DATE: 16 JUNE 2025

The CNB's approach to the calibration of borrower-based measures

Contents

1 INTRODUCTION 2

2 BASIC INFORMATION ON THE CALIBRATION OF BBMS 4

3 APPROACHES USED TO ASSESS RISKS IN THE HOUSING MARKET 5

3.1 Indicator approach 5

3.2 Simulation approach 13

3.3 Expert approach 14

4 RISK ASSESSMENT PROCESS AND SELECTION AND CALIBRATION OF BBMS 15

5 COMMUNICATIONS 20

APPENDIX 21

CONTACT: Financial Stability and Resolution Department E: financial.stability@cnb.cz
Na Příkopě 28 www.cnb.cz
115 03 Prague 1

1 Introduction

The CNB is the designated macroprudential authority for the Czech Republic. It is responsible, among other things, for assessing **the degree of systemic risk to financial stability stemming from developments on the property and mortgage markets.**[1]

As international experience of financial crises has shown, risks associated with the housing and mortgage markets can take on a systemic dimension and their materialisation can have major adverse impacts on the financial system and the economy as a whole. Pre-crisis periods have been typified by relatively high or rising rates of house price growth, supported – amid very relaxed market credit standards – by high growth in highly risky new mortgage loans, leading to accelerating indebtedness, or in some cases, over-indebtedness of households. Individual lenders' idiosyncratic credit risks seemed to be sufficiently covered by collateral or capital. At the turning point in the cycle, however, it became evident that a systemically significant amount of loans had insufficient coverage. Sharp declines in asset prices, including prices of sold-off properties, have deepened and prolonged recessions and greatly increased the overall societal cost of crises.[2] For these reasons, great attention is paid in the EU to risks related to property bubbles accompanied by an over-indebted household sector. Monitoring and assessing risks arising from the property and mortgage markets has therefore become increasingly important in fulfilling the mandate of financial stability authorities.

The CNB focuses in great detail on cyclical and structural systemic risks associated with mortgage lending to retail clients. The ultimate objective of its macroprudential policy responding to these risks is stability of the domestic financial system. The main intermediate objectives are to maintain the resilience of mortgage lenders and a high level of solvency of individual borrowers, primarily by **dampening cycles in the provision of highly risky mortgage loans**.[3]

The CNB uses a range of prudential instruments to achieve these objectives. **This document focuses on borrower-based measures (BBMs).**[4] These comprise **upper limits on LTV** (loan-to-value; i.e. the ratio of the loan size to the value of collateral), **DTI** (debt-to-income, i.e. ratio of debt

1 In this text, "mortgage market" refers to the market for loans secured by residential property, "mortgage loan" refers to a consumer credit secured by residential property, and "property market" refers exclusively to the residential property market. In this sense, these terms are used interchangeably throughout the text. The document does not cover loans secured by commercial property, corporate loans secured by residential property or the commercial property market.

2 For example, Crowe, C., G. Dell'Ariccia, D. Igan and P. Rabanal (2014): How to deal with real estate booms: Lessons from country experiences, IMF WP/11/91; Jorda, O, M. Schularick and A. M. Taylor (2016): The great mortgaging: Housing finance, crises and business cycles, Economic Policy; Whelan, K. (2014): Ireland's economic crisis: The good, the bad and the ugly, Journal of Macroeconomics, 39(B): 424–440; and Ortega, E. and J. Penalosa (2012): The Spanish economic crisis: Key factors and growth challengers in the euro area, Banco de Espana, WP No. 1201.

3 The intermediate objective is not to smooth the residential property price cycle. The movement of these prices in the Czech Republic, i.e. the long-term imbalance between supply and demand for these properties, is driven by a whole range of factors. Changing them would require the coordination of several economic policies. These factors include household income, demographic trends, interest rates, the availability of credit, investor demand, the size of the housing stock, the volume of new construction, construction costs, land availability (national and regional rules governing land use), zoning, building regulations, public infrastructure, rental market regulations (tenant and owner protections), rent subsidies and the availability of social housing. Prices are also affected by housing subsidies and taxes, including property taxes, capital gains taxes, taxes on rental income, inheritance taxes and mortgage interest relief (Licchetta, M., Martins, V. D. and B. Vašíček (2025): Selected macroeconomic and social aspects of housing affordability, Intereconomics, Vol. 60, No 2.

4 To mitigate systemic risks arising from the housing market, the CNB may also apply capital buffers, risk weight floors and microprudential tools under Pillar 2.

to the net annual income of the loan applicant) and **DSTI** (debt-service-to-income, i.e. the ratio of total debt service to the net monthly income of the borrower).[5]

The CNB uses such limits **to counter excessive easing of credit standards** by mortgage lenders. Maintaining prudent credit standards through the business cycle generally helps lower the risk of over-indebtedness and strengthens the financial resilience of households. This keeps the credit quality of the mortgage portfolio robust and supports the resilience of lenders and, by extension, the entire financial sector. The CNB decides whether to set binding limits, to make changes to existing limits or to specify recommended limits on the basis of mortgage portfolio quality, the degree of relaxation of market credit standards and the intensity of new systemic risks arising from the housing market. In addition, it recommends a whole range of other parameters to mitigate risks in the housing loan market, such as prudent limits on credit ratios[6] and conditions related to loan maturity length, potential non-standard repayment schedules and lending for buy-to-let purposes. In this sense, **the CNB maintains a constant policy presence on the housing market**.

The CNB usually decides whether to set or recalibrate binding BBMs once every six months. **In doing so, it follows national legislation**[7] and the guidelines of international institutions.[8] It considers a broad set of indicators, along with the results of analyses and models, which are then assessed by experts. While there is broad international agreement on the right types of indicators and analyses to use,[9] opinions differ regarding the signals they provide for assessing systemic risk. This affects not only the actual decision to set BBMs, but also their calibration. The differences in opinion stem from differences in the legislation, definitions and rules for computing credit ratios. They also reflect the varying broader macrofinancial conditions across countries, including the debt levels of different sectors of the economy, characteristics of the housing and mortgage markets and the structure of the financial system.[10] For these reasons, the efficiency, effectiveness and stringency of BBMs across the financial cycles of different countries may differ considerably.[11]

A comprehensive approach[12] to calibrating BBMs has been widely discussed. Emphasis is placed on appropriate calibration, as excessively strict BBMs may have unintended consequences. These

---

5 The precise definitions of the LTV, DTI and DSTI ratios and the method and rules for calculating them are set out in Decree No. 399/2021 Coll., on credit ratios.

6 These are recommended limits on credit ratios, above which mortgage loans should be granted very prudently.

7 Specifically, Articles 45a to 45c of Act No. 6/1993 Coll., on the Czech National Bank; also, for example, Act No. 257/2016 Coll., on Consumer Credit, Act No. 21/1992 Coll., on Banks and legislative acts of Directive 2014/17/EU on credit agreements for consumers relating to residential immovable property. This area has not yet been harmonised by binding European legislation.

8 For example, ESRB (2013): ESRB recommendation on intermediate objectives and instruments of macro-prudential policy (ESRB/2013/1), FSB (2012): FSB principles for sound residential mortgage underwriting practices and EBA (2013): Opinion of the European Banking Authority on good practices for responsible mortgage lending.

9 For example, CGFS (2023): Macroprudential policies to mitigate housing market risks, No 69 CGFS.

10 There are large differences across countries in the availability of owner-occupied housing. These differences are partly due to national budget policy. Countries also differ in terms of microprudential supervision and the overall quality of mortgage portfolios in banks' balance sheets, as well as in the calibration of capital buffers, risk weight floors and so on. Aware of the costs associated with the introduction of BBMs, countries often apply relatively large volume exemptions, relax the rules across their cycles (see here, for example) or have a large proportion of first-time buyers covered by government programmes that automatically exempt them from the regulations.

11 If, for example, the risks of a mortgage loan are transferred to a third party (through insurance/reinsurance), BBMs are far less effective and the country may not even consider using them. In contrast, in countries where the mortgage portfolio is already significantly risky and household indebtedness is high, BBMs tend to be highly effective and may be set at relatively stringent levels in the long term.

12 Valderrama, L. (2023): Calibrating macroprudential policies in Europe, IMF, WP/23/75; ECB (2024): Implications of higher inflation and interest rates for macroprudential policy stance, ECB Occasional Paper Series No. 358.

include households taking on additional debt outside the regulated sector and widening social inequality due to creditworthy households being denied access to mortgage loans.[13] Additionally, by setting an upper limit, the CNB indicates a certain reference level, which may also have an adverse consequence: the impact of setting the upper limit on the part of the market not restricted by this limits. This can manifest as a certain relaxation of lending standards – i.e., for less risky loans, the credit ratio values may shift upwards, approaching the set limits from below.[14] Aware of such unintended consequences, **the CNB always carefully assesses the purpose, efficiency and effectiveness of any BBM when making its decisions**. It also takes into account possible interactions with other macroprudential policy tools in use, and with other economic policies.

The main aim of this document is to **present key aspects of the CNB's approach to the calibration of upper limits on LTV, DTI and DSTI** and thereby contribute to greater transparency of the decision-making process and to the formation of rational expectations among all stakeholders.

Considering the nature of systemic risks, the CNB maintains some flexibility in its decision-making and is prepared to take into account new information leading to greater resilience of lenders in its approach. For this reason, this document may be revised or updated as needed, in particular with regard to changes in statistical reporting and potential revisions of data entering the decision-making process, refinements of the CNB's modelling system, legislative changes and changes in internationally recognised practices.

