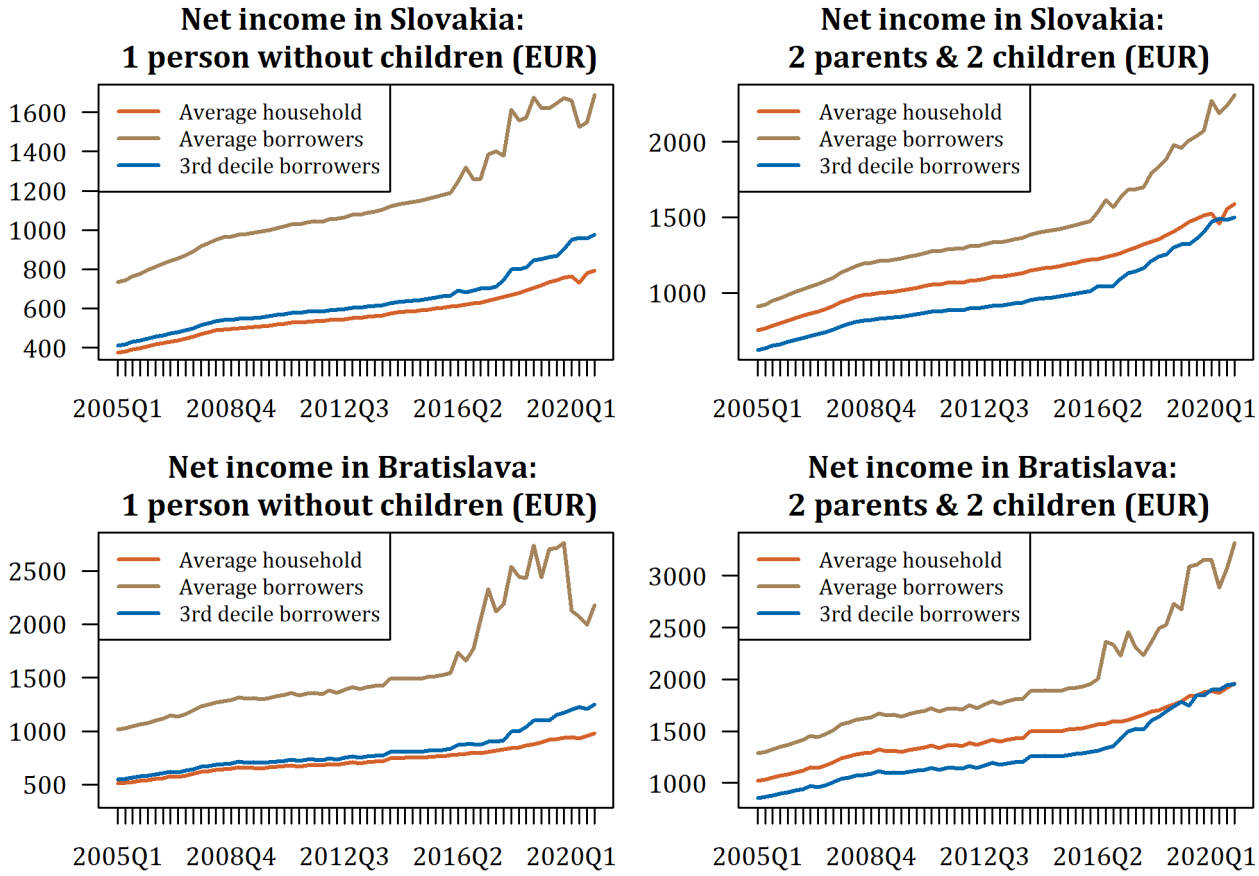
Household income

The household income used in the calculations is the household's net income reduced by the subsistence minimum based on the size and composition of the household. This is to mirror the methodology used for the DSTI limit introduced by the NBS. Retail loans are granted mainly to single debtors or two co-debtors. Moreover, according to the survey of Slovak indebted households conducted by NBS in 2020 (Cupák et al., 2020), households with no children or up to 2 children have the most significant shares of indebted households. The share of debtors with more than 2 children is relatively low. As the number of children directly enters the DSTI ratio calculation, the assumption of a household with 2 children is relatively prudent. For these reasons, in this paper we consider two types of household composition – single person without children and two parents with two children.

First, we use time series of average wage from the Statistical Office of Slovak Republic. As only gross wages are available, net income is calculated based on the assumption of fixed share of taxes and other deductions. However, our hypothesis is that an average mortgage debtor has usually higher than average income. Therefore, we also use time series obtained from a database containing individual loan tapes, where net income of debtors is available. The values are available from 2016Q1, so we approximate the values for earlier periods using the development of the average net income available from the Statistical Office of Slovak Republic. We use net income of a single debtor and separately of two co-debtors, since we assume these two types of household. In the analysis we will focus also separately on the 3rd decile borrowers[6]. The idea behind is that usually average real estate prices are constraining mainly for the lower end of mortgage debtors and not debtors from the higher end of income distribution. Income development of all considered types of households/borrowers are shown in Figure 1.

[6] Net income of the 3rd decile borrowers is obtained from individual loan tapes database.

Figure 1 Household net income for two different household compositions



Source: Statistical Office of SR, National Bank of Slovakia.

Real estate prices

We compare estimated house prices with the actual average real estate prices available on a quarterly basis from the Property Price Map. Time series are available from 2005Q1 to 2020Q4. We compare estimated and actual real estate prices for Slovakia and separately for the Bratislava region. To obtain real estate prices from the Property Price Map, we multiply the average price in $€/m^2$ by the average size of properties. The average size of the house used in the calculations is based on the average size available from the Property Price Map and is 66.14 m^2 for Slovakia and 71.64 m^2 for Bratislava region[7].

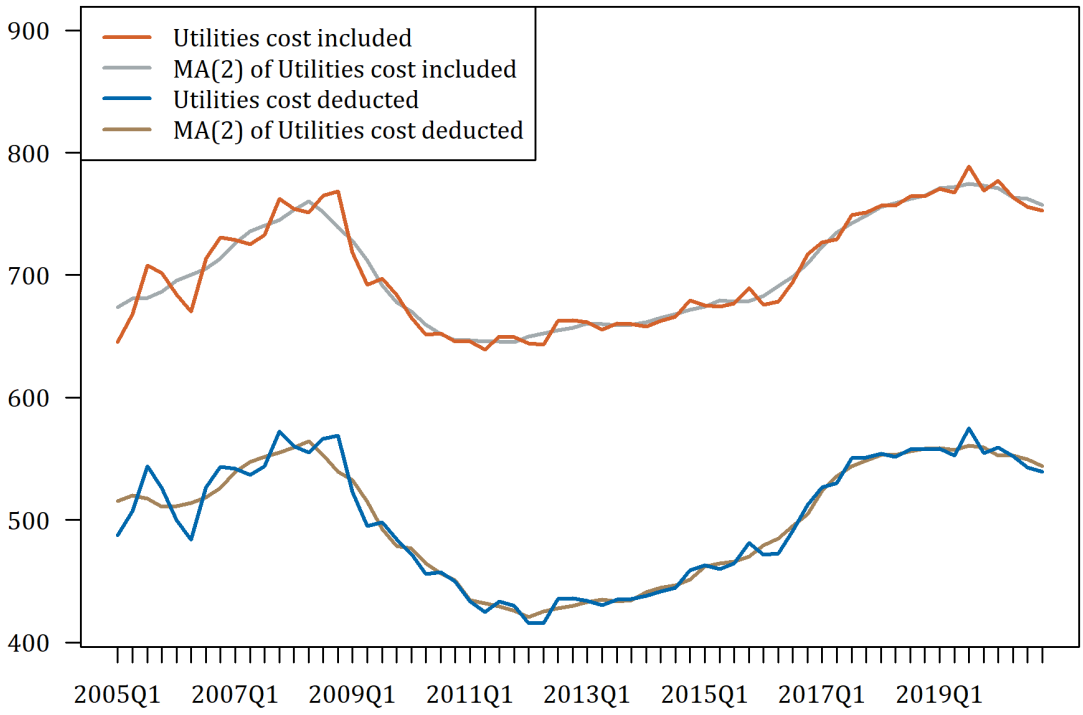
Rent

We use time series of rents in capital city, Bratislava, from the Property Price Map, where the values are given on monthly basis in $€/m^2$. As we compare real estate prices on a quarterly basis, the quarterly values of rents are calculated as the average value of three corresponding months. The obtained quarterly values show high volatility, especially at the beginning of time series, due to different methodological shortcomings at that time. To avoid these volatilities, we smooth the series using moving average of length 2 quarters. Finally, we use the average size of the house in Bratislava (71.95 m^2) available from Property Price Map to get the values of the average rent per real estate in Bratislava (Figure 2).

[7] While we calculate average prices, it is clear that not all households are buying property with average size. A sensitivity analysis based on flat size is therefore provided below, see Figure 6.

Unfortunately, it is not clear whether the utilities cost is included in the values of rent from the database, so we assume both marginal scenarios – all utilities are included and utilities are not included at all. Based on the last wave (2017) of the Household Finance and Consumption Survey (HFCS), we assume the average utilities cost for Slovak households is 200€ per month. We use this value as a basis point in 2017 and for other years we adjust it by the energy price index.

Figure 2 Average rent in Bratislava for both marginal scenarios of utilities cost inclusion (EUR)



Source: Property Price Map, National Bank of Slovakia.