2 Basic information on the calibration of BBMs

The CNB assesses the housing market situation at least once every six months. **The purpose is to identify and quantify systemic risks arising from developments on the housing market.** Based on this assessment, the CNB is authorised to activate, change or recommend upper limits or other measures designed to mitigate such risks and reduce the potential impact of their materialisation. In assessing risks and deciding to activate BBMs, the CNB generally takes into account in particular:

a) indicators related to market of credit to households,
b) residential property market indicators,
c) market credit standards (mortgage lenders' conditions),
d) household vulnerability indicators (household indebtedness and stress test results),
e) mortgage lender vulnerability indicators (bank stress test results),
f) the CNB's macroeconomic forecast and related projections of macrofinancial variables, including quantification of the uncertainty associated with tail events,
g) other macroprudential instruments and other economic policy instruments (in particular fiscal, monetary and microprudential policy tools).

13 CGFS (2023): Macroprudential policies to mitigate housing market risks, CGFS Papers No. 69; Plašil, M. and Z. Komárková (2022): Setting the upper LTV limit at the CNB, CNB, Thematic Article on Financial Stability 1/2022; ESRB (2015): The ESRB handbook on operationalising macroprudential policy in the banking sector.

14 This effect was observed when setting upper limits on credit indicators in Slovakia, see Cesnak, M., A. Cupák, P. Fessler and J. Klacso (2025): Heterogeneous impacts of macroprudential policies: Financial advisors, regulatory caps, and mortgage risk. OeNB Working Paper No. 263.

Decisions to set or reduce binding upper limits under the Act on the CNB take effect no earlier than four months from their date of publication. Where the CNB abolishes or raises existing limits, there is usually no delay in their entry into effect. Higher limits are applied by law to mortgage applicants under 36 years purchasing owner-occupied housing: 10 pp higher for LTV, 5 pp higher for DSTI and one multiple of net annual income higher for DTI. In the current calendar quarter, the law allows banks to exceed the limits for up to 5% of the total volume of mortgage loans granted in the previous quarter.

Decisions to set or reduce recommended limits, which the CNB communicates to lenders by means of official information, also have a delayed entry into effect. Exemptions from the recommendations are always determined on the basis of a case-by-case assessment of the potential scope and type of the risks identified. Recommended limits may therefore differ from binding ones.

The CNB regularly monitors and assesses compliance with binding and recommended limits and publishes the aggregate results half-yearly in its Financial Stability Reports. If the CNB identifies that the statutory limits or exemptions have been breached, it may impose remedial measures. In cases where it identifies non-compliance with its recommendations, the CNB responds within the scope of its supervisory powers over lenders.

3 Approaches used to assess risks in the housing market

The key steps prior to selecting an appropriate BBM to maintain prudent credit standards and deciding to cap the relevant ratio are (1) **to identify systemic risks** arising from developments in the housing market and (2) **to estimate their magnitude** (typically in the form of potential growth in the frequency of default and the size of credit losses), which could negatively affect the stability of the domestic financial sector.

The CNB uses three main approaches to identify systemic risks and risk transmission channels: an indicator approach (see 3.1 Indicator approach), a simulation approach (see 3.2 Simulation approach) and an expert approach (see 3.3 Expert approach).

3.1 Indicator approach

The aim of this approach is to recognise in good time whether **conditions are being created on the housing market for the formation or build-up of potential systemic risks, and to identify the underlying factors**.[15] The CNB distinguishes between two sets of indicators (see Table 1). The first comprises macrofinancial indicators, which reflect the current and expected overall situation in the mortgage and property markets. The second consists of indicators of the riskiness of new mortgage loans, which reflect market credit standards.

The advantage of the indicator approach is that it produces results that are easy to interpret while maintaining a relatively comprehensive picture of market developments. In interpreting the indicators, the CNB takes into account their sensitivity to changes in the dynamics of the input variables, as the relative importance of these variables may vary across the financial cycle.

15 IMF (2014): Staff guidance note on macroprudential policy – Detailed guidance on instruments, IMF Policy Paper; BIS (2012): Operationalising the selection and application of macroprudential instruments, CGFS Papers No. 48.

Table 1

Main indicators used by the CNB to identify potential systemic risks

Type	Indicator	Note
Macrofinancial indicators	Year-on-year change in credit to households	Calculated from total outstanding credit to households.
	Year-on-year change in new mortgage loans	Calculated from pure new mortgage loans to households for house purchase, including increases.
	Year-on-year change in residential property prices	Calculated from the housing price index, including land.
	Credit to households-to-gross disposable income ratio	Calculated as the ratio of total outstanding credit to households to gross disposable income.
	Apartment price-to-income ratio	Calculated as the ratio of the transaction price of a 68 m^2 apartment to the average gross nominal annual wage in the Czech Republic.
	Apartment price-to-rent ratio	Calculated as the ratio of the apartment transaction price per m^2 relative to annual rent per m^2.
	Mortgage loan size-to-income ratio	Calculated as the ratio of the average size of pure new mortgage loans to the average gross nominal annual wage in the Czech Republic.
	Mortgage loan size-to-apartment price ratio	Calculated as the ratio of the average size of pure new mortgage loans to the transaction price of a 68 m^2 apartment.
	Composite risk perception indicator based on values at least one standard deviation higher than the five-year (or long-term, respectively) average	The composite indicator is calculated as a three-quarter moving average and is based on the sum of binary variables that equal 1 if the value of the monitored variable at time *t* is greater than either the five-year moving average plus one standard deviation (first specification) or average plus one standard deviation both calculated starting in 2010 (second specification) – see Appendix 1. The variables monitored are: year-on-year change in credit to households, year-on-year change in new mortgage loans, year-on-year change in residential property prices, the credit to households-to-gross disposable income ratio, the apartment price-to-income ratio, the apartment price-to-rent ratio, the mortgage loan size-to-income ratio and the mortgage loan size-to-apartment price ratio.
Indicators of the riskiness of new mortgage loans	Share of pure new mortgage loans with DSTIs above the recommended prudential limit	Calculated as a percentage of total pure new mortgage loans.
	Share of pure new mortgage loans with DTIs above the recommended prudential limit	Calculated as a percentage of total pure new mortgage loans.
	Share of pure new mortgage loans with LTVs above the recommended prudential limit	Calculated as a percentage of total pure new mortgage loans.
	Mean and median DSTIs for pure new mortgage loans	Calculated using pure new mortgage loans.
	Mean and median DTIs for pure new mortgage loans	Calculated using pure new mortgage loans.
	Mean and median LTVs for pure new mortgage loans	Calculated using pure new mortgage loans.
	Distribution of pure new mortgage loans by DSTI category and monthly income	Distribution of pure new mortgage loans.
	Distribution of pure new mortgage loans by DTI category and monthly income	Distribution of pure new mortgage loans.
	Prudential housing affordability indicator for a safe DSTI of 40%	Calculated as the difference between the price of the property financed by a mortgage loan and the hypothetical price assuming that the mortgage loan has a DSTI ratio of 40%.
	Ratio of the property price to net annual income for households with a mortgage loan	Calculated as the ratio of the purchase price of a property financed by a mortgage loan to the net annual income declared in the mortgage loan application.

3.1.1 Macrofinancial indicators

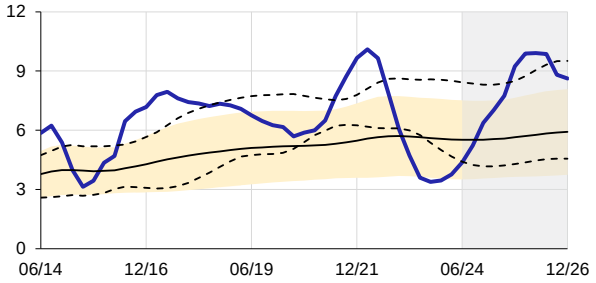
The main macrofinancial indicators are total outstanding credit to households, the volume of new mortgage loans, transaction prices of residential property, the ratio of total credit to households and their income, the ratio of residential property prices to households' income, the ratio of residential property prices to rents, the ratio of the average loan size to households' average income and the ratio of the average loan size to the average property price (see Chart 1). The first five are based directly on the Act on the CNB (see Chart 1, a–e), while the following three (see Chart 1, f–h) are taken into account in the approach on the basis of BIS[16] and IMF[17] guidelines.

Chart 1

Illustration of the evolution of macrofinancial indicators

a) Year-on-year change in credit to households

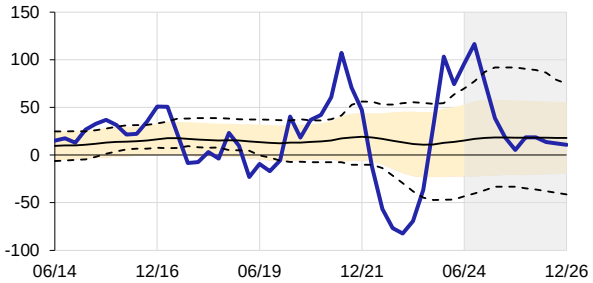
(%)



Note: The chart is based on total outstanding credit to households.

b) Year-on-year change in new mortgage loans

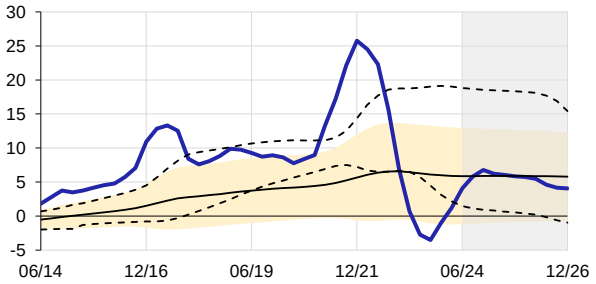
(%)



Note: The chart shows pure new mortgage loans for house purchase, including increases.

c) Year-on-year change in residential property prices

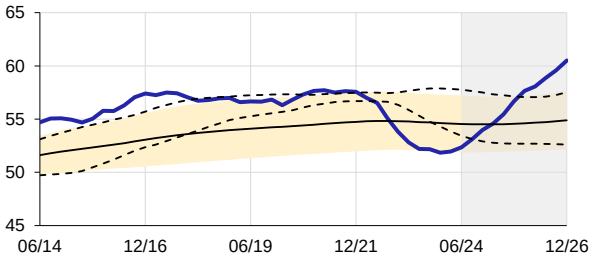
(%)



Note: The chart depicts the housing price index, including land.

d) Credit to households-to-gross disposable income ratio

(%)



Note: The chart depicts the total outstanding credit to households relative to their gross disposable income according to national accounts.

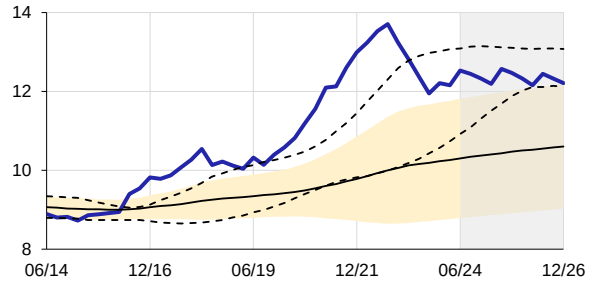
16 BIS (2012): Operationalising the selection and application of macroprudential instruments, CGFS Papers No. 48.

17 IMF (2014): Staff guidance note on macroprudential policy-detailed guidance on instruments, IMF Policy Paper.

Chart 1 – continued

e) Apartment price-to-income ratio

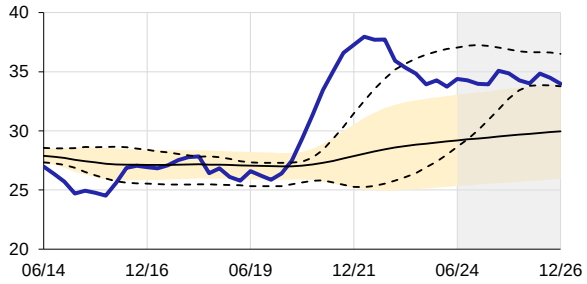
(gross annual income)



Note: The chart shows the transaction price of a 68 m^2 apartment relative to average gross annual wage in the Czech Republic.

f) Apartment price-to-rent ratio

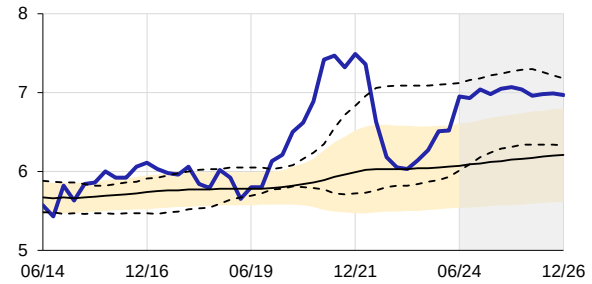
(multiples of annual rent)



Note: The chart shows the apartment transaction price per m^2 relative to annual rent per m^2.

g) Mortgage loan size-to-income ratio

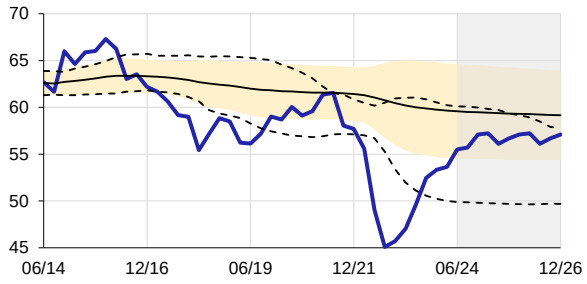
(gross annual income)



Note: The chart shows the average mortgage loan size relative to average gross annual wage in the Czech Republic.

h) Mortgage loan size-to-apartment price ratio

(%)



Note: The chart shows the average mortgage loan size relative to the transaction price of a 68 m^2 apartment.

Shared comment: The dashed black lines show a spread of one standard deviation from the average over the last 20 quarters. The black solid line shows the long-term average calculated using the time series starting in 2010. The yellow area shows a spread of one standard deviation from the long-term average. The grey area shows the projected values consistent with the CNB's autumn forecast (Autumn 2024 MPR).

To facilitate evaluation of the information contained in the macrofinancial indicators and to obtain a quick overview of the market situation, the indicators are combined into composite indicators that describe the level of risk based on values at least one standard deviation higher than the five-year or long-term average (see Chart 2; methodology in Appendix 1).[18] **High composite indicator values signal that conditions may be emerging in the market** for the formation or build-up of potential systemic risks. Conversely, **low values indicate** market conditions under which **systemic risks** tend to be subdued.

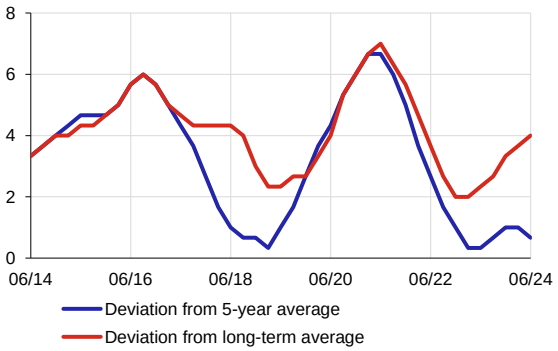
18 The outlook is modelled half-yearly using mortgage loan and property price projections based on the CNB's official macroeconomic forecast. The outlook for the indicators is updated regularly, partly because the forecast always converges towards the steady state with inflation close to the CNB's target. It is therefore not able to sufficiently capture rapid and unexpected changes in total loans.

The CNB also monitors the interaction between the composite indicators and the financial cycle indicator (see Chart 3), which it uses to obtain an overall assessment of the position of the economy in the financial cycle, i.e. in areas other than the property and mortgage markets. This enables the CNB to evaluate how much observed developments are specific to the mortgage market and how much they reflect broader economic conditions. Such an assessment is important for the CNB's decision-making on how to respond to observed developments – by changing the BBMs, by changing the capital requirements (particularly the CCyB) or a combination of both.

Chart 2

Composite risk perception indicators

(0 minimum, 8 maximum)



Note: The composite indicators are constructed on the basis of values at least one standard deviation higher than the average and are smoothed by the 9-month moving average (for details, see Appendix 1).

Chart 3

Financial cycle indicator

(0 minimum, 1 maximum)

3.1.2 Indicators of the riskiness of new mortgage loans

The CNB uses the second set of indicators to assess market credit standards, i.e. the degree of risk associated with new mortgage loans. It distinguishes between individual mortgage lenders and the market as a whole. The main indicators are (i) the breakdown of mortgage loans by credit ratios and applicants' income, (ii) the ratio of residential property prices to the income of households that use mortgage financing to purchase property, (iii) the observed prudential affordability of housing, and (iv) the probability of property prices falling relative to the set level of collateral, i.e. the LTV limit.

Particular attention is paid to the breakdown of mortgage loans by credit ratios. The CNB monitors the level at which each ratio is capped internally by the lender, both individually and in combination with the other ratios. It therefore also assesses whether any combinations of internal limits are causing increased risks to financial stability.[19] **The riskiness of loans granted under the volume**

19 Excessive bias towards one ratio at the expense of the others is not considered optimal credit risk management. For example, an overly relaxed DSTI/DTI (high PD) coupled with a very stringent LTV (low LGD) may seem like sufficient risk management from the lender's perspective. However, such a setup may give rise to systemic risks, because if the economy enters a contractionary phase of the cycle accompanied by high unemployment, a scenario could materialise in which collateral is sold due to the emergence of large amounts of non-performing loans, with negative knock-on effects on house prices.

exemptions and above the recommended prudential limits is analysed in detail (see Chart 4A), as lenders should assess such loans very prudently (see section 4).

Chart 4A

Illustration of the share of pure new mortgage loans granted above the recommended prudential limit

(share in %)

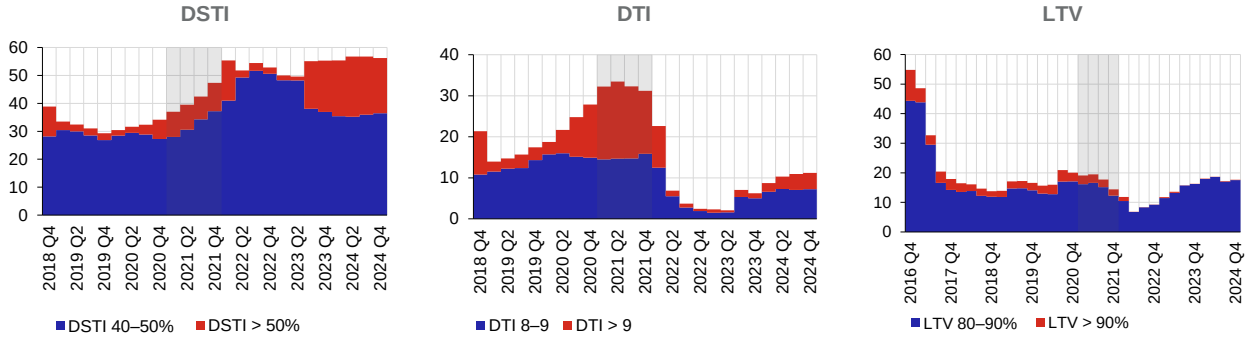
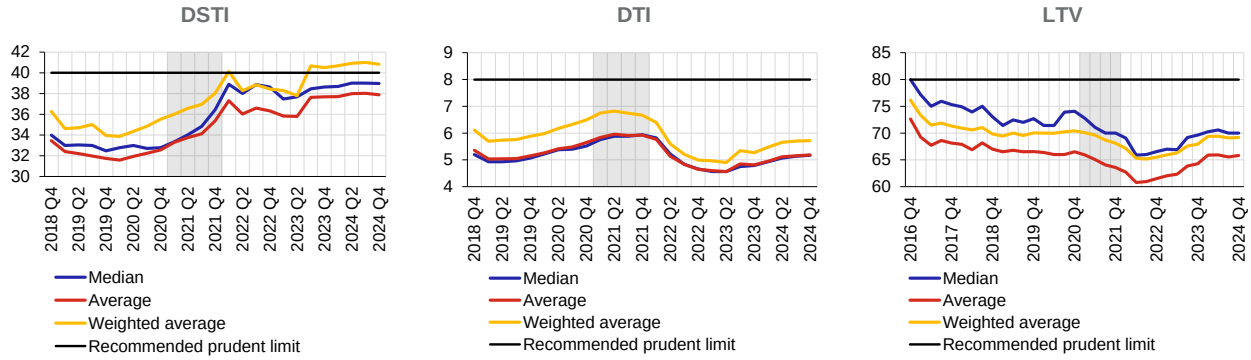