4.2. Parameters

We take borrower-based measures set by the NBS into account with respect to their gradual tightening:

$$LTV_t^{max} = \begin{cases} 1; & t = 2005Q1, \dots, 2014Q4 \\ 0.90; & t = 2015Q1, \dots, 2018Q2 \\ 0.80; & t = 2018Q3, \dots, 2020Q4 \end{cases}$$

$$DSTI_t^{max} = \begin{cases} 1; & t = 2005Q1, \dots, 2018Q2 \\ 0.80; & t = 2018Q3, \dots, 2019Q4 \\ 0.60; & t = 2020Q1, \dots, 2020Q4 \end{cases} \quad (14)$$

$$DTI_t^{max} = \begin{cases} \infty; & t = 2005Q1, \dots, 2018Q2 \\ 8; & t = 2018Q3, \dots, 2020Q4 \end{cases}$$

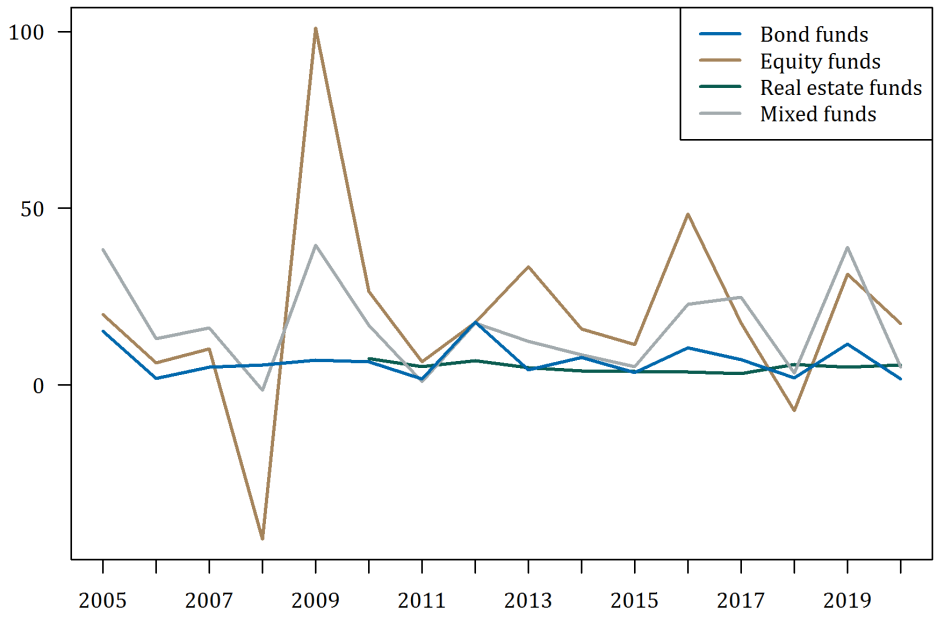
Validity of (C2) from 1Q2015

Our goal is to reach the maximum house prices safely attainable for the household. By "safely attainable" we mean in the way that none of the conditions (C1) - (C4) is violated. Therefore,

the calculations are done in a way to reach the results that are as close to thresholds (14) as they can be. For the same reason we set the mortgage loan maturity to $N = 30$ years and the consumer loan maturity $M = 8$ years, which represents the upper bound of maturities introduced by NBS. There are few exceptions, when those bounds can be exceeded, but in this paper we do not take them into account. This is to reflect the fact we estimate maximum attainable property prices for an average mortgage debtor and mortgages with exceptions are usually granted to above-average households (in terms, e.g., of income) or to a specific group of debtors (e.g. young families).

Setting the value of the opportunity cost parameter is not straightforward, as there are plenty of investment opportunities with different returns. Since we consider retail investors, we assume this investor in case of Slovakia can, as an alternative, invest into a collective investment funds. We consider four main types of domestic funds - bond funds, equity funds, real estate funds (data available from 2010) and mixed funds. The values of funds' performance are obtained from Analytical data of the financial sector published quarterly by NBS[8] (Figure 3). The average yearly return of real estate funds is 5.1%, while the average yearly return of bond funds is a little higher: 6.9%. In case of equity funds and mixed funds the annual returns reach higher values, but these values are also more volatile.

Figure 3 Average performance of four main types of domestic funds in Slovakia (% p.a.)



Source: National Bank of Slovakia.

For these reasons we use the constant value of opportunity cost $i_t^e = 7\%$ for the baseline model and then we provide some sensitivity analysis.

Tax-deductibility of interests paid was introduced in Slovakia only in 2017 and only for young families satisfying certain conditions. Therefore, we don't take this option into account and set

[8] https://www.nbs.sk/en/financial-market-supervision-practical-info/publications-data/selected-data/analytical-data-of-the-financial-sector

the values of $intcost_{t+i|t} = 0$ in (13) for every corresponding period. Income tax τ is set in term of Slovak legislation to 19%.

4.3. Forecasts

Household income forecast

Household income and mortgage interest rate forecasts are used in the DBC approach as well as in the intrinsic-value approach. For the period 2005Q1 to 2010Q3 we predict the future values of the annual growth rate of household income using autoregressive regression of order 1 (AR(1)):

$$x_t = \delta + \rho . x_{t-1}$$
$$gn = \frac{\delta}{1-\rho}, \tag{15}$$

with (persistence) parameter $\rho = 0{,}25$ and long-run steady-state value $gn = 4\%$ or $gn = 5\%$.[9]

Forecasts for 2010Q4 to 2016Q3 are based on the NBS's official mid-term (2 years ahead) forecasts. Values after the first two years are predicted using AR(1) model (15) with parameters $\rho = 0.25$ and $gn = 4\%$ or $gn = 5\%$.

For period 2016Q4 to 2020Q4 the predictions are made in the same way as in the previous section, the only difference is that the mid-term forecasts are made 3 years ahead. Missing quarterly and monthly values are obtained using linear interpolation (see Appendix B).

Mortgage interest rate forecast

For period 2005Q1 to 2008Q4 we assume constant interest rates equal to their value in the last observed period.

For period 2009Q1 to 2010Q3, when interest rate started to continuously decline, our assumption is that the market expected that in two years the rate will return to its last year's average value. During the first year we expect the value to be fixed on its actual value, and then, during the second year, linearly rising to the value of last year's average. Then we fix this value for the rest of the mortgage loan repayment period. This assumption is based on monetary policy normalization expectations, which were present in those times. The value of last year's average is chosen in order not to „overshoot" the real expectations in those times.

For period 2010Q4 to 2016Q3 the forecast of the interest rates is based on the official Slovak National Bank's mid-term (2 years ahead) predictions, Values after the first two years are predicted by fixing the last value of mid-term prediction.

For period 2016Q4 to 2020Q4 the predictions are made the same way as in previous section, the only difference is that mid-term forecasts are made for a 3 years period. Missing monthly values are then obtained using linear interpolation (see Appendix C).

[9] The values $\rho = 0.25$ and $gn = 4\%$ are used in line with Andrle and Plašil (2019a). We also use $gn = 5\%$ as the potential income growth can also assumed to be 3% + 2% inflation.

Rent forecast

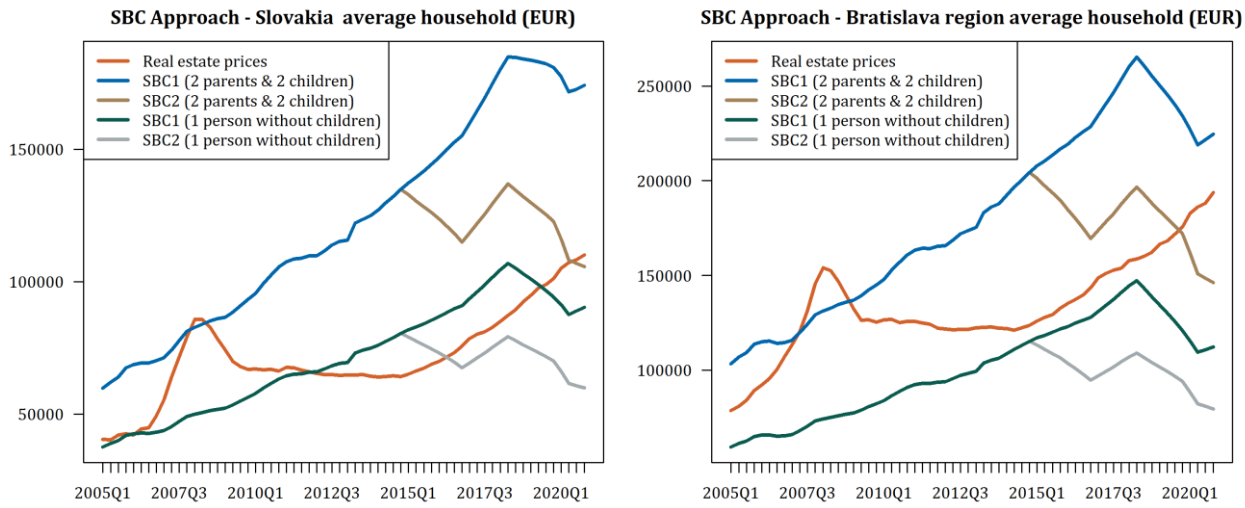
During the mortgage loan repayment period the expected developments of rents are estimated using income growth forecasts. After this period, it is set to grow at the steady-state long-run value, $gn = 4\%$ or $gn = 5\%$.

4.4. Results

Static Borrowing Capacity Approach

SBC approach with average income of Slovak households from the Statistical Office and a family with 2 parents and 2 children points to a possible overvaluation during the pre-crisis period in 2007 and 2008 (Figure 4). Based on the results, an average household could not afford during that period an average property.[10] After the crisis, lowering interest rates and increasing income led to a robust increase in affordability (widening the gap between attainable house price and actual house price).

Figure 4 Static Borrowing Capacity Approach – Results for average households



Source: Author's calculations, Property Price Map, National Bank of Slovakia.

Based on the estimations, the increase of income had a larger effect on the increase of attainability. Fixing income or interest rate at their values as of 2005Q1 leads to lower attainable prices, while the impact of the fixation of income is considerably larger (Appendix D). Since 2014, the implementation of borrower-based measures decreased the affordability, at least for households with not enough own capital. The two methods – SBC with and without a consumer loan, give a range of attainable house prices, while the lower end is gradually approaching actual average house prices. The difference in the results of these two methods is caused by implementing the LTV limit. The impact of the other two limits (DSTI and DTI) is shown in Appendix E. While the DTI limit decreased affordability for households with enough financial reserves, DSTI limit has an impact mainly on households opting also for consumer loan. This result is in line with our expectations, as the DTI limit was designed to ease households' indebtedness, while the DSTI limit was designed to ease households' debt-service