Chart 4B

Illustration of the evolution of mean and median ratios for pure new mortgages

(%, DTI in multiples of annual income)

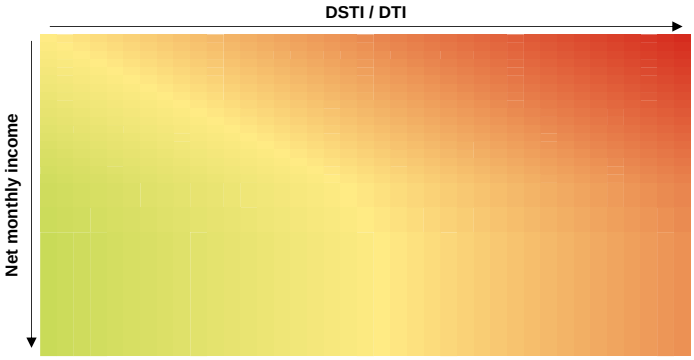


Note: The grey area indicates the one-year period preceding the CNB Bank Board's decision in 2021 to reintroduce/tighten the limits. For the weighted average, the weight is the loan size.

In the context of assessing potential loan default or potential over-indebtedness of households, the CNB also focuses on the **DSTI and DTI breakdown of mortgage loans depending on household income.** For medium- and low-income households, even relatively low values of these ratios can be significantly risky. Chart 5 illustrates the direction of increasing risk of default (upper right) and the set of households that could be highly sensitive even to a relatively moderate decline in net income or a small increase in expenditure, whether related directly to debt service (refixing) or to other needs (such as higher expenditure due to rising inflation).

Chart 5

Illustration of the distribution of pure new mortgage loans by DSTI/DTI category and monthly income



Note: The colours are for illustrative purposes only. They are intended to indicate the usual direction of increasing risk of default. The arrows show the direction of increasing values.

Information on market credit standards is also provided by the prudential housing affordability indicator[20] (see Chart 6; methodology in Appendix 2) and the ratio of residential property prices to household income (see Chart 7). The CNB monitors both these indicators at the theoretical and observed level.[21] At the theoretical level (the blue line), they provide information on the (un)affordability of housing in the Czech Republic and the risk of household over-indebtedness at the aggregate level.[22] At the observed level (the red line), the indicators show whether and to what extent this risk is materialising, due in part to excessively relaxed credit standards. The CNB uses these indicators to monitor whether a potential widening of the gap between property prices and household income at the macroeconomic level is confirmed at the individual level, that is, at the level of individual mortgage loans (i.e. it monitors the distance between the blue and red lines). In this way, it assesses whether households are purchasing property at higher prices than their income situation would justify, as this could cause them to become systematically over-indebted.

In the context of assessing LTV limits, the CNB mainly monitors **residential property prices** across property types and regions of the Czech Republic, as well as the **probability of a large fall in house prices** (see Charts 8 and 9). The materialisation of the risk of a drop in house prices could lead to widespread downward revaluation of collateral and, in the event of the emergence of large amounts of non-performing loans (NPLs) and a large fall in prices, to a substantial rise in credit losses incurred by lenders.

20 In some CNB publications, this indicator is also called the property price overvaluation indicator, which is based on a macroprudential approach. For details, see the cnBlog article Gregor, J., Z. Komárková and A. Kučera (2024): Nadhodnocení cen nemovitostí jako jedno z rizik hypotečního trhu (House price overvaluation as a mortgage market risk; in Czech only).

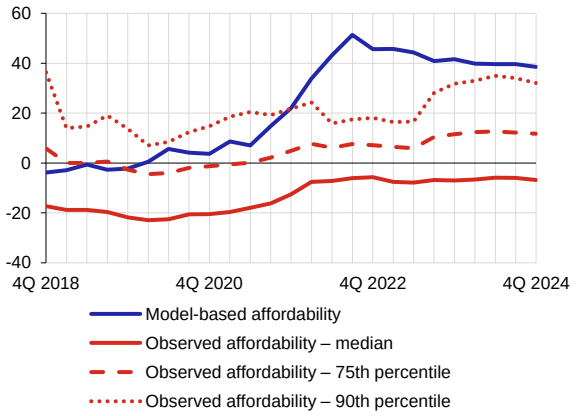
21 The concept at the theoretical level refers to values based on macroeconomic data. The calculation involves average property prices in regional capitals at the national level and household incomes corresponding to the national mean or median level. The concept at the observed level refers to values based on microeconomic data. These are calculated at the level of individual new mortgage loans provided to households in the given quarter.

22 This expresses how risky it is for a median/mean-income household to buy a typical apartment (68 m^2) using a loan, given the prevailing interest rates and economic conditions. The higher the indicator, the greater the risk of the household becoming over-indebted.

Chart 6

Illustration of the prudential housing affordability indicator for a safe DSTI of 40%

(deviation of property price from prudently affordable value in %)

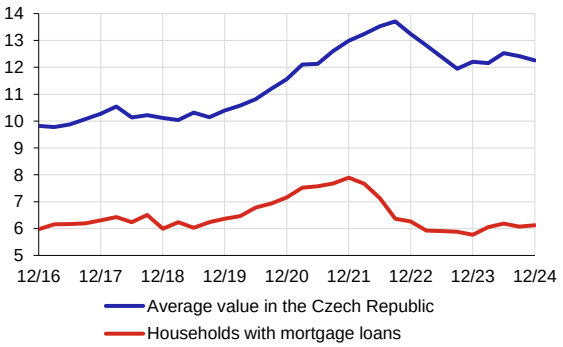


Note: A higher value indicates lower affordability (see Appendix 2 for the calculation method).

Chart 7

Illustration of the property price-to-income ratio

(multiples of annual income)



Note: The blue line shows the average transaction price of a 68 m^2 apartment relative to the average gross annual wage in the Czech Republic. The red line shows the average price of an actually purchased property relative to the borrower's net annual income when the loan was taken out.

Chart 8

Illustration of the evolution of apartment prices in regions by segment

(average transaction prices in CZK thousands/m^2; December 2024)

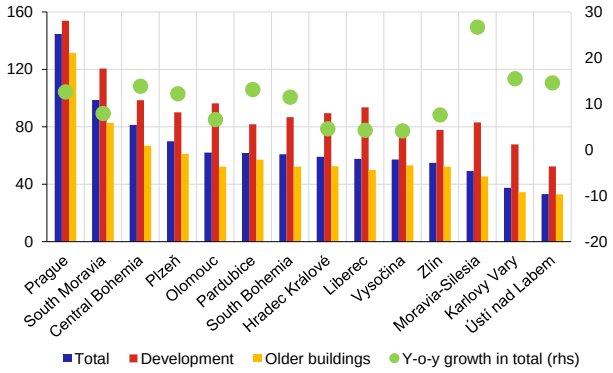
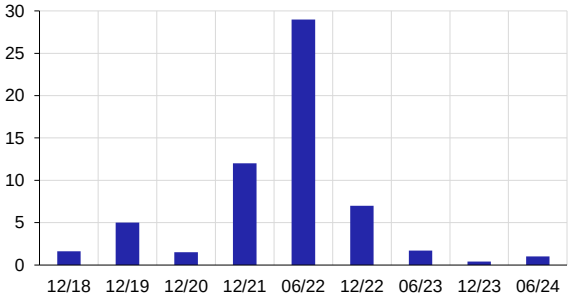


Chart 9

Illustration of the probability of a fall in apartment prices

(%)



Note: The probability of average apartment prices falling by more than 10% over the next two years.

3.2 Simulation approach

The simulation approach is based on the structure of the household stress test. **It aims to quantify potential credit losses given various BBM calibrations**.[23] The lender's potential costs are also taken into account.[24] A five-year period is normally used for the simulations. The advantage of the simulation approach is that it is interlinked with overall macroeconomic developments.[25] The scenario usually first assumes several years of relatively favourable economic conditions – reflected in growing activity in the mortgage market and potential relaxation of credit standards – under the different BBM calibrations considered. In this period, the accumulation of systemic risks is simulated. In the second phase, an adverse scenario is employed to simulate the materialisation of these risks. The simulation approach thus not only analyses the threat of a build-up of risks, but also allows us to assess the subsequent impact of any materialisation of these risks.

The stress test itself is based on a micro-macro model and uses available information on individual mortgage loans. This allows for both the size and the quality of the credit portfolio to be taken into account. A key element of the model is a household balance sheet simulator, which calculates the liquidity and solvency positions of households. Simply put, if a household does not have enough income to service its loans and cover its housing costs and other essential expenses and simultaneously exhausts all its available liquid assets (savings), it becomes insolvent. In terms of the model, its probability of default equals one. The household's simulated expected loss is then computed. The size of the loss depends on the amount of outstanding principle coupled with any penalty interest and fees, the value of collateral and the recovery cost. The individual simulated losses at the household level can then be used to compute the total loss at the level of the whole mortgage loan portfolio.[26]

A key element is the quantification of the benefits of the BBM under consideration in the form of a reduced inflow of risky loans into the mortgage portfolio and hence also diminished loan losses at the time of risk materialisation. The simulated loan losses with no BBMs (DSTI, DTI and LTV all deactivated) are thus compared with the loan losses with one or more BBMs activated. Significant differences in the losses signal a need to respond.

23 Static upper limits are considered in the simulations, i.e. the ratios stay constant throughout the simulation period.

24 The approach does not consider all the lender's costs, nor does it take into account the potential costs of prospective borrowers and the related effects on, for example, consumption, construction and GDP growth. It focuses solely on the lender's foregone interest income.

25 The simulation is based on several assumptions. The most important ones are described in Appendix 3.

26 A brief methodological summary is given in Appendix 4. A detailed description of the approach used can be found in Gregor, J. (2024): A stress test approach to the calibration of borrower-based measures: A case study of the Czech Republic, CNB Working Paper 2/2024.

3.3 Expert approach

The expert approach is intended to add a broader context to risk assessments based on the indicator and simulation approaches by considering other relevant information. It has the advantage of a high degree of flexibility, which is particularly useful in a rapidly changing environment. **This approach also takes more account of the risks and uncertainties of the CNB's baseline forecast and related projections.** It takes the specific nature of past and predicted future adverse shocks, structural changes in the economy and other factors into consideration as well. Unlike the first two approaches, it does not have a precisely specified nature and, over time, some factors may have a greater weight in the decision-making process than others.

The expert approach takes into account the following factors in particular:

from the perspective of macrofinancial conditions

- the broader macroeconomic environment and economic outlook (e.g. labour market developments, the total debt of the household sector, the savings and saving rate of households, and the time it takes an average-income household to save up for a down payment on an average apartment);
- the current and projected monetary and fiscal policy stance, in particular in the context of how they affect mortgage loans and house prices;[27]
- the outlook for the mortgage and property markets (e.g. projected credit growth and house price growth);
- structural features of the domestic property market (the long-term imbalance between the demand for and the supply of standard apartments in regional capitals, the share of private property ownership in the Czech Republic, and general demographic trends);

from the perspective of the situation in the financial sector

- **the level of new mortgage loans with elevated risk** (primarily the volume and number of mortgage loans provided with high BBM ratios; see Chart 10 for an illustration);
- **the rate of change of the mortgage portfolio** (any increase/decrease in portfolio quality through the (non-)provision of new, potentially highly risky loans due to changes in the calibration of BBMs is not instant and absolute; see Chart 11 for an illustration);
- the market share of lenders with relaxed credit standards;
- the overall quality of lenders' loan portfolios (e.g. the NPL ratio, the default rate, the probability of default (PD), the loss given default on total mortgage loans outstanding, and the risk weights of property exposures);
- the overall resilience of lenders (i.e. their capital and liquidity positions and profitability);
- the configuration of other prudential policy tools (e.g. additional capital requirements to mitigate property concentration risk[28]).

---

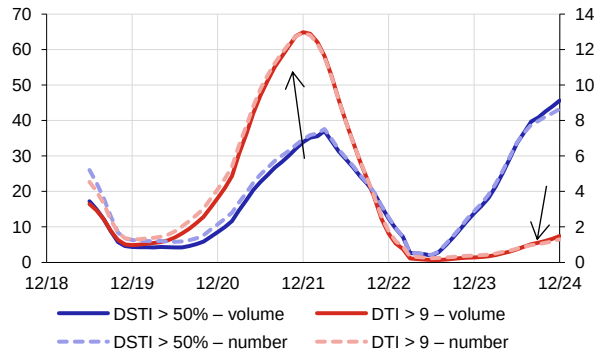
27 In general, longer (shorter) periods of easy monetary and/or fiscal policy increase (reduce) the volume of total and highly risky mortgage loans. See, for example, Jorda, O., M. Schularick and A. M. Taylor (2015): Interest rates and house prices: Pill or poison? FRBSF Economic Letter, 25, and Sutton, G. D., D. Mihaljek and A. Subelyte (2017): Interest rates and house prices in the United States and around the world, BIS Working Paper No. 665.

28 The CNB assesses potential risk mitigation overlaps between BBMs and the SyRB, the CCyB, the O-SII buffer and measures under Article 458 CRR and Pillar 2. All these tools can be used to some extent to address risks arising from the housing market.

Chart 10

Illustration of the evolution of mortgage loans with elevated risk

(pure new loans in CZK billions; right-hand scale: number in thousands)

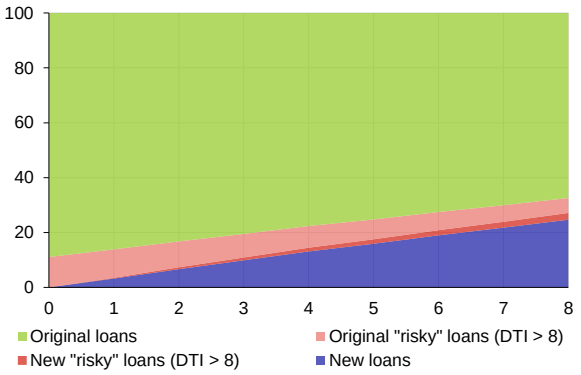


Note: 12-month sum of the volume and number of mortgage loans provided.

Chart 11

Ratio of inflow of new loans to outstanding loans over a two-year horizon

(%; x-axis: number of quarters from start of simulation)



4 Risk assessment process and selection and calibration of BBMs

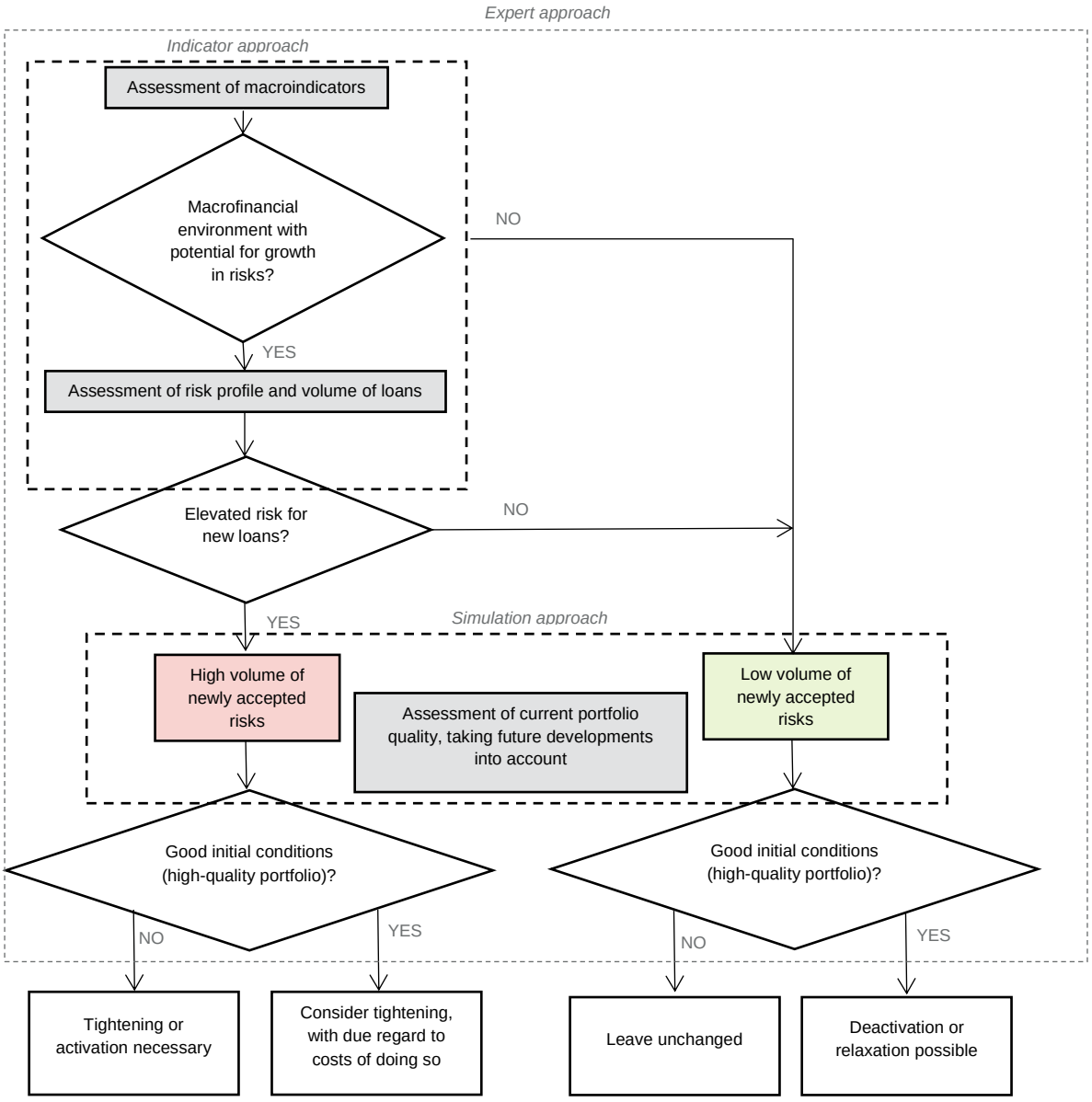
Figure 1 illustrates the risk assessment process under the above approaches (see section 3). The indicator approach is used to analyse the level of macrofinancial risks and risks at new mortgage loan level, i.e. to determine the credit standards applied. The simulation approach is employed to measure the resilience of the current mortgage portfolio, taking into account future adverse developments. The expert approach complements the above two approaches by adding other relevant information and overarches the whole process.