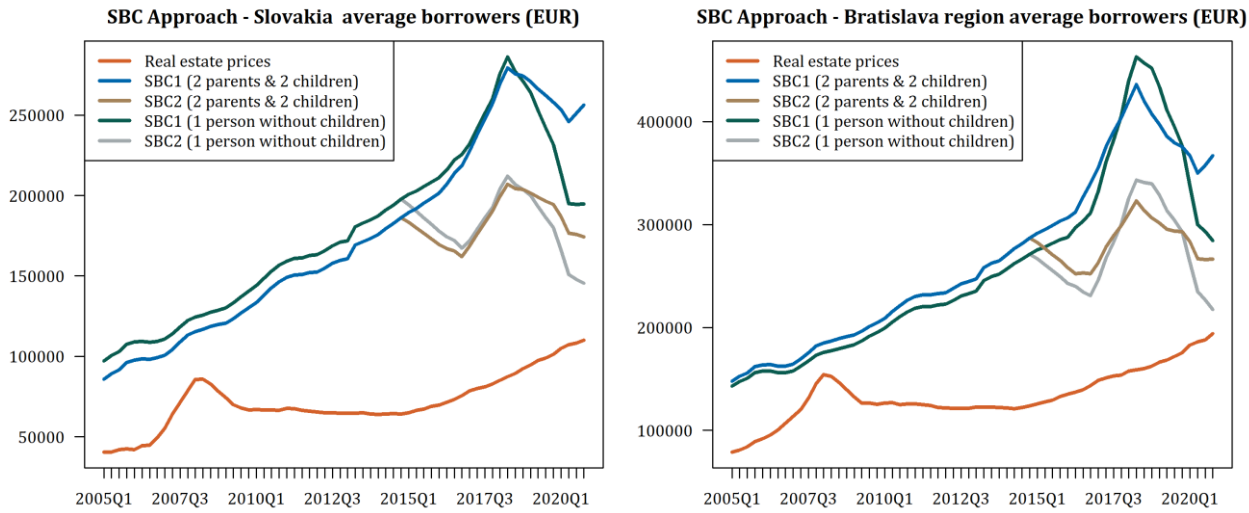
[10] In case of such unaffordability, households tend to reach for smaller houses.

burden. This points to a fact that borrower-based measures applied can indeed ease upward pressure on house prices even in an environment of historically low interest rates, unemployment and increasing income. The impact of the limits, however, depends also on the structure of demand, on the share of borrowers with and without own capital and on other factors. These results hold for Slovakia and Bratislava region, as well as for all other regions of Slovakia (see Appendix F). As the average income of a single person is simply half of a family with 2 parents in this case, obviously the results for a single person show the average property prices mostly above those attainable for such a single person.

However, one could expect that it is not a family with an average income that takes a housing loan. This hypothesis is confirmed when calculating the SBC approach with average income of actual borrowers. The results show attainable house prices well above average prices during the whole observed period (Figure 5). While borrower-based measures decrease availability in this case as well, attainable property prices remain well above average property prices. Naturally, these calculations are affected by selection bias, as only clients verified by banks and qualifying for the loan enter the calculation.

As we use the SBC approach to calculate the maximum available loan a client can take from the bank, this result gives an upper bound to potential house prices, as in general clients when asking for a loan have some reserves left also above the subsistence minimum. Another interesting result is that calculating the SBC approach with the average income having two or only one debtor gives very similar results, meaning that on average, if a single person is asking for a loan, this person has an income comparable to a pair of debtors. Again, these results hold both for Slovakia and Bratislava region.

Figure 5 Static Borrowing Capacity Approach – Results for average borrowers

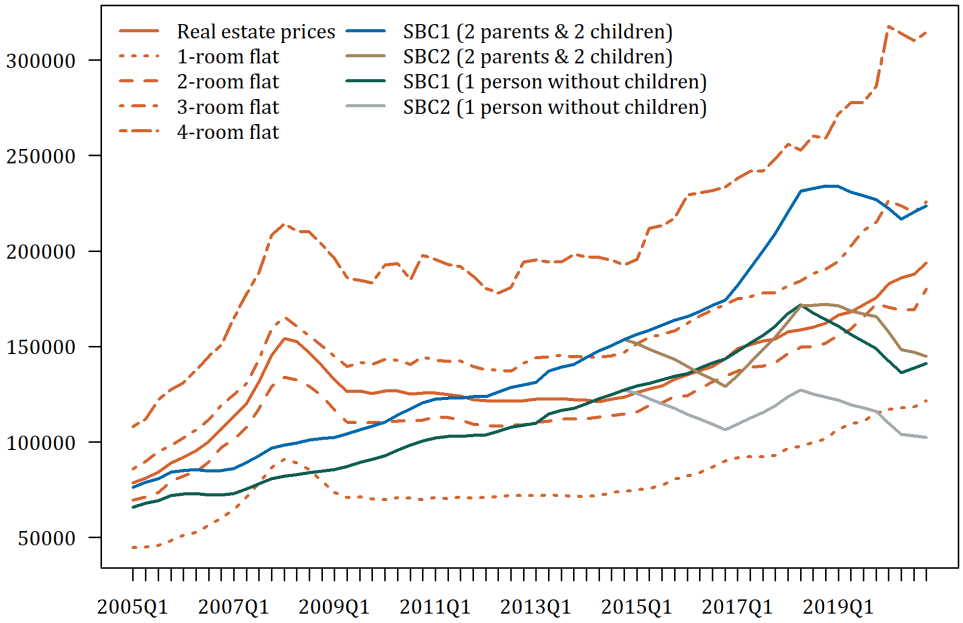


Source: Author's calculations, Property Price Map, National Bank of Slovakia.

While average borrowers can attain average properties, the prices are more constraining at the lower end of income distribution of borrowers. In Figure 6 we provide results for Bratislava region, for the 3rd-decile income of borrowers. In this case, there is a marked difference between attainable house prices in case of two debtors and a single debtor. For single debtors, attainable house prices range between the average price of flats with single room and two

rooms, pointing to the fact that single debtors at the lower end of income distribution are more constrained and are probably creating the main demand for smaller flats in the capital city. In case of two debtors, attainable prices range basically between flats with 2 or 3 rooms, even exceeding average prices of flats with 3 rooms at the end of the observed period.

Figure 6 Static Borrowing Capacity Approach – Results for Bratislava region 3rd-decile borrowers (EUR)



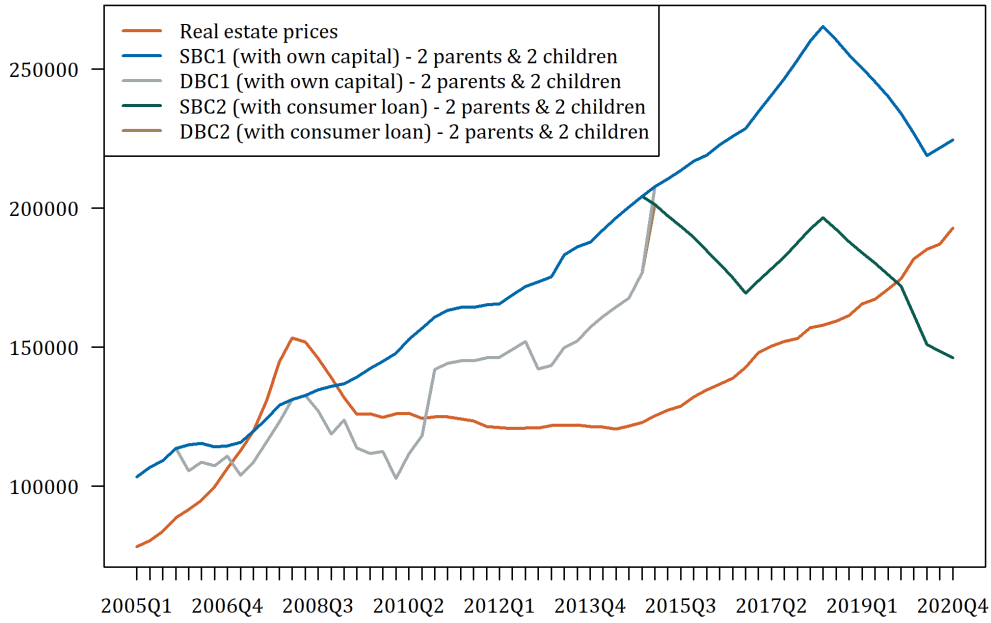
Source: Author's calculations, Property Price Map, National Bank of Slovakia.

Dynamic Borrowing Capacity Approach

Results for Dynamic Borrowing Capacity using time series, parameters and forecasts mentioned in previous sections are identical to the results achieved by Static Borrowing Capacity approach. This is due to the fact that expected income growth sufficiently covers the changes in mortgage interest rate growth expectations. However, during or after crisis periods, expectations about income growth in the future can be relatively pessimistic. Taking this into account, we consider forecast using AR(1) model (15) with parameter $\rho = 0.75$ and $gn = -1\%$, i.e. we expect slower adjustment of the current income growth to the negative long-run steady state value. Results for an average household in Bratislava region are shown in Figure 7 below.

In the first period (2005Q1-2008Q3), the results achieved by the DBC approach are almost the same as results achieved by the SBC approach. The reason are high values of income growth at that time (5% - 10%) together with expectations of slow adjustment to the negative long-run value. Hence, the predicted income continues to rise for a relatively long time, so the follow-up decline is not strong enough to violate any of the prudential limits (see left side of Appendix G). During the period after the crisis, the difference in SBC and DBC results is notable, due to decrease in income growth, so the adjustment to the negative growth is much more quickly (see right side of Appendix G). The results show that pessimistic expectations enough may explain to some degree the decrease in real estate prices during 2009.

Figure 7 Borrowing Capacity Approach – Results for an average household in Bratislava region and pessimistic expectations of income growth (EUR)

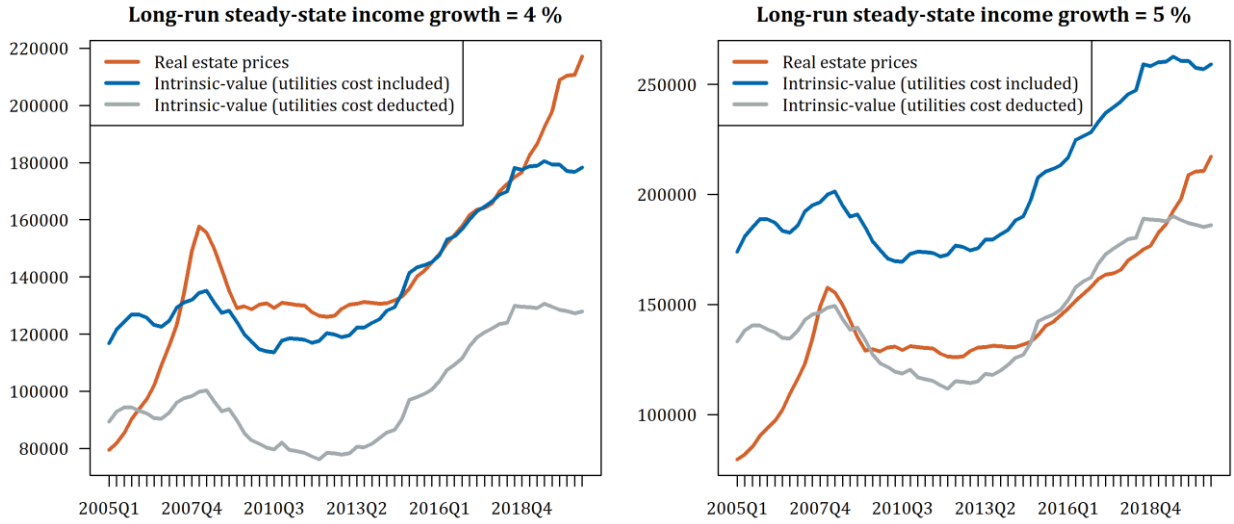


Source: Author's calculations, Property Price Map, National Bank of Slovakia.

After borrower-based measures have been gradually implemented, the results of SBC and DBC approaches become identical. It indicates that applied prudential limits have created enough space to negative shocks for borrowers.

Intrinsic-value Approach

Figure 8 Intrinsic-value Approach – results for both marginal scenarios of utilities cost inclusion (EUR)



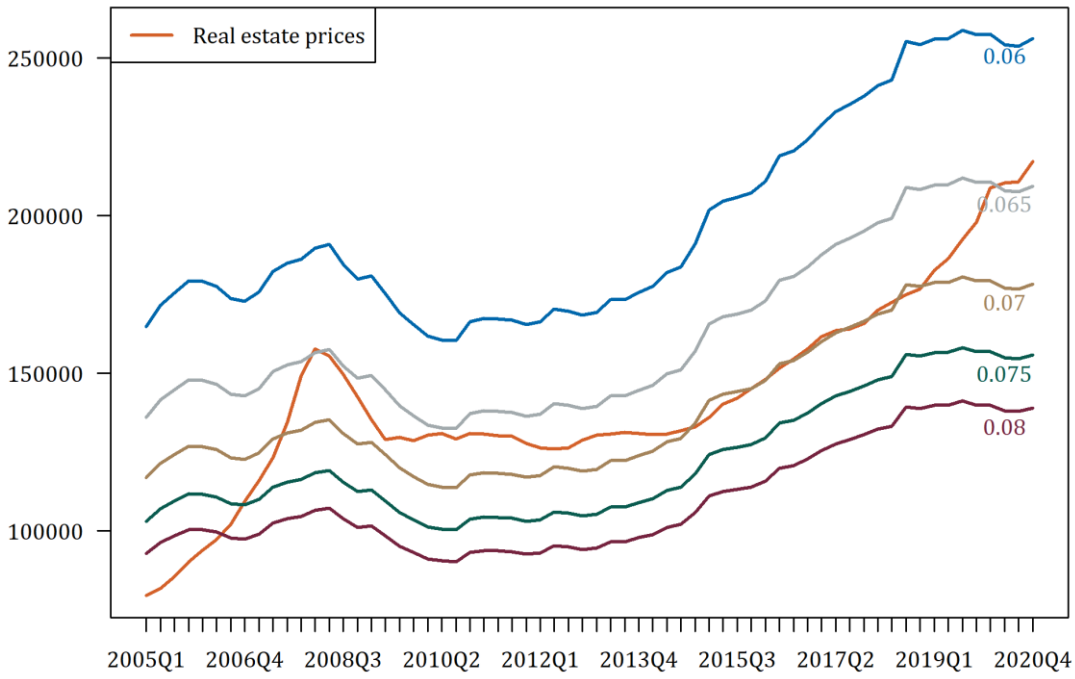
Source: Author's calculations, Property Price Map, National Bank of Slovakia.

As the rental market is liquid enough only for the capital city, we provide results only for the capital city, Bratislava. Results show that the assumption of utilities costs included (deducted), long-run income growth of 4% (5%) and the opportunity costs at the level of 7% can to a large extent replicate the development of house prices. When considering utilities costs included and

a long-run income growth of 4% (Figure 8, left side), prices seem to be overvalued in the pre-crises period up to end-2008. There is not so large difference after that period. Average prices were slightly below, or at the same level as the estimated prices until end-2019, when the gap was closed. Currently real estate prices are already above the estimated intrinsic values. Alternatively, we also consider utilities costs deducted and a long-run income growth of 5% (Figure 8, right side). In this case, the estimations do not point to such a strong overvaluation in the pre-crises period. On the other hand, the gap is widening in the latest quarters here as well.

As the opportunity cost is an important parameter that affects the results, we provide some sensitivity analysis (Figure 9). Basically, the higher is the assumed opportunity cost (it means the investor is more risk-averse), the lower is the net present value of the property given the expected growth of rents. Lower net present value than makes the investment into properties less attractive. However, if there is pressure to decline returns on alternative assets and an environment of low returns persists for a longer period of time, investors can be satisfied with a lower return on real estate in the long run. Nevertheless, if we assume during 2010 and 2013 there was a relatively calm period where average house prices were basically unchanged, the opportunity cost at the level of 7% seems to be a relatively good approximation for both cases of long-run income growth.

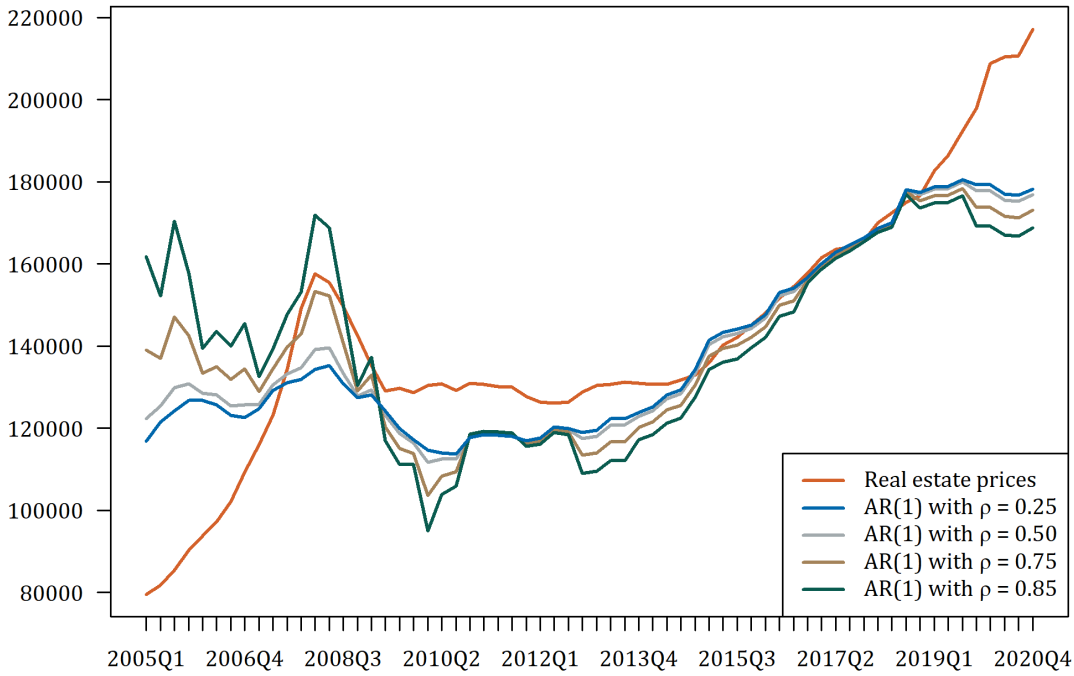
Figure 9 Intrinsic-value Approach – Opportunity cost sensitivity analysis (EUR)



Source: Author's calculations, Property Price Map, National Bank of Slovakia.
Note: utilities costs included, long-run income growth of 4%.

Another parameter affecting the results is the coefficient of adjustment, ρ, that determines how quick is the expected adjustment of the income growth to its assumed long-run value ($gn = 4\%$). The higher is the value of the parameter, the longer is the adjustment of income growth (**Figure 10**).

Figure 10 Intrinsic-value Approach – Rent growth sensitivity analysis (EUR)



Source: Author's calculations, Property Price Map, National Bank of Slovakia.
Note: utilities costs included, long-run income growth of 4%.

It means that in periods of high income growth (2005Q1 – 2008Q3, when income growth ranged between 5% and 10%), a higher value of this parameter leads to overly optimistic expectations. This can to a large extend explain the increase of property prices in the pre-crisis period. On the contrary, a higher value of this parameter during a period of low income growth (2009Q2 – 2010Q3, when income growth ranged between 0% and 3%) results in a marked decrease in the implied prices.