The CNB usually sets BBMs when:

1. due to favourable macrofinancial conditions and relaxed credit standards, lenders across the market are generating relatively large shares, numbers and/or volumes of mortgage loans with elevated risk[29] (see 3.1 Indicator approach);
2. this situation has the potential to jeopardise the stability of mortgage lenders and households (see 3.2 Simulation approach);
3. and the other macrofinancial information available does not indicate any change in risk perception in the sense of a likely imminent decline in the taking on of risks by lenders and households (see 3.3 Expert approach).

29 Loans with elevated risk are loans that show signs of potential over-indebtedness of households (relatively high PD, i.e. DSTI and DTI) and/or ineffective collateralisation (relatively high LGD, i.e. LTV).

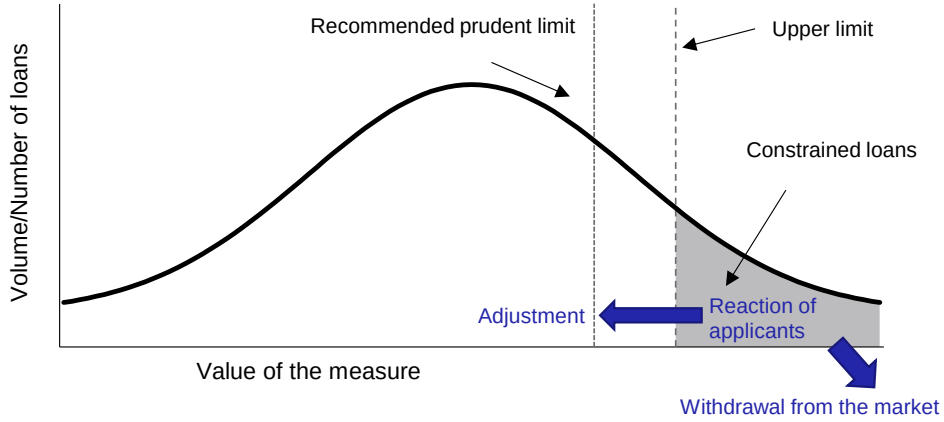
Figure 1:
Simplified BBM calibration process



The CNB introduces BBMs to shift relaxed market credit standards back to a level preventing the accumulation of systemic risks. It primarily influences credit conditions for households that lie at the right end of the distribution from the BBM perspective (see Chart 12). These households may be forced to choose between adjusting to the CNB's requirement and leaving the market. Depending on the response chosen, there will then be a change in the risk characteristics of new loans or a decline in their volume and number. The adjustment usually takes place via loan size, declared

income or collateral value.[30] This should result in a lower debt burden of prospective borrowers, and/or higher collateral.

Chart 12: Effect of BBMs



The CNB tries to influence the borrower and lender adjustment channel by choosing and calibrating BBMs.[31] It monitors factors that indicate **overall loan riskiness** in order to select the optimal BBM or combination of BBMs, to introduce them at the right time, and to avoid calibrating them too tightly and causing undesirable procyclical effects.[32] From this narrow perspective, loans provided at the right end of the distribution according to one ratio can be considered riskier than the rest. However, the other ratios may be sending different signals about the riskiness of such loans (see Chart 13).[33] Therefore, correctly interpreting mixed signals about loan riskiness is a critical step in assessing the effectiveness of a chosen BBM.

LTV limits are primarily set to **keep lenders sufficiently resilient.** Prudent calibration of this BBM should prevent excessive losses from occurring due to mortgage loan defaults in an environment of rapidly falling house prices. This BBM can help to avert sharp growth in loan size and indirectly also prevent households from getting into too much debt, especially when property prices are rising faster than income and the down payment requirement is increasing. Nevertheless, sufficient **resilience of households** should be ensured primarily by means of prudently calibrated income-based BBMs (DSTI and DTI limits). DSTI is suitable for reducing the risk of insolvency. It is closely tied to interest

30 Under certain conditions, adjustment to the requirement may also make indebted households more vulnerable. A high down payment requirement may also completely deplete an indebted household's financial reserve or increase the household's debt as a result of it taking out a loan for the down payment outside the regulated financial sector (see, for example, here).

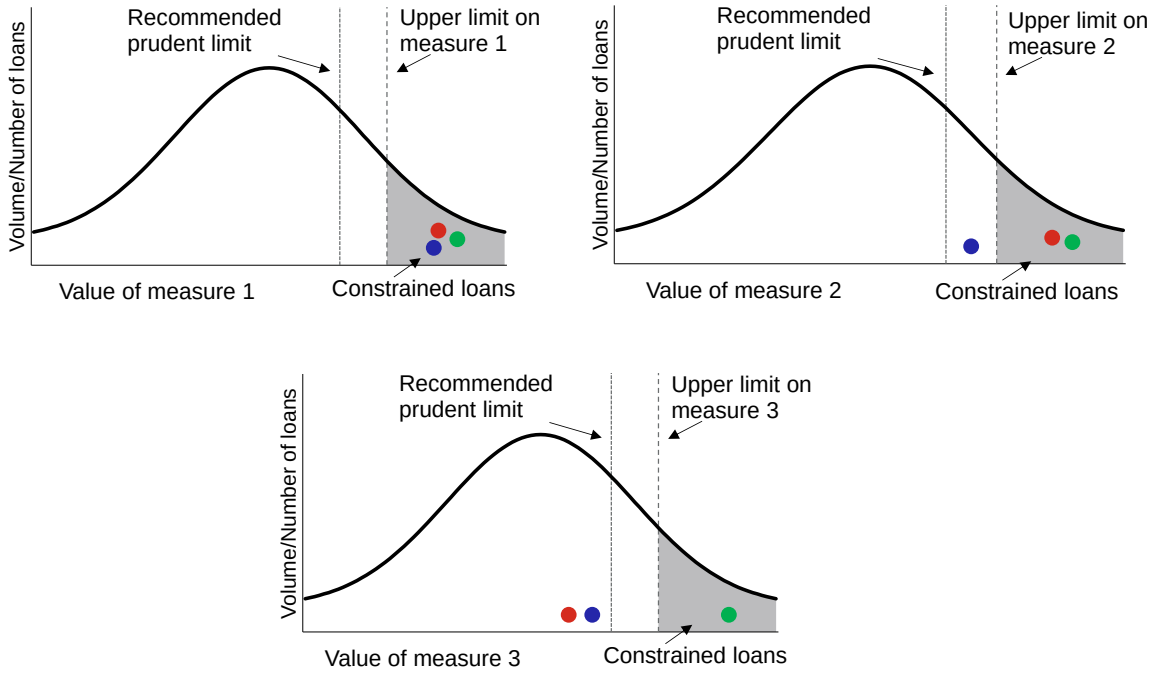
31 For example, if the specific objective in the given situation is to limit the size of new loans with elevated credit risk (to reduce indebtedness), an increased down payment requirement may not be sufficiently effective. Simplifying to some degree, a DTI limit would be a more effective tool than an LTV limit from this perspective.

32 BBMs are not entirely cost-free. They purposely restrict mortgage loan flows and thus potentially affect economic growth and have redistributive effects (see, for example, here, here and here). The CNB makes sure that the benefits (constrained highly risky loans) exceed the costs (constrained effective demand for loans). The benefits of regulation generally increase as the number of loans provided rises in the expansionary phase of cycle.

33 For example, higher DSTI values for loans provided in an environment of high interest rates with an outlook for a decrease in rates do not necessarily indicate elevated loan riskiness if total indebtedness is relatively low (low DTI due to relatively high borrower income) and collateral is relatively high (low LTV).

rates and is therefore likely to be recalibrated more frequently so that it remains efficient and effective across the interest rate cycle. DTI is generally suitable for mitigating the risk of excessive leverage – that is, it should prevent households taking on excessive debt – and is quite effective for purposely reducing the total indebtedness of the household sector after a period of strong and/or sustained credit growth. It is operationally simpler and its effect is not sensitive to interest rate changes. DTI and DSTI are closely interlinked by their nature (see Chart A4 in Appendix 3).

Chart 13: Signals of mortgage loan riskiness



Note: The green point signals loans with elevated risk. In the case of blue and red points, the signals may not be entirely clear.

The CNB usually sets BBMs either at the recommended prudential limits[34] or slightly above them.[35] It also takes lenders' internal limits into account. **The recommended prudential limits are 80% for LTV, 40% for DSTI and 8 times net annual income for DTI.** These values are based on the CNB's internal analyses, according to which the risk of mortgage loan default and the risk of greater loss materialisation start to increase rapidly at these thresholds.[36] The CNB checks the conclusions of these analyses annually. As these values are affected primarily by structural factors (the relationship between income and prices), they can be assumed to be stable in the medium to long run.

34 Recommended limits on credit ratios, above which mortgage loans should be granted only very prudently.

35 See, for example, Provision of a general nature on setting upper limits on credit ratios No. I/2021.

36 See, for example, Box 4 of the Spring 2022 Financial Stability Report and Plašil, M. and Z. Komárková (2022): Setting the upper LTV limit at the CNB, CNB, Thematic Article on Financial Stability 1/2022.

Regarding LTV, the CNB recommends mortgage lenders not to exceed 100% for any new mortgage loan. This value is constant across the cycle, as it is targeted at structural systemic risks. The main objective is to prevent – from a long-term perspective – market standards from being relaxed beyond the level that gives rise to risks to financial stability, regardless of the phase of the financial cycle.