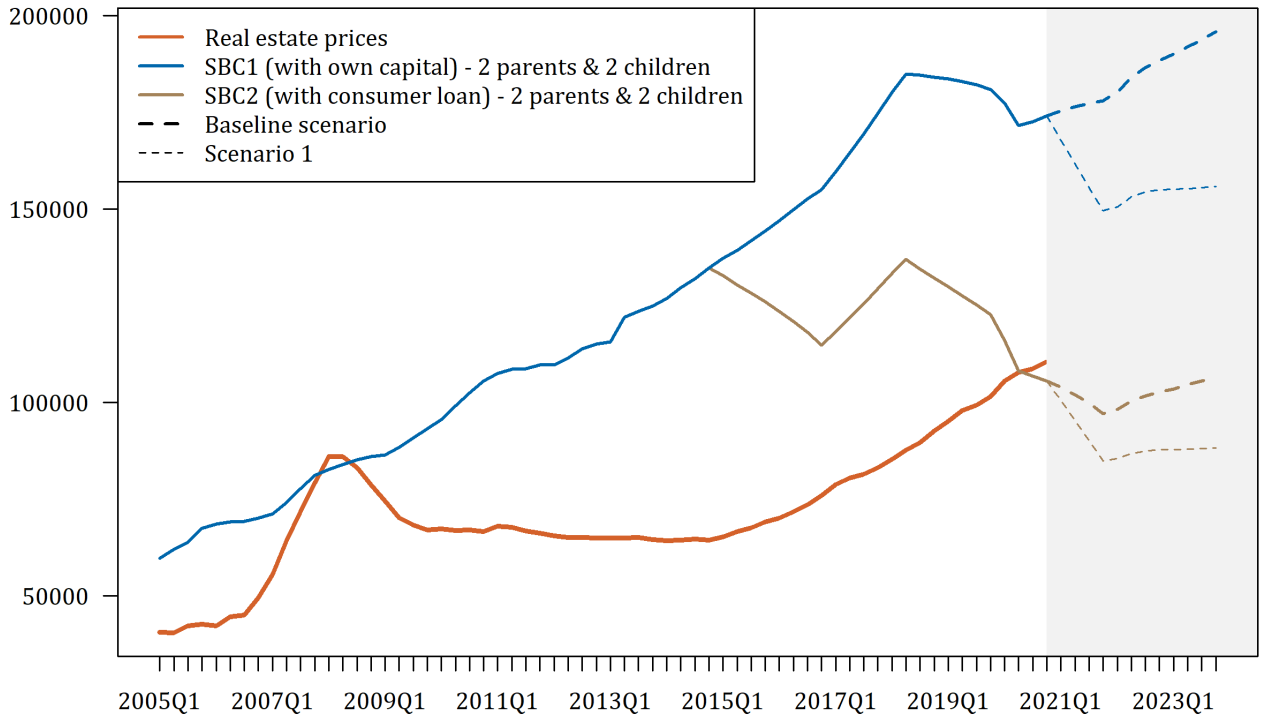
4.5. Property Price Forecasts

The SBC and intrinsic value approach can be used also to forecast the possible range of future attainable house prices. In the below table, we provide two scenarios, one baseline and one more strict. The coronavirus pandemic had an impact on the expected economic development as well, having a negative impact mainly at the beginning of 2020. The official prediction of the NBS as of 2020Q1 for 2020 was relatively negative, expecting the GDP to drop in a range between -5.8% and -13.5%. More importantly for the estimation of attainable house prices, wages were also expected to decrease in 2020, within a possible range of -2.5% and -5.3%. However, beside the coronavirus, forecasts are affected by the tightening of DSTI limit, as the maximum DSTI decreases from 80% to 60% in 2020Q1. To distinguish between the impact of this DSTI tightening and the impact of the expected drop in income, we add a baseline scenario based on the NBS official prediction as of 2019Q4. For the interest rates we expect that in the negative scenario they increase by 1 percentage point in 2021 and then remain flat. In the baseline scenario we expect interest rates to remain flat.

TABLE 1 SCENARIOS USED FOR HOUSE PRICE FORECAST			
		Income, y-o-y growth	Interest rates growth
Baseline scenario	2021	3.3%	+0 p.p.
	2022	4.0%	+0 p.p.
	2023	4.3%	+0 p.p.
Scenario 1	2021	-1.7%	+1 p.p.
	2022	1.8%	+0 p.p.
	2023	0.9%	+0 p.p.

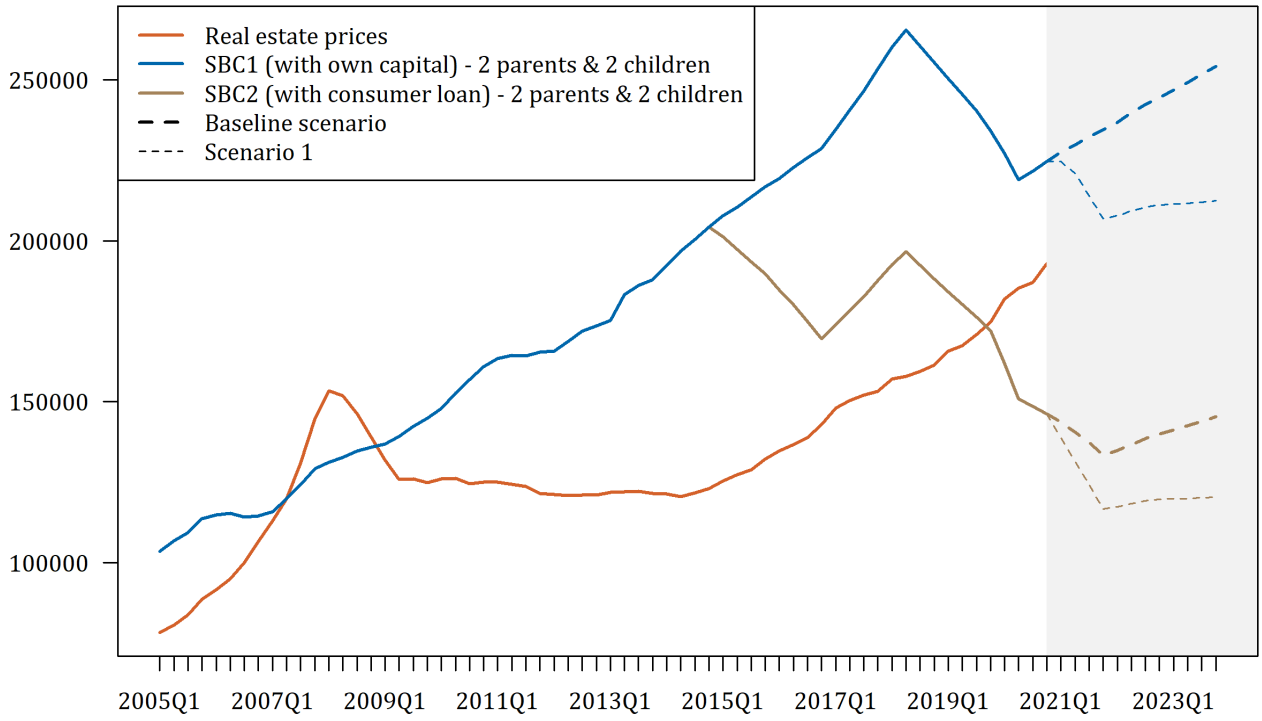
Forecasts are calculated using SBC approach and the average income from the statistical office for a family with 2 children. As expected, tightening of the DSTI causes a decrease of attainable house prices. The decrease is more pronounced at the lower end of the range, for capital constrained borrowers. The assumed decrease of income and increase of interest rates creates further downward pressure on house prices. The model shows that for potential capital constrained borrowers, average prices as of end-2019 could be well above attainable prices, what could create significant downward pressure on property prices in the coming period. This result holds for Slovakia (Figure 11) as well as Bratislava region (Figure 12).

Figure 11 Forecast of attainable house prices – Slovakia (EUR)



Source: Author's calculations, Property Price Map, National Bank of Slovakia.

Figure 12 Forecast of attainable house prices – Bratislava region (EUR)



Source: Author's calculations, Property Price Map, National Bank of Slovakia.

Conclusions

In this paper, we apply the borrowing capacity approach and the intrinsic value approach to assess property prices in Slovakia. Both methods are useful when only short time series are available. Another advantage is that property prices are not used within the calculation at all, therefore the potential outcome of over- or undervaluation is not based on any long-run value of observed property prices. We estimate the maximum attainable house price for a given household. It means that we apply downpayment, DSTI or DTI parameters in line with the limits implemented by the NBS. We consider the possible top-up in the form of a consumer loan for a household not having enough own capital. Finally, we make use of an internal database of NBS of individual retail loan data that gives us a better picture of the average income of borrowers.

Results based on the SBC approach point to a possible overvaluation during the pre-crisis period in 2007 and 2008. After the crisis, lowering interest rates and increasing income led to a robust increase in affordability. Since 2014, the implementation of borrower-based measures decreased the affordability, at least for households with not enough own capital. Based on the results, borrower-based measures could ease under some circumstances the upward pressure on house prices even in an environment of historically low interest rates, unemployment and increasing income. These results hold both for Slovakia and Bratislava region.

When calculating the SBC approach with average income of actual borrowers, attainable house prices are well above average prices during the whole observed period. This is true even though borrower-based measures decrease availability in this case as well. Naturally, these calculations are affected by selection bias, as only clients verified by banks and qualifying for the loan enter the calculation.

In most cases the results of the SBC and the DBC are very similar. However, during or after crisis periods, expectations about income growth were relatively pessimistic leading to notable differences between the two approaches. Results show that pessimistic expectations enough may explain to some degree the decrease in real estate prices during 2009.

We were able to apply the intrinsic-value Approach on capital city, Bratislava, where the rental market is liquid enough. Results show that obtained valuations are quite close to the observed development of house prices. However, they are to a large extent dependent on the choice of parameters, like opportunity cost (which depends purely on the investor's risk appetite) or the coefficient of adjustment that determines how quick is the expected adjustment of the income growth to its assumed long-run value.

References

Andrle, M., & Plašil, M. (2019a). Assessing House Prices with Prudential and Valuation Measures. *IMF Working Paper, WP/19*/59.

Andrle, M., & Plašil, M. (2019b). Assesing House Prices in Canada: Borrowing Capacity and Investment Approach. *IMF Working Paper, WP/19*/248.

Cár, M., & Vrbovský, R. (2018). Alternatívy Kompozitného Indexu na Hodnotenie Vývoja Cien Bývania. *Analytický Komentár NBS, 54/2018*.

Cupák, A., Klacso, J., & Šuster, M. (2020). Surveying the Impact of the Covid-19 Recession on the Financial Situation of Indebted Households. *NBS Working paper, 6/2020*.

ECB. (2011). Box 3: Tools for Detectinga Possible Misalignment of Residential Property Prices from Fundamentals. *Financial Stability Review June 2011*.

ECB. (2015). Box 3: A Model-Based Valuation Metric for Residential Property Markets. *Financial Stability Review November 2015*.

Gattini, L., & Hiebert, P. (2010). Forecasting and Assessing Euro Area House Prices Through the Lens of Key Fundamentals. *ECB Working Paper*(1249).

Geng, N. (2018). Fundamental Drivers of House Price in Advanced Economies. *IMF Working Paper, 18*(164).

Harnos, L. (2018). Cycles of the Housing Market in Hungary from the Economic Crisis Until Today. *64*(2), pp. 3-14.

Hejlová, H., Hlaváček, M., & Komárek, L. (2017). A Comprehensive Method for House Price Sustainability Assessment in the Czech Republic. *Prague Economic Papers, 26*(3), pp. 269-285.

NBS. (2019a). *Analysis of the Slovak Financial Sector 2018*. National Bank of Slovakia.

NBS. (2019b). *Financial Stability Report May 2019*. National Bank of Slovakia.

Olszewski, K. (2012). The Impact of Commercial Real Estate on the Financial Sector, Its Tracking by Central Banks and Some Recommendations for Macro-Financial Stability Policy of Central Banks. *SSRN Electronic Journal*. doi:10.2139/ssrn.2190851

Philiponnet, N., & Turrini, A. (2017). Assessing House Price Developments in the EU. *Discussion Paper, 48/2017*.

Rychtárik, Š., & Krčmár, M. (2010). Financing of Housing via Bank Loans and its Interpretation. *Nehnuteľnosti a bývanie, 02/2010*.

Trojanek, R. (2011). House Price Cycles - the Case of Poland. *Journal of International Studies, 4*(1), pp. 9-17.