The CNB considers abolishing BBMs at times when market credit standards are at sustainable levels, the mortgage portfolios of consumer credit providers are at sustainably high-quality levels and the systemic risk stemming from the housing market is subdued. Under certain conditions, the CNB may increase the limits (i.e. recalibrate the BBMs); however, this will probably be contingent on structural changes in the characteristics of households (such as an upward shift of the entire household income distribution).[37]

When deciding on BBMs, the CNB also **takes into account the extent to which the systemic risk associated with developments in the mortgage and housing markets is already covered by other micro- or macroprudential tools.** The correlation between the composite indicators (see Chart 2) and the financial cycle indicator indicates that there is some overlap between BBMs and the countercyclical capital buffer (CCyB) in terms of regulating the mortgage market (see Chart 3). The CNB takes this overlap into account by setting the CCyB rate in relation to the risks of the existing portfolio, whereas BBMs are targeted at new loans. Therefore, with tighter BBMs, i.e. greater restriction of the inflow of risk into banks' balance sheets, the risks of the mortgage portfolio will naturally decrease steadily. *Ceteris paribus*, this will affect the necessary CCyB rate (to the extent of the part of the CCyB that covers mortgage portfolio risks).

The CNB applies a similar approach to the assessment of overlaps with other relevant capital instruments, i.e. the Pillar 2 requirements, the sectoral systemic risk buffer and macroprudential measures setting risk weight floors.

The calibration of BBMs primarily reflects the riskiness of households, i.e. mortgage loan applicants. In this sense, BBMs thus allow the CNB to respond to an increase in systemic risk in a relatively targeted way. This justifies the use of BBMs in parallel with capital buffer requirements.

37 This is due to the effect of the CNB's limits on lenders' internal credit standards. The CNB's limits constitute a reference level in the perception of risks. In certain circumstances, increasing the limits could lead to an unwanted upward shift of all internal limits on these ratios (such as the setting of a relatively high limit on income-based ratios for low-income applicants).

5 Communications

The CNB issues press releases to communicate the outcome of its assessments of the systemic risk associated with the housing market and the levels of new/recalibrated BBMs. A new/recalibrated BBM becomes legally binding on institutions on the publication of a Provision of a general nature on setting upper limits on credit ratios, which the CNB publishes in a manner allowing remote access. The provision also includes an assessment of the overall situation in the housing market and the values of the key indicators used for the decision. Where the CNB's assessment does not result in a new/recalibrated BBM, the CNB does not issue a new provision. The CNB publishes updated assessments of the overall situation only in its Financial Stability Reports.

The CNB communicates and justifies recommendations regarding limits on ratios by issuing official information. It also uses official information to recommend other risk management processes for housing loans.

To facilitate traceability of past provisions and their justifications, a history of provisions and official information is available on the CNB website under Financial stability – Macroprudential policy – Requirements for LTV, DSTI and DTI limits.

Appendix

1. Construction of the composite risk perception indicators

For the first indicator (*D1*), an indicator function is used to determine whether the value of each variable at time *t* is higher than the sum of the mean and its standard deviation over the past 20 quarters:

$$D1_x = 1 \quad \textbf{when} \quad x_t \quad > \quad \frac{1}{n}\sum_{i=1}^{n} x_{t-i} + \sqrt{\frac{1}{n}\left(\sum_{i=1}^{n}(x_{t-i} - \frac{1}{n}\sum_{i=1}^{n} x_{t-i})^2\right)} \quad \textbf{otherwise} \quad 0,$$

where *x* are the individual variables (see Chart 1, a–h), $D1_x$ are 0/1 dummies for the individual variables and *i* are quarters, with the horizon length *n* set to 20 quarters (n = 20).

In the case of the second indicator ($D2_x$), an indicator function is used to determine whether the value of each variable at time *t* is higher than the sum of the long-term mean and its long-term standard deviation:

$$D2_x = 1 \quad \textbf{when} \quad x_t \quad > \quad \frac{1}{n}\sum_{i=0}^{n} x_{t-i} + \sqrt{\frac{1}{n}\left(\sum_{i=0}^{n}(x_{t-i} - \frac{1}{n}\sum_{i=0}^{n} x_{t-i})^2\right)} \quad \textbf{otherwise} \quad 0,$$

where *n* is the horizon length in quarters. The initial year for calculating the long-term means and the standard deviations is 2010. The resulting composite indicators range in value from 0 to 8.

2. Calculation of observed and modelled prudential housing affordability

This indicator generally signals whether the affordability of housing in the Czech Republic is increasing or decreasing over time depending on interest rates. Put simply, it is the deviation of the market price of a property from the value which, under certain assumptions, the household will be able to finance safely (the "fundamental value"):[38]

$$deviation = 100 * \left(\frac{market\ price}{fundamental\ value} - 1\right) = 100 * \left(\frac{market\ price}{safe\ loan\ size + own\ funds} - 1\right),$$

where $safe\ size = \text{"safe" DSTI} * \text{net monthly income} * \frac{(1-(1+IR_M))^{-T_M}}{IR_M}$,

where IR_M is the monthly interest rate and T_M the term of the mortgage in months.

The indicator has two strengths. The first is its interpretation: the greater the deviation, the higher the risk of households being able to purchase a more expensive property than they can safely finance, i.e. taking out a larger mortgage loan than they can safely repay. The indicator's second strength is its comprehensiveness. It includes information both on households' income and the

38 For more information on the calculation of the indicator, see Plašil, M. and M. Andrle (2019): Assessing house price sustainability, CNB, Thematic Article on Financial Stability 1/2019.

interest rate and on the size of the down payment made by the applicant on the property. It therefore contains information both on the possible "safe" level of debt in terms of DSTI or DTI, and on the down payment, or LTV.

The CNB regularly calculates the indicator's "theoretical value" (model-based affordability). It does so using a model of a hypothetical median-income household that takes a prudent approach to loan financing. The calculation therefore defines the safe value of DSTI at 35%/40%, which caps the affordable ("safe") mortgage loan size for such a household. At the same time, the hypothetical household has limited funds of its own. It has the minimum it needs to make the down payment. The calculation assumes a down payment of 20%.[39] The household therefore needs a loan of 80% of the property price. The fundamental value of the property for this hypothetical household is the sum of the "safe" loan size and its own funds. It is also assumed that the hypothetical household buys a 68 m^2 apartment at the average market price.[40] The model-based affordability is given by the difference between the market price of such an apartment and the fundamental value of the property. A positive value means that the apartment is affordable for the household only with elevated credit risk. The calculated safe loan size is lower than the amount it would need to borrow from the bank to buy the apartment.

The CNB also computes the observed level of the indicator for individual mortgage loans. This allows it to determine whether, and to what extent, there were indeed households on the market similar to the hypothetical one, and hence whether banks' credit standards were so relaxed that households could indeed buy properties that were not "safely" financeable using a loan at the time.

3. Main assumptions used in the simulation approach

A key element of the simulation approach to the suitable calibration of BBMs is the definition of the LTV, DTI and DSTI distribution of new mortgage loans. The latter is based on historical observations, and – in the case of a regulatory option not exercised so far – the definition of the probability distribution of new mortgage loans is adjusted by expert judgement (see Charts A1–A3). The definition of the distribution of new mortgage loans is then used in a simulation in the form of a shared probability distribution according to LTV and DTI/DSTI, whichever is the tighter; the tightness depends on the average interest rate on new mortgage loans in the given period (see Chart A4).

The simulation also takes into account the statutory 5% volume exemption. Banks thus are restricted by the BBM limits, which they may exceed in respect of 5% of the volume of loans provided in the previous quarter. To preserve a prudent regulatory approach, the simulation assumes that the 5% volume exemption is taken up fully and banks thus lend up to the limits of what the BBMs allow. However, the macroeconomic environment rarely allows banks to apply the 5% exemption to the full

[39] Therefore, the model-based value of the indicator does not reflect the relatively common situation of households where the purchase of one property is linked to the sale of another (the sale of an old/small apartment and the purchase of a new/bigger one). Through the sale of the other property, these households usually acquire more than 20% of the price of the new property.

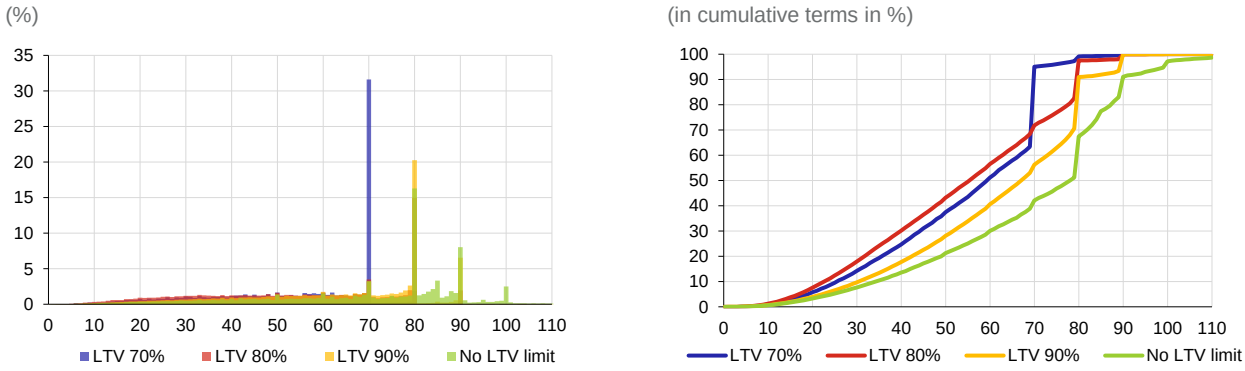
[40] In the Czech Republic, the average is significantly affected by prices of apartments in Prague, hence it is skewed upwards. The market price is meanwhile calculated only on the basis of transactions in regional capitals.

for DTI and DSTI simultaneously. This is because these indicators have a similar but not identical regulatory effect and are therefore not equivalent. In reality, the 5% limit is fully used up only for the tighter of the two ratios. The simulation process in the stress test is configured in the same way, as the choice of the tighter of the tools is based on the assumption that the DSTI is computed using a 30-year mortgage term and the average mortgage rate in the given period.