Appendix A Algorithms

The algorithm of SBC Method 1 (with own capital)

Step 1: Set the desired values of $LTV_t, DSTI_t$ ratios in line with conditions (C1) and (C3).

Step 2: Set the value of parameter $\alpha = DSTI_t$.

Step 3: Given α, N, Y_t, i_t calculate the values of mortgage loans L_t^{shock} and $L_t^{noShock}$ and choose the lower one according to condition (C2) to get a new value of monthly payments $\alpha' \times Y_t$, with $\alpha' \leq \alpha$, so the condition (C1) is still satisfied.

Step 4: Check if the DTI condition (C4) is satisfied.

- If the condition is satisfied, proceed to Step 5.
- If it's not, decrease the value of mortgage loan L_t by value $\boldsymbol{step} \times \boldsymbol{d}$, where $step$ is a suitably chosen constant, that controls the speed of the algorithm convergence and $d = DTI_t - DTI_t^{max}$ (the distance from DTI limit). Proceed back to Step 4.

Step 5: Divide the final value of the mortgage loan L_t by LTV_t ratio to get the attainable house price P_t^{SBC}.

The algorithm of SBC Method 2 (with the consumer loan)

Step 1: Set the desired values of $LTV_t, DSTI_t$ ratios in line with conditions (C1) and (C3).

Step 2: Set the values of parameters $\alpha + \beta = DSTI_t$.

Step 3: Given $\alpha, \beta, M, N, Y_t, i_t, r_t$ calculate the values of mortgage loans L_t^{shock}, $L_t^{noShock}$ and corresponding values of consumer loans C_t^{shock} a $C_t^{noShock}$.

Step 4: Check if $LTV_t^{real}\left(= \frac{L_t^{shock}}{L_t^{shock} + C_t^{shock}}\right) = LTV_t$.

- If equality is satisfied, proceed to Step 5.
- If equality isn't satisfied, first increase/decrease the parameter α by $\boldsymbol{step} \times \boldsymbol{d}$, where $step$ is suitably chosen constant, that controls the speed of algorithm convergence and d is the distance from LTV_t ratio set in Step 1 (increase or decrease depends on position of LTV_t^{real} from LTV_t). Next, calculate the value of $\beta = (DSTI_t - \alpha)$, so the preset value of $DSTI_t$ ratio is preserved. Calculate a new values of L_t^{shock} and C_t^{shock} and proceed to Step 4.

(Repeat Step 4 also for $L_t^{noShock}$)

Step 5: Choose $L_t = min\left(L_t^{noShock}, L_t^{shock}\right)$ and the corresponding value of the consumer loan C_t.

Step 6: Check if the DTI ratio condition (C4) is satisfied.

- If the condition is satisfied, proceed to Step 7.
- If it's not, decrease the value of the mortgage loan L_t by $\boldsymbol{step} \times \boldsymbol{d} \times \boldsymbol{LTV_t}$ and also decrease the value of the consumer loan C_t by $\boldsymbol{step} \times \boldsymbol{d} \times (\boldsymbol{1} - \boldsymbol{LTV_t})$, where $step$ is suitably chosen constant controlling the speed of algorithm convergence and $d = DTI_t - DTI_t^{max}$ (distance from the DTI limit). LTV_t value is used in this calculation in order to ensure that new values of the mortgage loan and the consumer loan are in line with the desired value of the LTV_t ratio set in Step 1. Proceed to Step 6.

Step 7: The final value of the attainable house price $P_t^{SBC} = L_t + C_t$ is achieved.

The algorithm of DBC Method 2 (with the consumer loan)

Step 1: Start with the estimated sizes of the mortgage loan L_t and the consumer loan C_t and all relevant values of parameters, obtained by SBC 2 method. Set the value of K - the number of years, after which the value of the mortgage rate is reset to a new value.

Step 2: Create an amortization table for the mortgage loan L_t with respect to the parameter K and considered forecast of interest rate growth.

Step 3: Using the sizes of the mortgage payments from the amortization table together with the size of the consumer loan payments and with respect to the considered household income growth forecast, check if the DSTI condition (C1) isn't violated in any point in the future (on monthly basis).

- if the condition isn't violated, proceed to Step 4.
- If the condition is violated, decrease the size of loan L_t by $\boldsymbol{step} \times \boldsymbol{d} \times \boldsymbol{LTV_t}$ and the size of consumer loan C_t by $\boldsymbol{step} \times \boldsymbol{d} \times (\boldsymbol{1} - \boldsymbol{LTV_t})$, where $step$ is suitably chosen constant controlling the speed of algorithm convergence and d is the distance of expected DSTI ratio value from its maximum limit in a first period in which the condition is violated. Proceed back to step 2. Incorporated LTV ratio assures us, that the desired value of LTV ratio is preserved while changing the values of both loans.

Step 4: The final value of the attainable house price $P_t^{DBC} = L_t + C_t$ is achieved.

The algorithm of DBC Method 1 (with own capital)

The algorithm is similar to the previous one, but the consumer loan isn't included. Hence, in step 4, the desired house price is $P_t^{DBC} = {}^{L_t}/_{LTV_t}$.

The algorithm of Intrinsic-value method

Step 1: Set the desired value of the LTV_t ratio in line with condition (C3) and set an initial value of the mortgage payment equal to the initial value of monthly rent $A_t = R_t$. Set the value of K - the number of years, after which the value of the mortgage rate is reset to a new value.

Step 2: Given N, i_t and A_t calculate the size of mortgage loan L_t.

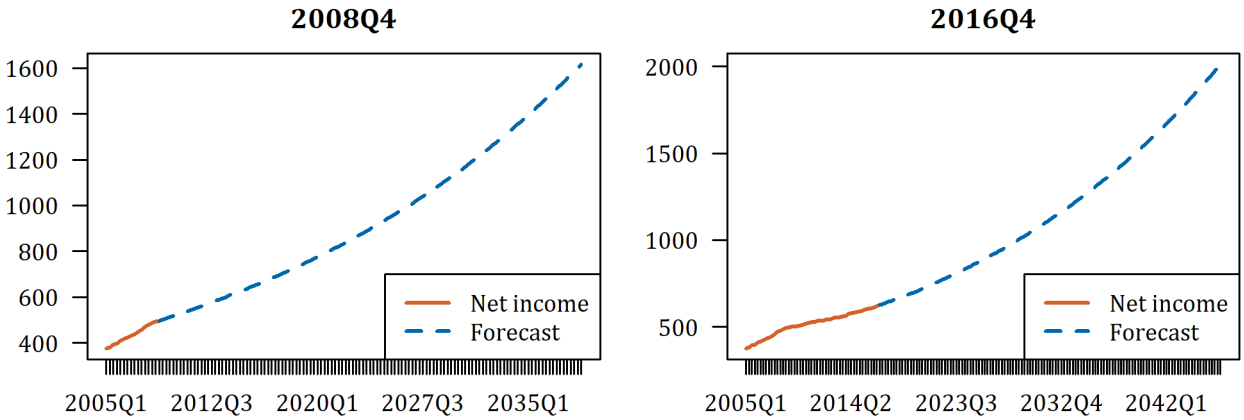
Step 3: Create an amortization table for the mortgage loan L_t with respect to the parameter K and considered forecast of interest rate growth. Based on this amortization table calculate the values of $mpay_{t+i|t}$ and $intcost_{t+i|t}$. Using the rental growth forecast calculate the values of $rent_{t+i|t}$. Use these results together with the given parameters in the valuation formula (13) to get the house value $V_{t|t}$.

Step 4: Check if $LTV_t = L_t/V_{t|t}$.

- if equality is met, proceed to Step 5.
- If it's not, decrease the initial value of the mortgage payments A_t by $\boldsymbol{step} \times \boldsymbol{d}$, where $step$ is suitably chosen constant controlling the speed of algorithm convergence and $d = L_t/V_{t|t} - LTV_t$. Proceed back to Step 2.

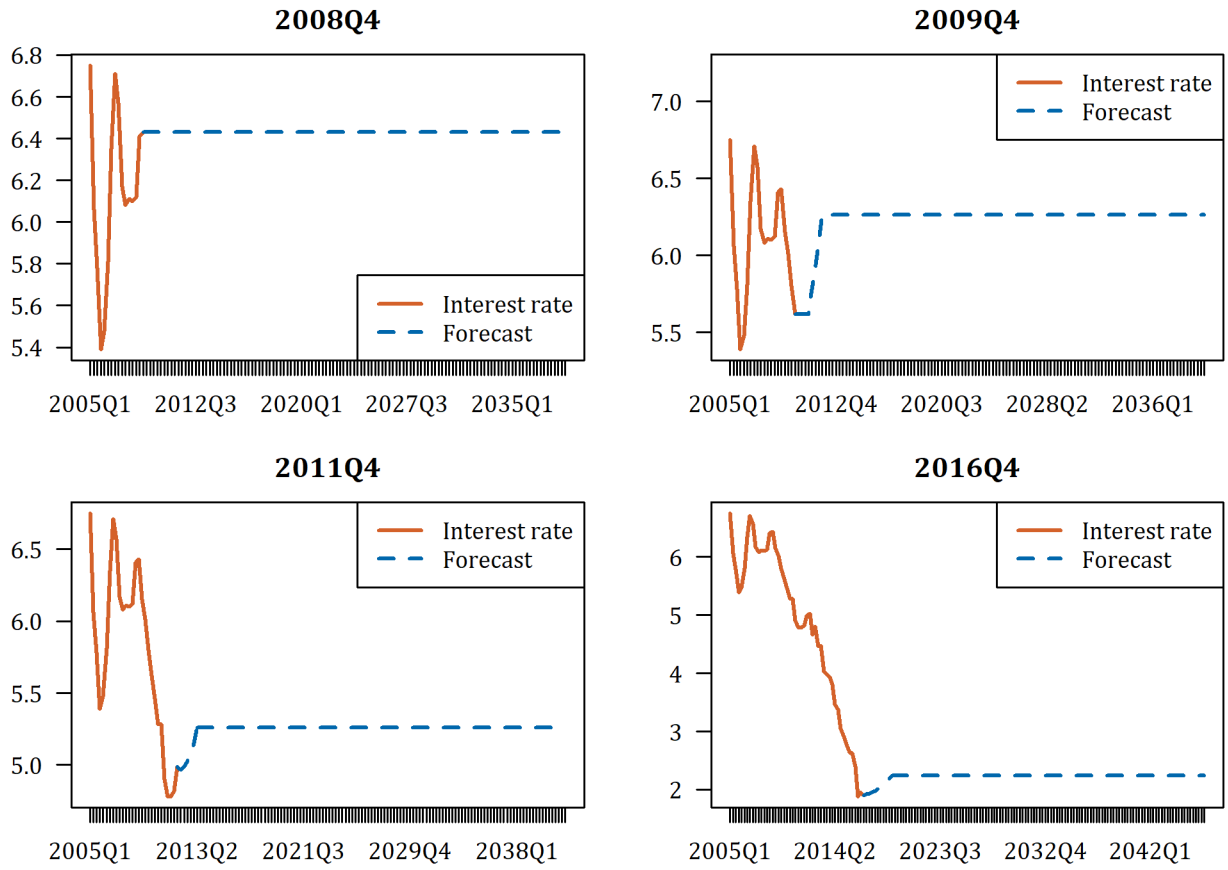
Step 5: The desired value $V_{t|t}$ is achieved.