Another important assumption besides that about the future LTV, DTI and DSTI distribution of new mortgage loans is that about the future number of new mortgage loans depending on the form of regulation in place. The empirical literature indicates that LTV regulation restricts lending less than DTI and DSTI regulation.[41] At the same time, the literature shows that limit-based regulation has a non-linear impact on the volume of new loans.[42] The simulation employs the concept of the maximum accessibility of a household to an average mortgage loan to estimate of the impact of various forms of LTV, DTI and DSTI regulation on the number of new loans. The concept consists in determining the number of households that qualify for a mortgage loan under given credit standards. To this end, assumptions are made about the distribution of income in the population and about the distribution of households' assets. On the basis of these assumptions, the change in accessibility of mortgage loans is computed for various forms of limit-based regulation.[43]

Chart A1

Hypothetical distribution of new mortgage loans by LTV



41 See, for example, Claessens, S., S. R. Ghosh and R. Mihet (2013): Macro-prudential policies to mitigate financial system vulnerabilities, Journal of International Money and Finance, 39: 153–185; Kuttner, K. N. and I. Shim (2016): Can non-interest rate policies stabilize housing markets? Evidence from a panel of 57 economies, Journal of Financial Stability, 26: 31–44; and Cerutti, E., S. Claessens and L. Laeven (2017): The use and effectiveness of macroprudential policies: New evidence, Journal of Financial Stability, 28: 203–224.

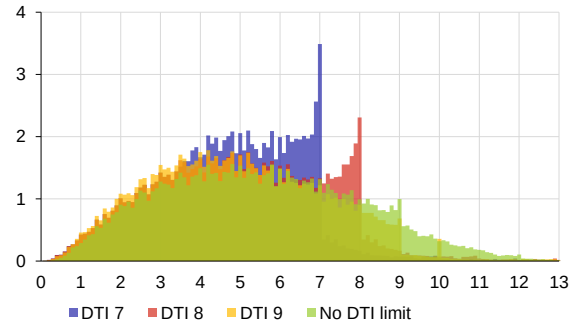
42 See Kelly, R., F. McCann and C. O'Toole (2018): Credit conditions, macroprudential policy and house prices, Journal of Housing Economics, 41: 153–167; and Alam, Z., A. Alter, J. Eiseman, G. Gelos, H. Kang, M. Narita, E. Nier, and N. Wang (2024): Digging deeper – evidence on the effects of macroprudential policies from a new database, Journal of Money, Credit and Banking.

43 More information is available in Appendix C of Gregor, J. (2024): A stress test approach to the calibration of borrower-based measures: A case study of the Czech Republic, CNB Working Paper 2/2024.

Chart A2

Hypothetical distribution of new mortgage loans by DTI

(%)



(in cumulative terms in %)

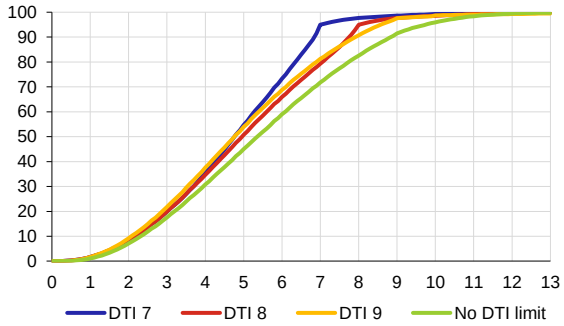
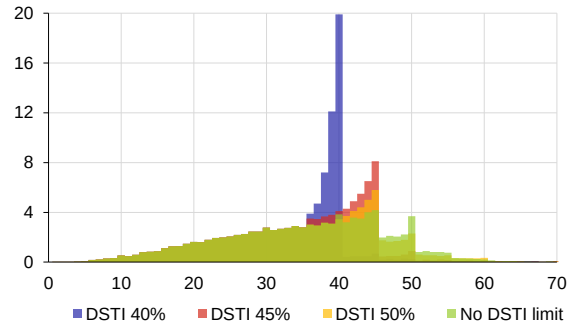


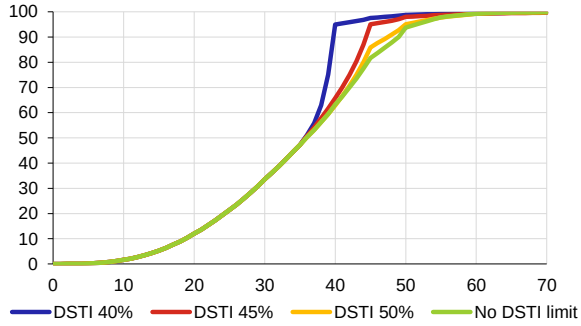
Chart A3

Hypothetical distribution of new mortgage loans by DSTI

(%)



(in cumulative terms in %)

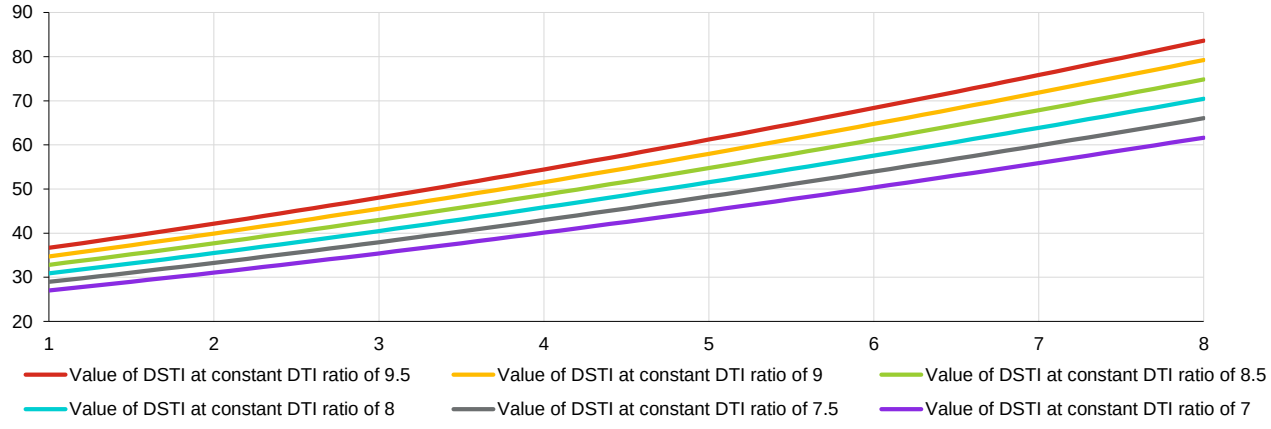


Note: For DSTI, the distribution depends on the level of interest rates (see Gregor, J. (2024): A stress test approach to the calibration of borrower-based measures: A case study of the Czech Republic, CNB Working Paper 2/2024). The distribution displayed above applies for rates in the range of 3% to 4%.

Chart A4

Equivalence of DSTI and DTI at different interest rates

(DSTI in %; x-axis: interest rates in %)



Note: The calculation uses a 30-year mortgage term.

4. Methodology used in the simulation approach

The stress test of households uses the financial margin (FM) approach:

$$FM_{i,t} = NI_{i,t} - LR_{i,t} - HC_{i,t} - NE_{i,t}$$

where NI is the net monthly income of households, LR repayments of all loans, HC housing costs and NE necessary expenses. Index i refers to the *i*-th household with a mortgage loan, and t is time.

The stress test also takes into account the liquid assets (usable savings) that households may use to overcome bad times if their financial reserves fall into negative territory.[44] In the event of exhausting all their liquid assets in a still adverse financial situation ($FM < 0$), households default on their loans. In terms of the model, their probability of default (*PD*) thus equals 1.

The expected loss on the loan (ELL) is then calculated. It depends on the outstanding principle (*P*), outstanding repayments coupled with any penalty interest and fees (*RP*), the expected value of collateral (*EC*) and the expected recovery cost *(ERC)*:

$$ELL_{i,t} = \max(P_{i,t} + RP_{i,t} - EC_{i,t} + ERC_{i,t}; 0),$$

where:

$$RP_{i,t} = repayment\ overdue \times \left(1 + PR_{i,t}\right); EC_{i,t} = \frac{FDR \times PP_{i,t+n}}{1+DR}; ECR_{i,t} = \frac{RCR \times PP_{i,t+n}}{1+DR} \quad ,$$

where PR is the penalty rate, FDR indicates the foreclosure discount rate, PP denotes the expected market value of the property at the date of sale, RCR indicates the recovery cost ratio and DR represents the discount rate, which is proxied by the 2W repo rate. n indicates the length of the recovery process.

The portfolio expected losses *(EL)* can be computed from the individual losses for individual households:

$$EL_t = PD_t \times LGD_t \times EAD_t,$$

where

$$PD_t = \frac{1}{n}\sum_{i=1}^{n} PD_{i,t},$$

$$LGD_t = \frac{\sum_{i=1}^{n}(PD_{i,t} \times ELL_{i,t})}{\sum_{i=1}^{n}(PD_{i,t} \times EAD_{i,t})},$$

$$EAD_t = \sum_{i=1}^{n}(PD_{i,t} \times EAD_{i,t}),$$

with *EAD* at the loan level equal to the outstanding principal (*P*) plus the value of outstanding repayments coupled with any penalty interest and fees (*RP*).

44 For more information, see Gregor, J. (2024): A stress test approach to the calibration of borrower-based measures: A case study of the Czech Republic, CNB Working Paper 2/2024.

To illustrate the whole situation, the CNB also carries out an analysis of the estimated benefits of the measure under consideration (*B*) in the form of the reduction in losses between the simulation with no BBMs ($EL\ no\ regulation$) and the simulation with BBMs ($EL\ regulation$):

$$B = \sum_{t=1}^{T} EL\ no\ regulation_t - \sum_{t=1}^{T} EL\ regulation_t,$$

where *T* is the number of quarters in the simulated horizon. The BBMs themselves can have several different calibrations, and the difference in the expected losses relative to the no-regulation simulation can be computed for each one.