Appendix B Household net income (EUR) forecasts for selected periods (national average)



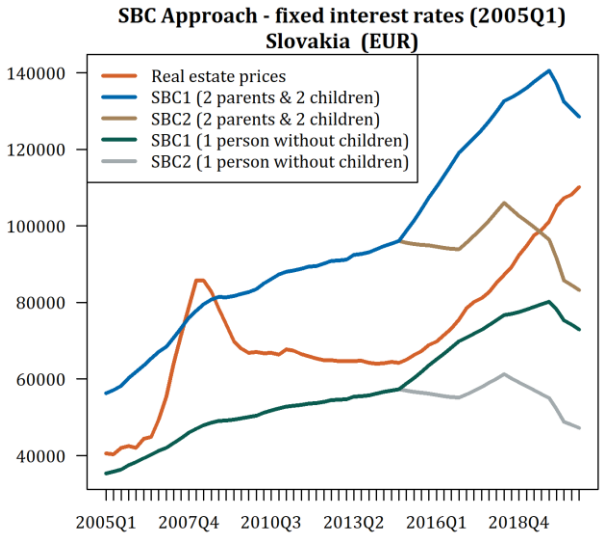
Source: Author's calculations, National Bank of Slovakia.

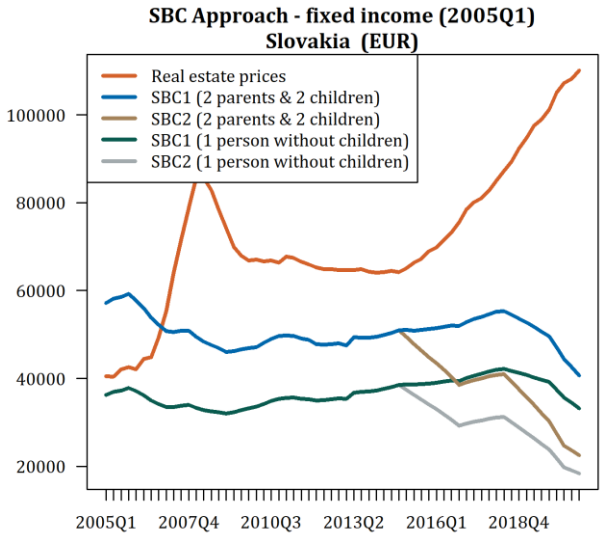
Appendix C Mortgage interest rate (% p.a.) forecasts for selected periods

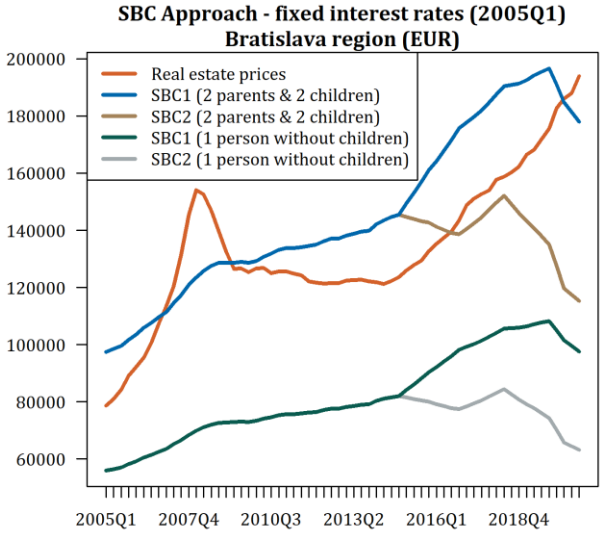


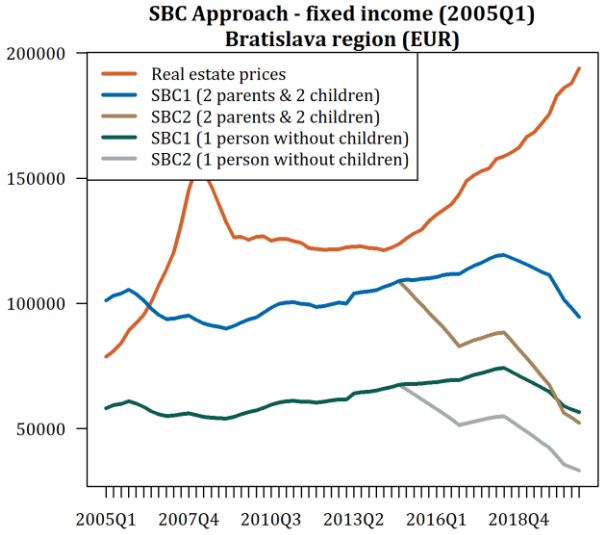
Source: Author's calculations, National Bank of Slovakia.

Appendix D Results of SBC method with fixed interest rates or fixed income



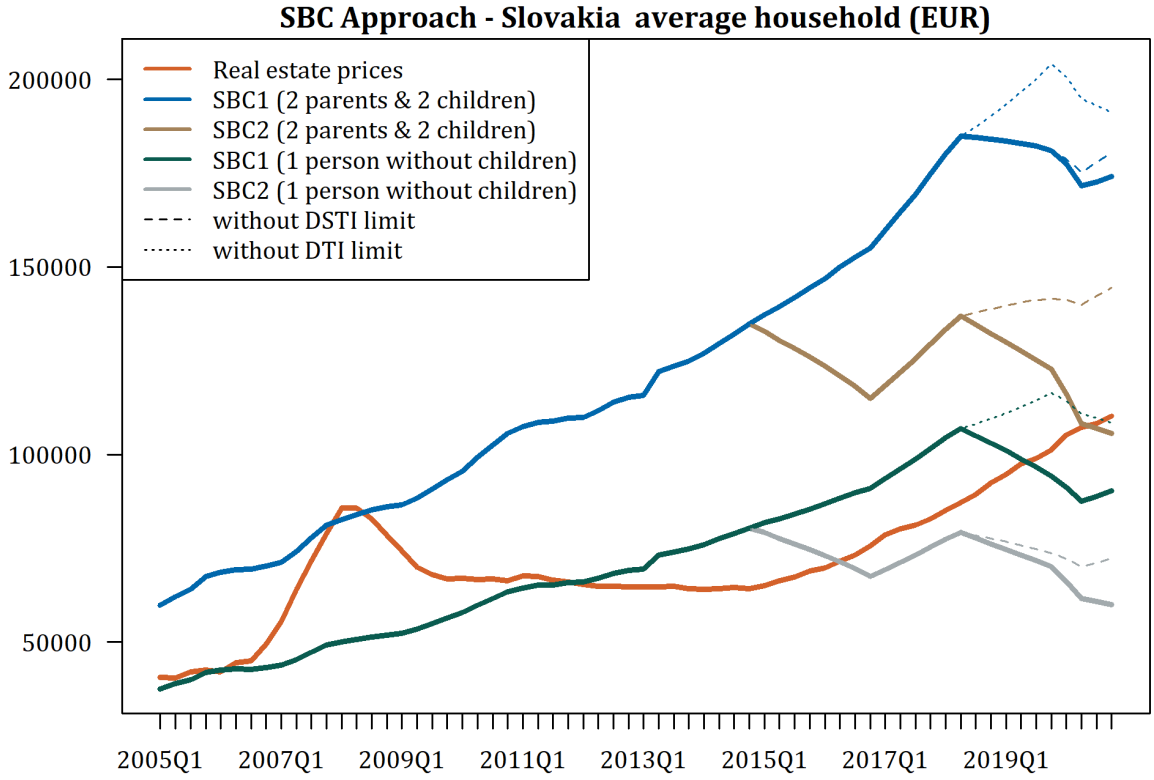


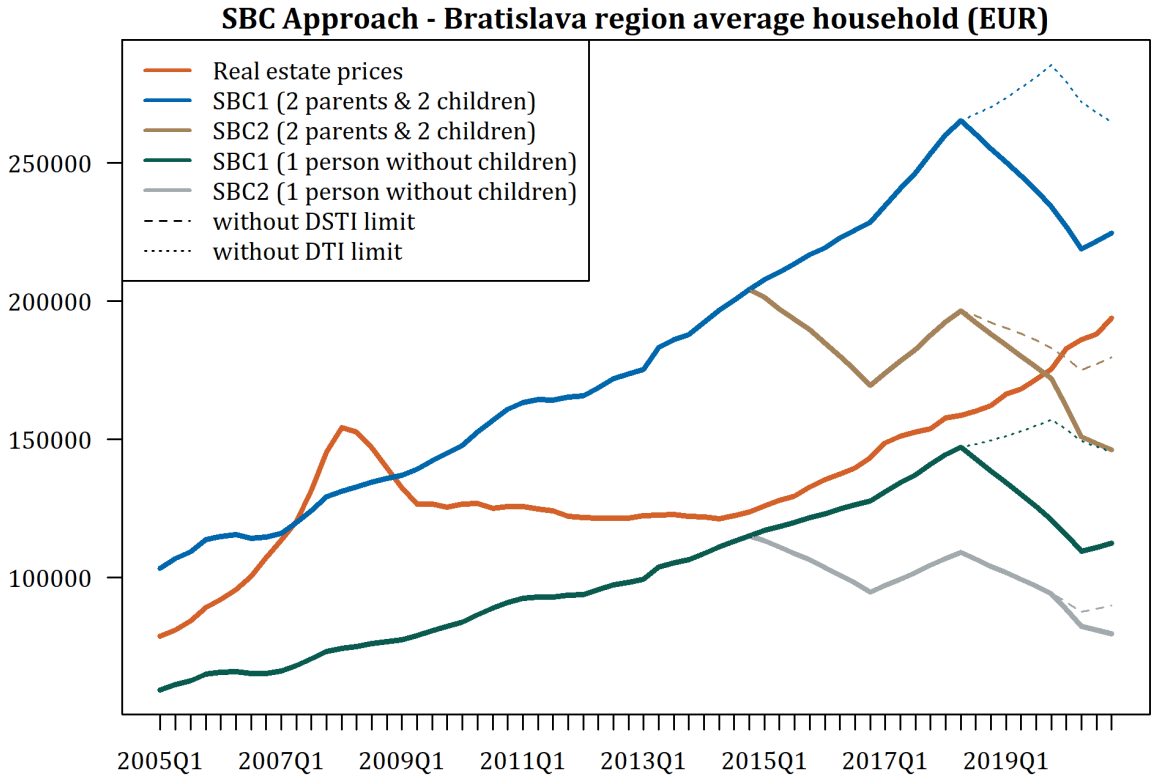




Source: Author's calculations, National Bank of Slovakia.

Appendix E Results of SBC method without DSTI or DTI limits

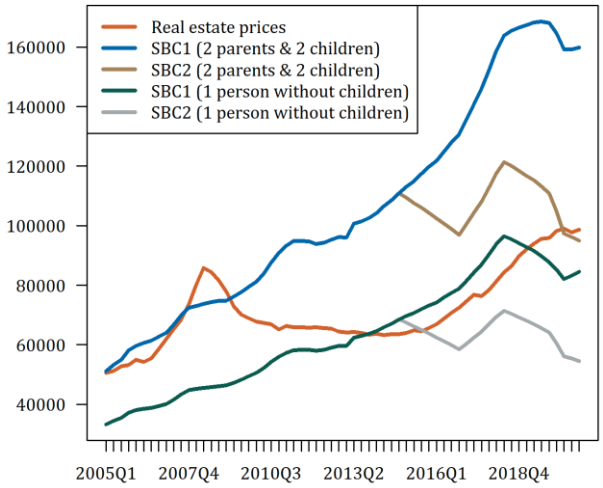




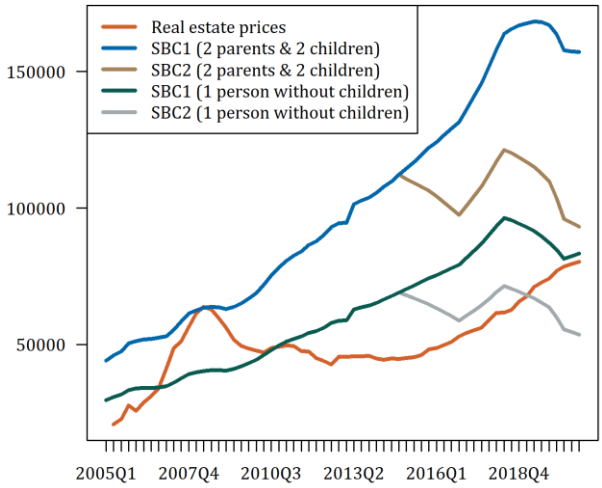
Source: Author's calculations, Property Price Map, National Bank of Slovakia.

Appendix F Results of SBC method for average household in other regions

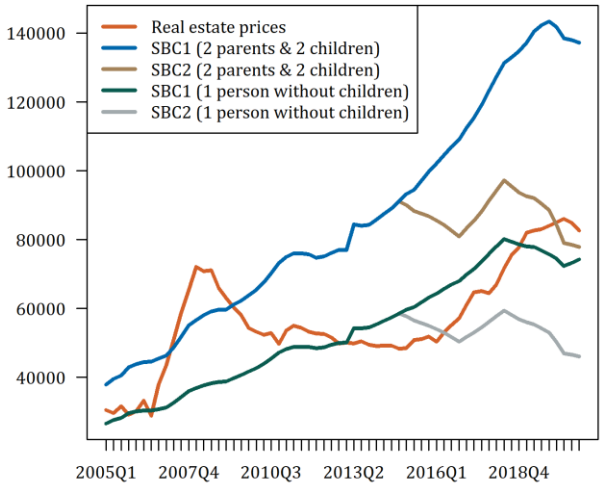
SBC Approach - Trnava region average household (EUR)



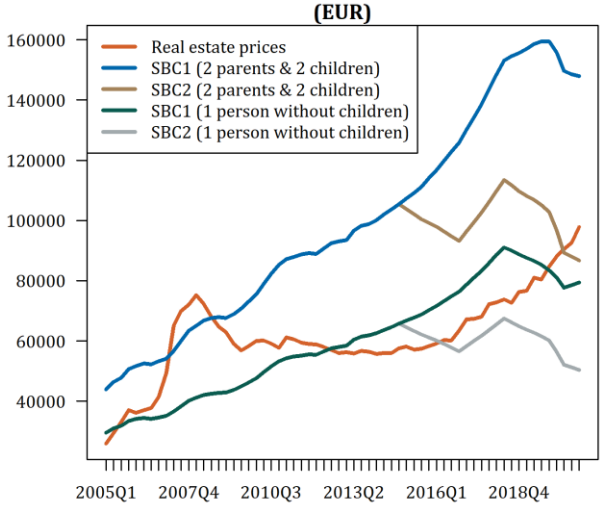
SBC Approach - Trenčín region average household (EUR)



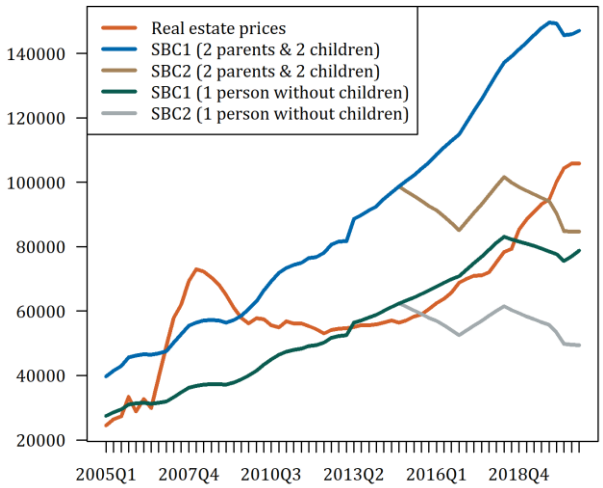
SBC Approach - Nitra region average household (EUR)



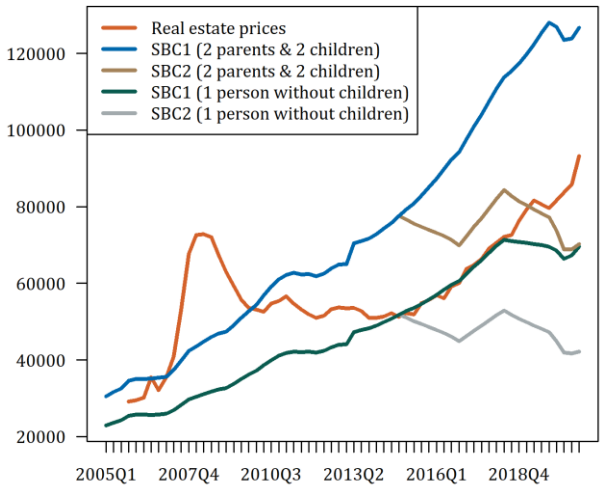
SBC Approach - Banská Bystrica region average household (EUR)

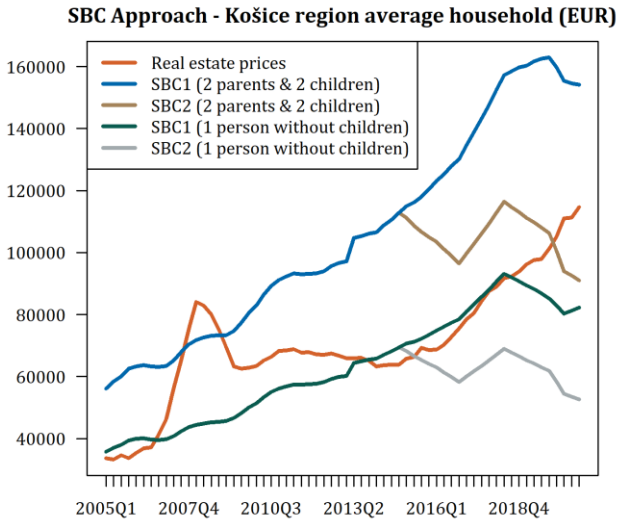


SBC Approach - Žilina region average household (EUR)



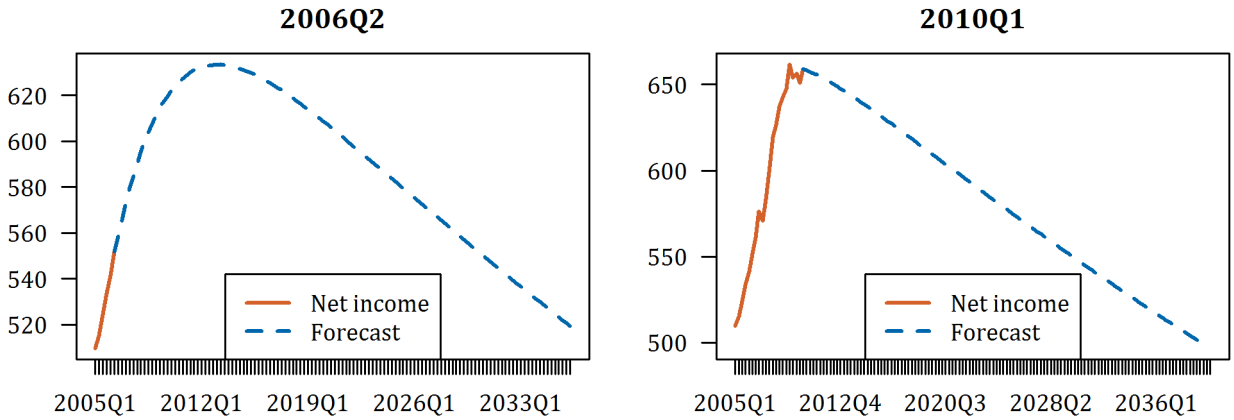
SBC Approach - Prešov region average household (EUR)





Source: Author's calculations, Property Price Map, National Bank of Slovakia.

Appendix G Pessimistic forecasts of household net income growth (EUR) (Bratislava region average)



Source: Author's calculations, National Bank of Slovakia.